**Ground-Water Characterization
Field Activities for 1995-1996
Laboratory for Energy-Related Health Research
University of California, Davis**

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**Pacific Northwest National Laboratory
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Summary

This report documents ground-water characterization field activities completed from August to December 1995 and in January 1996 at the Laboratory for Energy-Related Health Research (LEHR) in Davis, California. The ground water at LEHR is one of several operable units under investigation by Pacific Northwest National Laboratory^(a) for the U.S. Department of Energy.

The purpose of this work was to further characterize the hydrogeology beneath the LEHR site, with the primary focus on ground water. The objectives were to estimate hydraulic properties for the two uppermost saturated hydrogeologic units (i.e., HSU-1 and HSU-2), and to determine distributions of contaminants of concern in these units. Activities undertaken to accomplish these objectives include well installation, geophysical logging, well development, ground-water sampling, slug testing, Westbay ground-water monitoring system installation, continuous water-level monitoring, Hydropunch installation, and surveying.

Five ground-water monitoring wells were completed in two clusters. The first cluster contains three wells and is located east of the LEHR site; the second cluster contains two wells and is located south of the LEHR site. One well in the first cluster was completed at seven discrete intervals for sampling with a Westbay ground-water monitoring system. Slug testing of these and selected existing monitoring wells yielded hydraulic conductivity ranges and mean values that were slightly higher than previously reported values for HSU-1 and significantly higher for HSU-2.

Ground-water samples were collected from 61 Hydropunch locations. Analytical results from these locations and the wells indicate high chloroform concentrations trending from west/southwest to east/northeast in the lower portion of HSU-1 and in the upper and middle portions of HSU-2. The chloroform appears to originate near Landfill 2.

Tritium was not found above the MCL in any of the well or Hydropunch samples. Hexavalent chromium was found at four locations with concentrations above the MCL in HSU-1 and at one location in HSU-2. One well in HSU-1 had a total chromium concentration above the MCL. Nitrate-nitrogen above the MCL was found at several Hydropunch locations in both HSU-1 and HSU-2.

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1.0 Introduction

This report describes selected ground-water characterization field activities conducted in support of the remedial investigation/feasibility study (RI/FS) at the Laboratory for Energy-Related Health Research (LEHR) in Davis, California (Figure 1.1). It summarizes activities outlined in the *Field Activity Plan, Laboratory for Energy-Related Health Research, Davis, California* (PNL 1995, unpublished).^(a) Pacific Northwest National Laboratory (PNNL), in conjunction with International Technology (IT) Corp., Water Development Corp., Schlumberger Well Services, Westinghouse Hanford Co., Westbay Instruments, Inc. (Westbay), Lockheed Analytical Services (LAS), Gregg In Situ, Inc., and Morrow Surveying, performed these activities from August to December 1995 and in January 1996.

The purpose of this work was to further characterize the hydrogeology beneath the LEHR site, with the primary focus on ground water. The objectives were to estimate hydraulic properties for the two uppermost saturated hydrogeologic units (i.e., HSU-1 and HSU-2), and to determine distributions of contaminants of concern in these units. Activities undertaken to accomplish these objectives include well installation, geophysical logging, well development, ground-water sampling, slug testing, Westbay ground-water monitoring system installation, continuous water-level monitoring, Hydropunch installation, and surveying. Section 2.0 of this report presents the approach, rationale, and results from each of these activities. Section 3.0 summarizes the data management. Section 4.0 describes a refined hydrogeologic conceptual model for the site. The appendices provide additional, specific detail related to the characterization activities: Appendix A, as-built diagrams, well completion summaries, daily borehole logs, and daily borehole/well completion logs for newly installed wells; Appendix B, sediment physical analyses; Appendix C, geophysical logging systems and calibration for well UCD2-027; Appendix D, slug test results and analysis plots; Appendix E, a description of the Westbay system components and tools; and Appendix F, cone penetrometer testing (CPT) logs.

1.1 Background and Summary of Completed Work

Detailed source area descriptions and summaries of previous investigations are provided in the *Final Draft RI/FS Work Plan, LEHR Environmental Restoration, University of California at Davis* (DOE 1994). A summary of the completed work described herein is provided below and shown in Table 1.1.

Five ground-water monitoring wells were installed in August and September 1995 using the air rotary drilling method. The wells are located in two clusters (Figure 1.2). The first cluster is located

(a) Pacific Northwest Laboratory. 1995. *Field Activity Plan, Laboratory for Energy-Related Health Research, Davis, California*. Pacific Northwest Laboratory, Richland, Washington. (This report has not been published. References to it hereafter are cited as "PNL 1995, unpublished.")

REFERENCE: USGS 7.5 Minute Series Quadrangles;
Merritt, CA, 1981 and Davis, CA, 1982

Figure 1.1. Generalized Location Map

Table 1.1. Field Activity Schedule

Task	Start Date	Completion Date
Logistics, Site Preparation	8/15/95	8/16/95
Onsite Readiness Review	8/28/95	8/28/95
Install Well UCD2-027	8/29/95	10/6/95
Perform Geophysical Logging in Well UCD2-027	9/7/95	9/7/95
Install Well UCD2-026	9/13/95	10/6/95
Install Well UCD1-025	9/19/95	10/6/95
Install Well UCD2-035	9/26/95	10/6/95
Install Well UCD1-034	9/28/95	10/6/95
Install Surface Completions	10/2/95	10/6/95
Develop/Slug Test Well UCD2-027	10/11/95	10/19/95
Install/Sample Westbay System in Well UCD2-027	10/23/95	10/31/95
Install MOSDAX System in Well UCD2-027	11/1/95	11/1/95
Develop/Sample Well UCD1-034	10/17/95	10/17/95
Develop/Sample Well UCD2-035	10/18/95	10/19/95
Develop/Sample Well UCD1-025	10/19/95	10/20/95
Slug Test Well UCD2-035	10/30/95	10/30/95
Slug Test Well UCD1-034	10/31/95	10/31/95
Develop/Sample Well UCD2-026	11/1/95	11/1/95
Perform Slug Interference Test on Well UCD2-026	11/1/95	11/1/95
Perform Slug Interference Test on Well UCD1-025	11/2/95	11/2/95
Install Continuous Water-Level Monitoring Systems in Wells UCD1-025, UCD2-026, UCD1-034, and UCD2-035	11/3/95	11/3/95
Slug Test 16 Existing Monitoring Wells	10/30/95	11/6/95
Install/Sample/Analyze 18 Hydropunch Locations	10/3/95	10/10/95
Install/Sample/Analyze 21 Hydropunch Locations	11/15/95	12/1/95
Install/Sample/Analyze 22 Hydropunch Locations	3/11/96	3/22/96
Notes:		
1. A California Registered Geologist was involved during drilling operations.		
2. A Health Physics Technician was involved in all field activities.		

east of the LEHR site, approximately 60 ft south of Building U-1. This cluster contains three wells, UCD1-025, UCD2-026, and UCD2-027. Well UCD1-025 is completed near the bottom of hydrogeologic unit 1 (HSU-1). Well UCD2-026 is completed near the top of hydrogeologic unit 2 (HSU-2). Well UCD2-027 monitors seven intervals, three within HSU-1 and four within HSU-2. Geophysical logging was performed in well UCD2-027 to help select the screened intervals.

The second cluster is located south of the LEHR site and north of Putah Creek. This cluster contains two wells, UCD1-034 and UCD2-035. Well UCD1-034 is completed near the bottom of HSU-1. Well UCD2-035 is completed near the bottom of HSU-2.

The five monitoring wells were completed flush-to-ground in concrete pads in October 1995. Locking caps were installed on the stainless steel casings. Risers, with drains and caps, were placed around the stainless steel casings, within the concrete pads. Vaults, equipped with internal access ports and drainage vents, were set in the concrete pads. The vaults house dataloggers emplaced to continuously monitor water levels. Domed brass survey markers were placed in each concrete pad and stamped with the appropriate well number. A total of three pads were poured, one for well UCD2-027, one for wells UCD1-025 and UCD2-026, and one for wells UCD1-034 and UCD2-035.

Following completion, the wells were developed, ground-water samples were collected, and slug tests were performed. The screened intervals were developed to reduce turbidity. Ground-water samples were collected and analyzed for chloroform, tritium, hexavalent and total chromium, and nitrate-nitrogen on a rapid turnaround basis for screening purposes. Slug tests were performed in each well to provide information on the range of hydraulic properties within HSU-1 and HSU-2. In addition, slug tests were performed on 16 existing monitoring wells.

A Westbay MP55 Multi-Level Ground-Water Monitoring System was installed in well UCD2-027 after development and slug testing. This system was designed to monitor fluid pore pressures during hydraulic tests and to obtain ground-water samples from discrete intervals within HSU-1 and HSU-2. Continuous water-level monitoring equipment was installed in wells UCD1-025, UCD2-026, UCD1-034, and UCD2-035 to monitor diurnal and seasonal water-level trends and response patterns.

Ground-water samples were collected from 18 Hydropunch locations, installed radially outward from an existing monitoring well, UCD1-012, in October 1995 (see Figure 1.2). The samples were collected predominantly from two depth intervals and analyzed for chloroform, tritium, hexavalent and total chromium, and nitrate-nitrogen. An additional 21 downgradient Hydropunch locations were installed, sampled, and analyzed in November and December 1995. In March 1996, 22 Hydropunch locations were installed, sampled, and analyzed adjacent to Landfill 3 and offsite (Figure 1.3). The purpose of the Hydropunch installations was to assess the extent of ground-water contamination resulting from LEHR activities.

In October and November 1995, flush-to-ground well cover systems were installed on five existing wells located in high traffic areas. These wells, the five new wells, and the Hydropunch locations were surveyed for horizontal and vertical control in January and March 1996.

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Figure 1.3. Map Showing the Phase III Hydropunch Locations

2.0 Field Activities

The field activities described in this section include well installation, geophysical logging, well development, ground-water sampling, slug testing, installation of the Westbay ground-water monitoring system, continuous water-level monitoring, Hydropunch installation, and surveying. These activities were completed from August to December 1995, and in January and March 1996.

2.1 Well Installation

Five monitoring wells, UCD1-025, UCD2-026, UCD2-027, UCD1-034, and UCD2-035, were installed by Water Development Corp. in August and September 1995 to monitor contaminant concentrations in ground water and to provide structures for detailed hydraulic characterization. The wells were constructed in accordance with California Well Standards (California Department of Water Resources Bulletins 74-81 and 74-90 [DWR 1991]) and American Society for Testing and Materials (ASTM) ASTM D 5092, *Standard Practice for Design and Installation of Ground Water Monitoring Wells in Aquifers* (ASTM 1995b). Table 2.1 summarizes the well installation and design data, including the well number; order; drilling method; temporary and permanent casing diameters; drill and completed depths; coring interval; screen length, slot size, and interval; and HSU monitored. Well locations are shown in Figure 1.2.

Drilling permits were obtained from the Solano County Department of Environmental Health. Drilling operations were documented by a site geologist according to Procedure NHFP-DO-01, "Collection and Documentation of Borehole Samples and Well Construction Data" (PNL 1995, unpublished) and Last and Liikala (1987). Sediment cores and cuttings were also classified using ASTM D 2488-93, "Standard Practice for Description and Identification of Soils" (Visual-Manual Procedure) (ASTM 1995a). Oversight was provided by a California Registered Geologist. Appendix A contains as-built diagrams, well completion summaries, daily borehole logs, and daily borehole/well completion logs.

2.1.1 Drilling Method

The five wells were drilled using the air rotary casing hammer method. With this method, a drill bit is advanced through the subsurface and a threaded temporary carbon steel casing is driven behind it. Cuttings within the temporary casing are transported to the surface by highly pressurized air released through the drill bit. The temporary casing is advanced by an air-actuated top-head hammer. This method is well suited to areas where the geology consists of varied clay, silt, sand, gravel, and caliche mixtures similar to the LEHR site and typical of the California central valley within which the LEHR site is located. The advantages of using this method in these settings include a rapid drilling rate, the ability to collect continuous core, the use of temporary casing to keep the borehole open for geophysical logging and well construction, and less well development compared to drilling methods that rely on mud to keep the borehole open.

Table 2.1. Well Completion Summary

Well Number	Drilling Method	Temporary Casing Diameter (in.)	Permanent Casing Diameter (in.)	Drill Depth (ft bgs)	Completed Depth (ft bgs)	Continuous Core Sampling (ft bgs)	Screen Length (ft)	Slot Size	Screened Interval (ft bgs)	HSU Monitored
UCD2-027	Air Rotary	9.63	5	136	128	0-105	2 Each	20/10	7 Intervals ⁽²⁾	Both ⁽³⁾
UCD2-026	Air Rotary	9.63	4	102	102	6 Samples ⁽¹⁾	15.	20	87-102	HSU-2
UCD1-025	Air Rotary	9.63	4	75	75	0	15	10	60-75	HSU-1
UCD2-035	Air Rotary	9.63	4	130	122	0-61	15	20	107-122	HSU-2
UCD1-034	Air Rotary	9.63	4	80	76	0	15	10	61-76	HSU-1

Notes:

- Continuous core samples were collected from 18-19.5, 38.5-40, 58-59.5, 78-79.5, and 88-89.5 ft bgs in well UCD2-026.
- Screened intervals are from 53-55, 63-65, 73-75, 86-88, 96-98, 106-108, and 116-118 ft bgs in well UCD2-027.
- Three 10-slot screens were installed in HSU-1 and four 20-slot screens were installed in HSU-2 in well UCD2-027.

A Speedstar 16 drill rig was used for these wells. The outer diameter (OD) of the temporary casing was 9.63 in., with an 8.63-in. inner diameter (ID). Casing lengths were 5, 10, and 20 ft and selected accordingly to facilitate drilling, sample collection, and well construction. Continuous coring, drive sampling, and conventional air rotary drilling were employed, depending on sampling needs.

2.1.2 Sample Collection

Sediment core samples were collected from three of the five wells as shown in Table 2.1. An 8-in.-OD, 10-ft-long, hollow-stem auger flight was connected to the drill stem and used as the drill bit during continuous coring. The continuous core sampler, a 5-ft-long split barrel with a 4 in. ID, was lowered through the auger and drilled simultaneously with the auger, or driven ahead of it with a 140-lb hammer. An 18-in.-long air bit with a 7 in. OD was used to achieve a faster drilling rate when not collecting cores. Cores were screened in the field for volatile organic compounds (VOCs) and gross alpha and gross beta/gamma activity using portable instruments.

Sediment cores from wells UCD2-027 and UCD2-035 were used for detailed hydrogeologic characterization. Continuous core was collected from 0 to 105 ft below ground surface (bgs) in well UCD2-027 and 0 to 61 ft bgs in well UCD2-035. The core descriptions were consistent with Procedure NHFP-DO-01, "Collection and Documentation of Borehole Samples and Well Construction Data" (PNL 1995, unpublished), Last and Liikala (1987), and ASTM D 2488-93, "Standard Practice for Description and Identification of Soils" (Visual-Manual Procedure) (ASTM 1995a), as appropriate. Core samples were labeled (i.e., well name, depth interval, date) and placed in waxed core boxes for storage.

Selected sediment cores from wells UCD2-027 and UCD2-035 were subsampled for analysis of chloroform, tritium, hexavalent and total chromium, and nitrate-nitrogen on a rapid turnaround basis by LAS. Previous investigations have identified these constituents as the primary contaminants of concern at the LEHR site. Sampling intervals in well UCD2-027 were approximately 77 to 78 ft bgs (HSU-1), 82 to 83 ft bgs (HSU-2), and 95 to 100 ft bgs (HSU-2). Sampling intervals in well UCD2-035 were approximately 59 to 61 ft bgs (HSU-1), 105 to 110 ft bgs (HSU-2), and 130 ft bgs (clay below HSU-2). Samples were collected several different ways, including using lexan liners inside the continuous core sampler, hand-packing subsamples from the continuous core sampler in glass jars, and hand-packing drill cuttings in glass jars. The specific sample collection procedure used was determined by the drilling procedure employed when the sample was collected. Results from these analyses are presented in Section 2.1.6.3.

Discrete sediment cores from well UCD2-026 were collected using an 18-in. modified split-spoon sampler lined with stainless steel sleeves for analysis of physical parameters, including particle size distribution (sieve and hydrometer), bulk density, particle density, and porosity. Two samples each from the vadose zone (18 to 19.5 ft bgs and 38.5 to 40 ft bgs) and HSU-1 (58 to 59.5 ft bgs and 78 to 79.5 ft bgs), and one sample from HSU-2 (88 to 89.5 ft bgs), were collected. The samples were

documented on chain-of-custody forms as per Procedure NHFP-AD-4, "Sediment Sample Chain-of-Custody" (PNL 1995, unpublished) and were analyzed using the following procedures:

- SA-02, Sieve Procedure
- SA-03, Particle Size Analysis (Hydrometer Method)
- SA-7, Water Content
- SA-8, Clod Density/Bulk Density
- SA-9, Determining Particle Density

These procedures are documented in PNL (1995, unpublished). Analytical results from these samples are discussed in Section 2.1.6.2.

All sediment samples were released by an IT Health Physics Technician (HPT) before their removal from the drill sites.

2.1.3 Well Completion

The five wells were installed at two cluster locations. The first cluster is located east of the LEHR site, approximately 60 ft south of Building U-1. This cluster contains three wells, UCD1-025, UCD2-026, and UCD2-027. The second cluster is located south of the LEHR site and north of Putah Creek. This cluster contains two wells, UCD1-034 and UCD2-035. The number immediately succeeding the UCD designation generally refers to the hydrogeologic unit in which the well is completed (i.e., HSU-1 or HSU-2). Each cluster has wells monitoring HSU-1 and HSU-2. In addition, UCD2-027 is a multiple-completion well that uses the Westbay ground-water monitoring system. This system is discussed in more detail in Section 2.6. A diagram depicting the construction of these wells is shown in Figure 2.1.

Well UCD2-027 was drilled first, fully penetrating both HSU-1 and HSU-2, such that hydrogeologic information gained from this borehole could be used to complete the subsequent installations (UCD2-026 and UCD1-025). Well UCD2-026 was drilled 20 ft west of UCD2-027 and well UCD1-025 was drilled 15 ft west of UCD2-027. Likewise, well UCD2-035 was drilled first at the second cluster, with UCD1-034 installed 5 ft to the southwest.

The wells are constructed of type 304 stainless steel casing and screen with ASTM F-480 threads and viton O-rings. Schedule 10 pipe with schedule 40 couplings was used. The wells are 4 in. in diameter, with the exception of UCD2-027, which is 5 in. in diameter to accommodate the Westbay

Figure 2.1. Generalized Well Construction Diagram

ground-water monitoring system. Centralizers were factory welded to the casing and are approximately 3 in. long, 1 in. wide, and spaced 120° apart. Three sets of centralizers were placed in well UCD2-027, two sets of centralizers were placed in each of wells UCD2-026 and UCD2-035, and one set of centralizers was placed in each of wells UCD1-025 and UCD1-034.

2.1.3.1 Well Screen Placement and Rationale

Well screens are the continuous wire-wrap type. Screens installed in HSU-1 are 10-slot size; screens installed in HSU-2 are 20-slot size. Screened intervals are given Table 2.1. Wells in HSU-1 were constructed such that they monitor the lower portion of the HSU for the following reasons:

- Having completed the wells in the lower portion of the aquifer assures that large percentages of the screened interval will not become unsaturated during seasonal water-level fluctuations.
- Having completed the wells in the lower portion of the aquifer improved the ability to conduct slug tests in HSU-1 using compressed gas as the displacing volume. Tests conducted with compressed gas generate a larger, more controlled stress, and provide superior results compared to tests conducted with a slugging rod.
- Because well UCD1-025 was installed at a significant distance downgradient from known contamination sources, sufficient mixing should occur within the aquifer such that any contamination should be detected in the lower portion of the aquifer.
- Having completed the wells in the lower portion of the aquifer will improve the ability to monitor intercommunication between HSU-1 and HSU-2.

Well UCD2-026 was constructed to monitor the upper portion of HSU-2 for the following reasons:

- Having completed the well in the upper portion of the aquifer is consistent with the construction of existing HSU-2 wells.
- Having completed the well in the upper portion of the aquifer improves the ability to monitor intercommunication between HSU-1 and HSU-2.

Well UCD2-035 was constructed to monitor the lower portion of HSU-2 upgradient of all suspected on-site source areas to determine background concentrations for contaminants of concern, and downgradient of Putah Creek, which receives flow from the University of California at Davis (UC Davis) outfall. Well UCD2-027 was designed to monitor several discrete intervals within both HSU-1 and HSU-2 downgradient of all source areas except Landfill 3.

2.1.3.2 Sand Pack and Annular Seal

The specific types and depths of sand pack and annular seal materials placed in the annular space are described below. All sand pack and annular seal materials met California Well Standards and were placed using a tremmie pipe or by pouring as the temporary casing was removed. In well UCD2-027, water was injected into the tremmie pipe to assure proper placement and to avoid bridging. Pure Gold grout was generally pumped from the bottom of the interval to be sealed. The temporary casing was removed in small increments (i.e., 2 to 3 ft) to prevent formation materials from displacing the sand pack and annular seal materials. Measurements were made with an engineer's tape throughout the process, tagging the placement of the sand pack and annular seal materials to ensure that the bottom of the temporary casing was always deeper than the top of these materials. Water used during borehole construction was obtained from a tap adjacent to the dog pens at the LEHR site.

Sand Pack. A sand pack, consisting of well-graded, clean, quartz sand, was placed throughout the screened interval to approximately 3 to 4 ft above the top of the screen. In well UCD2-027, the sand pack extended approximately 1.5 ft above the top of each screen. RMC Lonestar Sand size #2/12 was used for the 20-slot screens and size #1/20 was used for 10-slot screens.

Bentonite Pellet Seal. A bentonite pellet seal was placed atop the sand pack, extending upward approximately 2.5 to 8 ft, depending on the specific well design. PEL-PLUG bentonite pellets, 3/8 in. in size, with a swelling time of 30 min, were used in wells UCD2-027, UCD2-035, and UCD1-034. These pellets were coated with a biodegradable nonstick coating. Baroid bentonite pellets, 3/8 in. in size, were used in wells UCD2-026 and UCD1-025 to avoid the instantaneous swelling problems upon wetting that occurred with the initial batch of PEL-PLUG pellets. An additional bentonite pellet seal was placed above the Pure Gold grout seal to the bottom of the concrete surface completion.

Pure Gold Grout Seal. A Pure Gold grout seal was placed above the bentonite pellet seal to a depth of between 3 and 4 ft bgs. This seal was set above the bentonite pellet seal of the uppermost screen in well UCD2-027. The grout seal contained approximately 30% solids and was a mixture of approximately 1 gal of water to 4 lb of grout. A double-diaphragm pneumatic pump was used to mix the grout in a 150-gal galvanized steel trough.

Surface Completion. Concrete was placed from the top of the uppermost bentonite pellet seal to ground surface. The concrete consisted of non-shrinking Portland cement and water in the proportion of 5 to 6 gal of water per 94-lb bag of cement.

All wells were completed flush-to-ground (up to 2 in. above grade). Locking caps were installed on the stainless steel casings. Protective risers, with drains and locking caps, were placed around the stainless steel casings, within the concrete pads. Locking vaults, equipped with internal access ports

and drainage vents, were set in the concrete pads. The vaults house dataloggers, emplaced to continuously monitor water levels. The drains were constructed of 2-in. ABS pipe connected to a perforated vent pipe. Surrounding the vent pipe is an 8-in.-dia. gravel bed encased in a geotextile fabric. A cap was placed on the end of the vent pipe to keep intruders out.

Domed brass survey markers were placed in each concrete pad and stamped with the appropriate well number. A total of three pads were poured, one for well UCD2-027, one for wells UCD1-025 and UCD2-026, and one for wells UCD1-034 and UCD2-035. The surface completions are shown in Figure 2.2.

2.1.3.3 Predevelopment

Following sand pack placement during well installation, the screened intervals were bailed using a 3-in.-OD, 5-gal capacity, stainless steel bailer, or were gently surged to predevelop the open interval and settle the sand pack. Approximately 40 to 75 gal was bailed from each screened interval to settle the sand pack and remove fine-grained sediment immediately surrounding the wellbore. The sand pack was allowed to fully settle before placing the bentonite pellet seal.

To keep the stainless steel casing from settling in the borehole, well UCD2-027 was not predeveloped. Bentonite pellets were placed below the stainless steel end cap and did not form a rigid seal.

2.1.4 Contamination Prevention and Decontamination Procedures

The drill rig was parked on plastic sheeting when positioned at each of the well locations. The plastic prevented leaking, spilled, or discarded fluids and materials from the rig or from the drilling/well construction activities from contacting the ground surface. The plastic was anchored over berms formed around the perimeter of the rig and was wide enough to accommodate additional work areas. Small work areas where core barrels were emptied and cleaned and soil cores were boxed were also underlain by plastic.

The drill rig, temporary casing, bits, various tools, and samplers were steam cleaned before they were sent to the site. The rig and equipment were also decontaminated between uses at each borehole to prevent cross-contamination from one drilling location to the next. Decontamination was performed at a centrally located pad using a portable high-pressure washer/steam cleaner. The pad was constructed with plastic sheeting and berms. The same pad was used for all decontamination activities. Resulting wastewater was allowed to evaporate. Between uses at each borehole, core barrels and stainless steel bailers were scrubbed clean with detergent and water and given a final rinse with deionized water. Assessments for radiological release of the rig and equipment were performed using portable screening instruments and wet/dry tritium smears between boreholes and before the equipment's removal from the LEHR site.

Figure 2.2. Surface Completions for Wells UCID1-025/UCID2-026/UCID2-027 and UCID1-034/UCID2-035

An oil-less compressor was used to provide the pressurized air that circulated drill cuttings from within the temporary casing to the surface. Lubrication for the temporary casing joints was hydrocarbon-free Teflon pipe dope. Use of the oil-less compressor and Teflon pipe dope avoided the potential introduction of contaminants to the formation during drilling. Well construction casing and screens were also steam cleaned onsite at the decontamination pad before each well installation to prevent potential contamination associated with the manufacturing process from being introduced to the borehole.

2.1.5 Investigation-Derived Wastes

Solid and liquid wastes generated during drilling were placed directly into lined roll-off bins from the rig cyclone. As the solids settled, the liquid fraction was pumped to a frac tank near well UCD2-027 or a poly tank near well UCD2-035.

Personal protective equipment (i.e., Tyvek coveralls, gloves) was placed in plastic bags and stored adjacent to the roll-off bins. Clean trash was disposed of in dumpsters at the LEHR site.

2.1.6 Discussion of Well Installation Results

Results from the installation of the five wells are discussed below. Hydrogeologic unit descriptions, physical analysis of sediment samples, and chemical analysis of sediment and ground-water samples are presented. For this report, a hydrogeologic unit is defined as a laterally continuous geologic unit with hydrologic significance. Hydrologic significance is indicated by hydraulic conductivity or hydrochemistry contrasts between units. Hydrogeologic units depicted here correspond to hydrostratigraphic units referenced in previous reports (DOE 1993, 1994, 1995). In a strict sense, a hydrostratigraphic unit as proposed by Maxey (1964) is defined as a body of rock having considerable lateral extent and composing a geologic framework for a reasonably distinct hydrologic system.

2.1.6.1 Hydrogeology

Consistent with DOE (1993), four hydrogeologic units were encountered during drilling operations. They are, in descending order, the vadose zone, HSU-1, HSU-2, and the unnamed aquitard beneath HSU-2. Unit depths and thicknesses and static water levels in the new wells are given in Table 2.2.

The vadose zone is comprised primarily of unsaturated clays and silts with sands and gravels intermixed, indicative of a relatively low-energy depositional environment. Immature caliche and organic matter were also noted. The fine-grained materials varied with depth, having been described as dark grey to brown and dry to very moist. The clays were further described as mottled and having low to high plasticity and slight to high toughness. Poorly to well-graded sands and angular to subrounded gravels were observed. Reaction to 10% HCl ranged from none to very strong.

Table 2.2. Hydrogeologic Unit Depths and Thicknesses

Well Number	Vadose Zone Thickness (ft)	HSU-1 Depth (ft bgs)	HSU-1 Thickness (ft)	HSU-2 Depth (ft bgs)	HSU-2 Thickness (ft)	Unnamed Aquitard Depth (ft bgs)	Water-Level Measurement Date	Static Water Level Below Protective Casing (ft)	Difference Between Protective and SS Casings (ft)	Static Water Level Below SS Casing (ft)
UCD1-025	42	42					10/12/95	41.96	0.87	41.09
UCD2-026	42	42	40				10/12/95	41.99	0.57	41.42
UCD2-027	42	42	40	82	44	126	10/11/95	41.70	0.90	40.80
UCD1-034	47	47					10/17/95	46.59	0.75	45.84
UCD2-035	47	47	29	76	54	130	10/18/95	47.07	0.68	46.39

Clay of an unusually high plasticity was encountered between 40 and 45 ft bgs in wells UCD2-027 and UCD2-026. It was necessary to wet the clay by pumping approximately 50 gal of water downhole at each of these locations to drill through it and circulate the cuttings to the surface with air. This highly plastic clay was not encountered at the other three locations. The vadose zone is approximately 42 ft thick near well UCD1-025 and 47 ft thick near well UCD1-034. However, thicknesses vary with seasonal water-level fluctuations. It is important to note that wells UCD1-034 and UCD2-035 are located on an artificially constructed levy that places the ground surface at these wells approximately 7 ft higher than wells UCD1-025, UCD2-026, and UCD2-027.

HSU-1 is lithologically similar to the vadose zone in texture, grading, toughness, and plasticity. Calcareous cement and caliche nodules were noted at several locations within this unit. Colors included olive brown, dark yellowish brown, and greenish to dark grey. Well-defined laminations were observed in well UCD2-027. The contact between HSU-1 and HSU-2 is at approximately 82 ft bgs in well UCD2-027 and 76 ft bgs in well UCD2-035, resulting in thicknesses of approximately 40 and 29 ft, respectively, for HSU-1.

HSU-2 extends to a depth of 126 ft bgs in well UCD2-027 for a thickness of 44 ft, and a depth of 130 ft bgs in well UCD2-035 for a thickness of 54 ft. This unit is comprised primarily of sands in the upper portion of the unit and gravels in the middle to lower portions of the unit, suggesting a relatively high-energy depositional environment. Samples were described as well-graded, unconsolidated, and wet, consisting of approximately 70% to 90% quartz and 10% to 30% mafic minerals. The sands ranged from very fine to very coarse; the gravels were very fine to medium pebble-sized and angular to rounded.

Flowing sand conditions were encountered in the upper portion of HSU-2. To keep the sands from entering the borehole during drilling and well completion, the temporary and permanent casings were partially filled with water. A relatively constant pressure head was maintained in this manner until the casing was advanced or removed beyond these flowing sand zones. As a precautionary measure while drilling with the air bit through the flowing sand zones, the bit was never extended more than 2 ft ahead of the temporary casing. For especially difficult drilling, the casing was advanced slightly ahead of the bit. These procedures could not be used with the hollow-stem auger bit because limited clearance between the auger and casing would lead to binding when the sands heaved into the casing. Sands heaved into the temporary casing on several occasions to the extent that drilling could not proceed until the sand was vacuumed from the casing and the pressure head was re-established to prevent more sand from entering the casing.

The collection of continuous core in flowing sand zones is not generally considered possible, primarily because the procedures required to drill through flowing sands do not allow the use of coring equipment and these sands are not readily retained within a core barrel. Every attempt was made to recover continuous core while drilling wells UCD2-027 and UCD2-035, however, core recovery was relatively unsuccessful for the reasons specified above. Core recovery was not attempted while drilling in flowing sand zones encountered in the subsequent wells. Sediments were classified using drill cuttings where continuous core could not be recovered, with the exception of well UCD1-025. A log

based on visual observations was not made at this location during drilling because of the proximity of the operation to wells UCD2-027 and UCD2-026.

The unnamed aquitard beneath HSU-2 was encountered in wells UCD2-027 and UCD2-035 at 126 and 130 ft bgs, respectively. Cuttings from the uppermost portion of this unit were described as light brown silty clay to clay with some caliche. These materials displayed high plasticity and toughness. The drill depth did not advance through the clay aquitard beneath HSU-2 at either location. The clay aquitard is thought to be approximately 90 ft thick in the vicinity of the LEHR site (DOE 1994). Drilling at well UCD2-027 advanced approximately 10 ft into the aquitard to facilitate the installation of the Westbay ground-water monitoring system.

2.1.6.2 Physical Analysis of Sediment Samples

Table 2.3 summarizes results from the physical analysis of sediment cores from well UCD2-026. Grain size distribution plots are shown in Appendix B. Three core samples each from the vadose zone and HSU-1, and two core samples from HSU-2, were analyzed. Average results for the vadose zone for bulk density, particle density, moisture content, and porosity were 1.49 g/cm³, 2.77 g/cm³, 22 %, and 46 %, respectively. Average results for HSU-1 for bulk density, particle density, moisture content, and porosity were 1.53 g/cm³, 2.74 g/cm³, 20 %, and 44 %, respectively. Average results for HSU-2 for bulk density, particle density, moisture content, and porosity were 1.85 g/cm³, 2.69 g/cm³, 21 %, and 31 %, respectively.

Table 2.3. Sediment Physical Analyses from Well UCD2-026

Depth (ft bgs)	HSU	Gravel (%)	Sand (%)	Silt (%)	Clay (%)	Bulk Density ⁽¹⁾ (g/cm ³)	Particle Density (g/cm ³)	Moisture Content (%)	Porosity (%)
18.5 - 19	Vadose Zone	0	9.2	36.2	54.6	1.43	2.77	24	48
19 - 19.5	Vadose Zone	0	28.6	42.3	29.1	1.40	2.80	22	50
39.5 - 40	Vadose Zone	0	15.9	24.4	59.7	1.64	2.75	19	40
58.5 - 59	HSU-1	0	11.6	24.7	63.7	1.55	2.73	18	43
59 - 59.5	HSU-1	0	32.9	40.0	27.1	1.48	2.78	20	47
79 - 79.5	HSU-1	0	42.2	38.3	19.5	1.56	2.71	22	42
88.5 - 89	HSU-2	4.3	95.1	0.6		1.99	2.69	21	26
89 - 89.5	HSU-2	6.4	91.2	2.4		1.71	2.69	20	36
Vadose Zone Average Value						1.49	2.77	22	46
HSU-1 Average Value						1.53	2.74	20	44
HSU-2 Average Value						1.85	2.69	21	31
Note:									
1. Bulk density values were measured after samples were dried (i.e., 0% moisture).									

The results from the physical analyses generally support visual core descriptions documented during drilling operations with respect to the relatively fine-grained nature of the vadose zone and HSU-1 and coarser texture of HSU-2. Additionally, the upper portion of HSU-2 is comprised of over 90% sand in this well. Average bulk density values slightly increased with depth, whereas average particle density values slightly decreased with depth. The average total porosity for HSU-2 was lower than for HSU-1.

2.1.6.3 Chemical Analysis of Sediment Samples

Table 2.4 provides results from the chemical analysis of sediment grab samples collected while drilling wells UCD2-027 and UCD2-035. Chloroform and hexavalent chromium concentrations, and tritium activities, were all below their respective laboratory detection limits. The hexavalent chromium result from 95 to 100 ft in well UCD2-035 was rejected during data validation because the holding time was exceeded. Total chromium concentrations ranged from 101 to 232 mg/kg. Sediments typically have relatively high metal concentrations. Nitrate-nitrogen concentrations ranged from <0.24 to 4.3 mg/kg.

2.2 Geophysical Logging

Four different downhole geophysical instruments were used to measure natural gamma activity, moisture or porosity content, and bulk density in well UCD2-027 on September 7, 1995. The purpose of these measurements was to evaluate the hydrogeologic characteristics of the surrounding formation and assist in the design of the Westbay ground-water monitoring system. The parameters were measured using oilfield borehole geophysical systems, including the spectral gamma ray logging system, neutron-neutron logging systems, and gamma-gamma density logging system provided by Schlumberger Well Services.

The downhole instruments deployed are commonly used in the petroleum industry or are a derivative of those instruments. These systems represent borehole geophysical logging (Ellis 1987, Hearst and Nelson 1985), a mature technology that has been used since the 1920s to support mineral exploration, serving as the primary source of geophysical data for the petroleum industry. Borehole geophysical technology consists of three major components (Figure 2.3): 1) a downhole instrument or sonde that measures one or more physical properties of the formation, 2) a cable that connects the sonde to the surface, conducting power down the hole and transmitting data up the hole, and 3) a wireline logging truck that controls the sonde location in the borehole, provides power, and houses a computer. The computer controls sonde operation and processes and displays real-time data. The resulting data are shown on a continuous strip chart commonly called a log because of its similarity to a well driller's log.

Table 2.4. Chemical Analyses for Sediment Samples Collected During Drilling

Sediment Samples

Sample ID	Sample Depth (ft bgs)	Site ID	Sample Date	HSU	Chloroform Detection			Tritium				Hexavalent Chromium Detection			Total Chromium			Nitrate-Nitrogen			Comments
					Conc. (mg/kg)	Limit (mg/kg)	Analysis Date	Activity (pCi/L)	Error (pCi/L)	MDA (pCi/L)	Analysis Date	Conc. (mg/kg)	Limit (mg/kg)	Analysis Date	Conc. (mg/kg)	Limit (mg/kg)	Analysis Date	Conc. (mg/kg)	Limit (mg/kg)	Analysis Date	
SSCL1003	76.7 - 77.78	CCS	8/31/95	HSU-1																Core sample, UCD2-027	
SSCL1004	81.7 - 82.783	CCS	8/31/95	HSU-1	<12 U ⁽¹⁾	12	9/2/95	-70	220	300	9/4/95	<0.5 U	0.5	9/1/95	136	10	9/25/95	4.3	0.2	9/1/95	Grab sample, UCD2-027
		CCS	8/31/95	HSU-2																Core sample, UCD2-027	
		CCS	8/31/95	HSU-2	<12 U	12	9/2/95	-100	210	300	9/4/95	<0.5 U	0.5	9/1/95	198	10	9/25/95	2.5	0.2	9/1/95	Grab sample, UCD2-027
SSCL1005	95-100	CCS	9/6/95	HSU-2				-50	220.	300	9/29/95	<0.5 H ⁽²⁾	0.5	9/13/95	232	10	9/25/95	0.63 H	0.2	9/13/95	Grab sample, UCD2-027.
SSCL1007	59 - 61	CCS	9/26/95	HSU-1	12 U	12	9/28/95	-90	230	360	9/29/95	<0.025 U	0.63	9/27/95	119	10	9/29/95	0.90	0.25	9/28/95	Grab sample, UCD2-035
SSCL1009	105 - 110	CCS	9/27/95	HSU-2	12 U	12	9/28/95	-10	220	300	9/29/95	<0.024 U	0.60	9/28/95	133	10	9/29/95	0.23 B ⁽³⁾	0.24	9/28/95	Grab sample, UCD2-035
SSCL1010	130	CCS	9/27/95	>HSU-2	13 U	13	9/28/95	70	220	290	9/29/95	<0.026 U	0.65	9/28/95	101	10	9/29/95	0.52	0.26	9/28/95	Grab sample, clay below HSU-2, UCD2-035
Notes:																					
1. U = Below Detection Limit																					
2. H = Holding Time Exceeded																					
3. B = Reported Value Less Than Contract Required Detection Limit but Greater Than Instrument Detection Limit

Figure 2.3. Borehole Geophysical Logging

2.2.1 Principle of Measurements for Logging Systems

The natural gamma activity and moisture/porosity systems have been adapted for environmental boreholes (Ellis et al. 1995), and the bulk density system has recently been adapted. A brief technical description of the three logging services, an interpretation of results, and the relationship of the hydrogeologic properties assigned to the hydrogeologic units follow. The discussion incorporates physical data collected from sediment cores. Relevant history for each measurement system, the calibration methods used, and the resulting precision and accuracy measured are presented in Appendix C.

2.2.1.1 Spectral Gamma Ray Logging System

The spectral gamma logging service employed in well UCD2-027 was the Hostile Natural Gamma Spectroscopy (HNGS) system. This system uses two scintillators composed of bismuth germanate to passively measure the energy and intensity of incident gamma rays emitted within the formation. Two detectors are used to increase the sensitivity without degrading the system's vertical resolution.

2.2.1.2 Neutron-Neutron Logging Systems

Neutron-neutron systems were used to measure the volume of moisture within the formation surrounding well UCD2-027. The sondes contained both thermal and epithermal neutron detectors to avoid overestimating the moisture content. Two different neutron-neutron systems were used, the compensated neutron log (CNT-G) and the accelerator porosity sonde (APS).

The CNT-G is a conventional neutron-neutron logging system that uses a 16-Ci AmBe source. It employs two thermal and two epithermal detectors. The CNT-G has a vertical resolution of 6 in., an average depth of investigation of 10 in., and a diameter of 3.6 in. (Schlumberger 1989). Measurements begin 3.8 ft above the bottom of the borehole.

The APS uses an electronic neutron source and employs one thermal and four epithermal neutron detectors. This sonde has a vertical resolution of approximately 3 in. and begins measuring about 13 ft above bottom.

2.2.1.3 Gamma-Gamma Density Logging System

The litho-density sonde (LDS) was used to measure formation bulk density. It uses dual detectors and has a vertical resolution of 4 in. and a depth of investigation of 4 to 6 in.

2.2.2 Log Interpretation

A hard copy log for each service used is available from the lead author upon request. Each log consists of four general sections: 1) header, 2) equipment description, 3) log (which may be displayed twice at different vertical scales), and 4) calibration and check summary. General well information,

including the well name, date logged, casing size, and datum used, are provided in the header. The header is filled out by the logging engineer during the logging process. The equipment description presents a schematic of the logging equipment that was lowered into the borehole. It includes the serial numbers of the tools and the vertical dimensions of each. The log presents the processed results, generally shown in three tracks. A narrow column containing the depth (in ft) is found between track 1 and tracks 2 and 3. The latter two tracks are generally contiguous. Each track contains 10 divisions, and a vertical line is indicated for each 2 ft of depth. Headings at the top and bottom of the log identify traces coded for the different measurements, plus the scales for each. The calibration and check summary depicts the calibration history for the logging tool in a table and also serves as a series of warning lights. Both representations include master calibration data, the results from pre- and post-logging checks, and the allowable tolerance.

2.2.2.1 Spectral Gamma Ray Log

Figure 2.4 is the HNGS field log for well UCD2-027. The header gives the name of the well, the time and date logged (12:15 on 9/7/95), the internal diameter of the casing (8.625 in.), and the external diameter of the casing (reported as bit size at 9.625 in.). The calibration and check summary indicates that the pre- and post-logging checks are within tolerance as defined by Schlumberger Well Services.

The log presents the results from two runs, a primary and a repeat. Repeats are commonly employed to check for adequate measurement precision. The results from the primary run are displayed at two different vertical scales, one at 5 in. equals 100 ft, and an expanded scale of 10 in. equals 100 ft. In both displays, each small horizontal grid line is 2 ft, and the darker horizontal grid lines are placed every 10 ft. The repeat is shown as an overlay at the 10-in. scale. The repeat overlay, although very good, is not as impressive as those displayed for the other logging systems, primarily because of the lower number of counts that a passive system (i.e., no active source of subatomic particles) deals with and the resulting lower precision. The statistics of radioactive decay can be accurately expressed as a Poisson distribution in which the fractional uncertainty (precision or f) can be expressed as

$$f \propto \frac{1}{\sqrt{Qt}} \quad (1)$$

where Q is the source strength and t is the time of observation (Ellis 1987). The activity of naturally occurring gamma-emitting radionuclides is much lower, tens of pCi, than the activity of the sources used in the other logging tools, greater than one Ci; thus, the resulting precision should be lower.

Track 1 includes gross gamma count (HSGR) in American Petroleum Institute (API) units, and a chi square curve for each detector (CHI1 and CHI2). API established calibration standards for gross gamma ray logging systems used in the petroleum industry. The definition of the API units of radioactivity is based on system response in a calibration model that has about twice the radioactivity of the typical shale, defined to be 200 API units (Ellis 1987). Chi-square (χ^2) is a statistical measure of the

Figure 2.4. Spectral Gamma Ray Log for Well UCD2-027

goodness-of-fit of the weighted least squares algorithm used to deconvolve the gamma ray spectrum into its components, typically potassium, uranium, and thorium. A χ^2 -value of around 1 indicates a good fit. A value that increases significantly above 1 may indicate the presence of other unresolved gamma-emitters; that is, created radionuclides for which HNGS spectra have not been calculated. The χ^2 -values in this well average 1.1, indicating acceptable goodness-of-fit.

Track 2 includes the concentrations of potassium (HFK) and thorium (HTHO) in wt% and ppm, respectively. Track 3 includes the activities of two created radionuclides, cesium-137 and cobalt-60. Uranium concentration is shown on tracks 2 and 3 so that anticipated activities will not overplot on either the potassium or thorium tracks.

Concentrations of potassium, uranium, and thorium can be used to interpret changes in formation lithology. Examination of these three curves (HFK, HURA, and HTHO) indicates subtle variations in the concentration of these elements. The most recognizable change in concentration occurs at 45 ft, the top of the water table, and this change is due solely to the increased attenuation of gamma rays by water in the formation and borehole below the water table.

Several peaks are distinguishable in the thorium curve (HTHO) and are highlighted in Figure 2.4. Thorium is a relatively insoluble element that typically occurs within clay minerals with a high cation exchange ratio, kaolinite and montmorillonite (Schlumberger 1991). Because its solubility is so low, thorium originally may have been a component of feldspars and micas that decomposed into clay minerals (Ellis 1987). Thus, it is likely that the thorium peaks are related to clay-rich units. Comparison to the Σ curve from the APS tool confirms this estimation, and is discussed in Section 2.2.2.3.

The uranium curve is fairly featureless. There is a slight peak, however, from 29 to 32 ft bgs. Uranium is a rare mineral, as is thorium. However, it is mobile and readily soluble in its oxidized state (U^{+6}). Where uranium is reduced (U^{+4}), it becomes insoluble and is trapped within the formation. Organic materials are commonly present in reducing environments and, as a result, uranium is commonly enriched in these zones. The daily borehole log for well UCD2-027 indicates that the core from 30 to 32 ft bgs contains organic partings and caliche nodules, which are consistent with a reducing zone. Organic material is also described in the daily borehole log from 16 to 16.5 ft bgs, and there is a slight increase in the uranium curve here. Organic material is not mentioned in the daily borehole log for any other cored intervals.

The potassium curve is also fairly featureless. Potassium typically occurs within K-feldspar, micas, and illitic clay minerals. In general, variations in the K-feldspar curve mimic those of the thorium curve, suggesting that most of the potassium is probably in clay minerals. Both the potassium and thorium concentrations are very low and the curves are monotonous through most of HSU-2, probably because of the very low clay content in this unit.

The ratio of thorium and potassium concentration can be used to determine the clay minerals present within the formation. Figure 2.5 shows a log interpretation chart that is commonly used to make this determination (Ellis 1987). The ratios of these two elements for HSU-1 above the water

Figure 2.5. Clay Typing With Spectral Gamma Logging Data
(from Schlumberger 1996)

table (i.e., where the logging tool is calibrated) are plotted in Figure 2.6, and it is evident that the predominant clay mineral is montmorillonite. The HSGR is similar to the HTHO. Thus, the HSGR curve primarily reflects variation in montmorillonite concentrations.

Track 3 of the HNGS log reports the activity of two created radionuclides, cesium-137 and cobalt-60. Neither is detected at a sensitivity of approximately 0.1 pCi/g (Fayer et al. 1995). Radium-226 is a member of the uranium decay series, and its presence as a contaminant would be reported as an anomalously elevated uranium curve. Most of the gamma ray activity measured within the uranium-238 decay series is due to bismuth-214, created from radium-226 by the following decay scheme:

The half lives for each daughter are shown, and it is apparent that significant bismuth-214 will be created shortly after radium-226 decays. The sensitivity of the HNGS system to radium-226 contamination is not currently known.

Figure 2.6. Thorium vs. Potassium Clay Typing Above the Water Table for Well UCD2-027

2.2.2.2 Gamma-Gamma Density Log

Figure 2.7 presents the LDS log measured at well UCD2-027. The header is very similar to the one discussed previously. The calibration and check summary indicates that the pre- and post-logging checks are within Schlumberger Well Services tolerances. Calibration of this system in Hanford Site boreholes in eastern Washington has not been completed; all numerical values displayed in the log may be inaccurate.

Figure 2.7. Gamma-Gamma Density Log for Well UCD2-027

The log presents the results from two high resolution runs, one shown as a repeat overlay. High resolution uses a sampling interval of 1 in.

Track 1 contains two curves: a caliper measurement (LCAL) that records the inner diameter of the casing, and bulk density correction (DRH). The latter is a correction curve that compensates for the presence of material between the gamma detectors and the formation. The DRH curve represents a correction ($\Delta\rho$) made to the apparent density seen by the log spacing detector. It is based on discrepancy between the long and short spacing measurements (Ellis 1987), and can be defined by the following equation:

$$\Delta\rho \propto t_{sc}(\rho_b - \rho_{sc}) \quad (2)$$

where the correction is proportional to the product of the thickness of the steel casing (t_{sc}) and the difference in density between the formation and casing (adapted from Ellis 1987). The consistently negative correction results from casing having a greater density (ρ_{sc}) than formation (ρ_b). The degree of compensation is primarily an inverse function of the formation bulk density, because casing density (ρ_{sc}) is fairly constant.

Tracks 2 and 3 display the measured bulk density (RHOM) and calculated density porosity (DPO). The density porosity was calculated using a grain density of 2.65 g/cm³. Recently analyzed sediment samples indicate that the matrix density varies from 2.69 to 2.80 g/cm³, with an average of 2.74 g/cm³. This discrepancy leads to an underestimation of DPO from 1 to 3 units of porosity (pu) for bulk densities of 1.5 to 2.0 g/cm³, respectively. Bulk density values measured from the sediment samples are plotted on Figure 2.7 and, in general, the correspondence to the RHOM is good, within 3 pu. Small discrepancies between the physical sample and log data can be due to one or a combination of the following factors: 1) calibration of the LDS is not complete, 2) the drilling process has altered the formation around the casing measured by the LDS, 3) the extraction of a core has altered the sample, and 4) the LDS interrogates a volume, while the sediment sample is a point measurement.

The bulk density correspondence between the samples and the log is not very good for the samples collected at 89 to 90 ft bgs. The discrepancy is probably caused by the heaving and liquefaction of the unconsolidated sands that are described in the daily borehole log as occurring between the top of HSU-2 (81.7 ft bgs) and 95 ft bgs. The break in density occurs at 96 ft bgs, a good correspondence with the daily borehole log. The physical samples were somewhat consolidated and further drilling activities probably greatly reduced the porosity of the formation.

Following oil-field convention, both displays show lower density (higher porosity) zones as excursions to the left. HSU-2 is characterized by a higher bulk density zone than HSU-1. This seems contrary at first because the sands of HSU-2 are more transmissive than those of HSU-1. However, the bulk density cannot differentiate between total and effective porosity, and much of the porosity for a typical clay is not effective. Furthermore, clays at the surface are less dense than sands. They do undergo significant compaction during diagenesis, with up to 90% compaction when buried at

1000 ft bgs. The clays present in HSU-1 have not experienced significant compaction, suggesting that they have probably never been buried deeper than they are today.

Thin, higher bulk density zones are present within HSU-1. Although none are called out in the daily borehole log, they are probably thin streaks of sand or gravels. This interpretation is confirmed by the low relative Σ for each in the APS log; this characteristic is discussed in Section 2.2.2.3.

The physics of the gamma-gamma density tool permit finer vertical resolution than can be measured with any of the other logging systems used at well UCD2-027. Comparison of the APS (displayed in the following section) and LDS logs graphically shows the enhanced vertical resolution of the LDS.

2.2.2.3 Neutron-Neutron Logs

The casing used in well UCD2-027 is significantly thicker than the casing installed in the calibration models at the Hanford Site (0.5 in. rather than 0.322 in.). This discrepancy affected the accuracy of the CNT-G tool and the slowing-down time measurement of the APS. Therefore, the log interpretation is based on the near-far curve of the APS (Figure 2.8), a measurement that is relatively insensitive to casing thickness.

Track 1 displays Σ (SIGF). Tracks 2 and 3 display two different moisture measurements: near-far (NFVW) and slowing-down time (SDVW) in the unsaturated zone, and a near-far porosity (LC01) for the saturated zone. For all curves, moisture content or porosity decreases to the right like the LDS display.

The SIGF curve shows much character. Elevated Σ is usually an indication of clay minerals because those minerals commonly contain boron and rare earth elements, elements with a high thermal neutron capture cross section. Several elevated Σ zones have been highlighted in Figure 2.8, and several correspond to the thorium peaks noted in the HNGS log, thus confirming that these zones are clay-rich. The detail of the Σ measurements suggests that HSU-1 is composed of a series of beds that increase upwards in clay content (these features are highlighted by the angled arrows). Meandering stream deposits are characterized by fining-upwards sequences that are commonly capped by a clay plug. The Σ log response strongly suggests that HSU-1 was deposited in the meander belt of a small stream (6 to 10 ft deep, as suggested by the thickness of the meander packages) that had traversed a region of low relief (high clay content in water). Putah Creek of today is a good model of what this ancient stream may have looked like.

The relative Σ value for the base of these postulated meander belt deposits is similar to the sands and gravels of HSU-2, a relationship similar to the relative bulk densities of the two packages. These data indicate that the sands within HSU-1 may be as permeable as those of HSU-2; however, their permeability does not transfer to greater aquifer transitivity because of heterogeneities caused by the cut and fill nature of meander stream deposition.

Figure 2.8. Neutron-Neutron Porosity Log (APS) for Well UCD2-027

The relative Σ value for several zones at the top of HSU-2 is elevated, and the shapes of these zones suggest a gradual lessening in Σ upwards. A possible cause is the anomalously high porosity of this zone resulting from the presence of heaving sands. If correct, the character of the Σ curve is caused by a gradual decrease in the quantity of water within the two small zones at the top of HSU-2 (82 to 86 ft bgs and 86 to 92 ft bgs).

Tracks 2 and 3 show the near-far moisture content (NFVW) in the unsaturated zone and the near-far porosity (LC01) in the saturated zone. Moisture analyses from sediment samples are plotted atop the NFVW curve, and there is very good correspondence. Each analysis was converted from weight % to volume % using the matrix density and porosity sample results.

The correspondence between the LC01 curve and the physical samples is not very good. This discrepancy is a function of the measurement and reveals something about this unit or about tool calibration. The neutron-neutron measurement responds to hydrogen content of the formation that is assumed to be water-filled porosity. The system cannot differentiate between hydrogen in water and hydrogen locked in the crystal lattice of minerals within the formation. The elevated porosity may be real and may be caused by hydroxides within the montmorillonitic clay.

The reason for the great discrepancy between the porosity measurements for HSU-2 is not certain. It may be caused, in part, by the disturbed formation that surrounds the borehole at the top of this HSU.

It should be noted that the contact between HSU-1 and HSU-2 is most noticeable in the near-far porosity curve, probably because of the significant decrease in clay minerals and associated bound hydrogen at the boundary to HSU-2. The contact is not as evident as one would expect because of an increased porosity within this zone resulting from the unconsolidated sands shown from 82 to 90 ft bgs.

2.2.2.4 Comparison Between Porosity and Density Logs

Both the neutron-neutron and gamma-gamma density logging systems measure porosity; however, their operation is based on fundamentally different physics. Comparing the two data sets commonly leads to an enhanced log interpretation.

The contact between HSU-1 and HSU-2 was noted at 81.7 ft bgs in the daily borehole log where a sandy clay gives way to a very clean sand. This contact has been plotted at that depth on every log. However, the contact is not apparent on any log, especially the HNGS and LDS logs. A cross plot of density from the gamma-gamma density log and porosity from the neutron-neutron log is presented in Figure 2.9. Log values collected every 6 in. are separated into two samples with a boundary at 82 ft. The data for each HSU do not overlap. The HSU-1 data have a higher porosity for any given bulk density.

Figure 2.10 shows a better discriminator for separating the two HSUs. It is a plot of Σ versus neutron-neutron porosity, and it shows that HSU-1 has both higher porosity and higher Σ 's than HSU-2. If this relationship holds in other wells, then geophysical logs can be used to adeptly pick this contact.

Figure 2.9. Neutron-Neutron Porosity vs. Bulk Density for Well UCD2-027

Figure 2.10. Neutron-Neutron Porosity vs. Σ for Well UCD2-027

Porosities as measured by both logging tools are plotted together on Figure 2.11. The curves agree, in general, throughout most of HSU-1 and the lower part of HSU-2. The discrepancy in the upper part of HSU-2 (i.e., density porosity is significantly higher than neutron porosity) is probably due to the disturbance of the formation by the heaving unconsolidated sands and resulting decrease in bulk density.

Figure 2.11. Density Porosity vs. Neutron-Neutron Porosity Below the Water Table for Well UCD2-027

2.2.2.5 Zone Selection for the Westbay System

The Westbay ground-water monitoring system was installed in well UCD2-027 shortly after logging was completed. One purpose of this system was to collect ground-water samples from discrete intervals within both HSUs. Therefore, the geophysical logs were used to ensure that the desired screened intervals were porous and transmissive. The log response with the best vertical resolution (necessary because the screened intervals are 2 ft long) and that provides the best measure of porosity was judged to be Σ . The bulk density curve was also used because it has good vertical resolution. Thus, a comparison of these two curves was used.

2.3 Well Development

The five new wells were developed following their completion. Each screened interval was stressed in a stepwise pumping fashion using a submersible pump to remove fine-grained sediments generated and/or mobilized during the drilling process. All development water was pumped into the frac tank near well UCD2-027 or the poly tank near well UCD2-035 for disposal. Well development activities were conducted in accordance with Procedure NHFP-GC-7, "Well Development" (PNL 1995, unpublished).

During development of well UCD2-027, a downhole inflatable straddle packer and pump arrangement was used to isolate the screened interval being developed from the other screens in the well. Initially, a single packer was set above the HSU-1/HSU-2 contact at approximately 79 ft, and the upper three screened intervals (designated zones 1 through 3 from the top down) were developed compositely. This step was followed by composite development of the lower four intervals (designated zones 4 through 7). Zones 1 through 3 are completed in HSU-1 and zones 4 through 7 are completed in HSU-2. The straddle packer and pump arrangement was then used to isolate and develop each individual screened interval. A straddle packer arrangement was not necessary for developing wells UCD1-025, UCD2-026, UCD1-034, and UCD1-035. Developing these wells required only that a submersible pump be set within the screened interval.

Table 2.5 presents the results of the well development. As expected, development of wells completed in HSU-1 generally yielded less flow than that produced during development of wells completed in HSU-2. Water levels were depressurized to the level of the pump intake during development of well UCD2-027, zones 1 and 2. For the individual tests conducted in zones 4 through 7, the maximum flow rate was limited by the capacity of the pump. Turbidities of less than 10 NTU were achieved for all screened intervals developed. Very little suspended sediment was noted after the first few minutes of pumping. The total volume of development water pumped was approximately 10,600 gal, 2200 gal from HSU-1 and 8400 gal from HSU-2. The total volume removed from well UCD2-027 was 3550 gal.

Table 2.5. Summary of Development Tests

Well Developed	Date Tested	Maximum Flow Rate (gpm)	Total Pumping Duration (min)	Maximum Observed Drawdown (ft)	Total Volume Pumped (gal)	Lowest Measured Turbidity (NTU)	Comments
UCD1-025	19-20Oct95	2.5	154	8.2	336	1.5	
UCD2-026	11/1/95	30	132	6.4	2910	1	
UCD1-034	10/17/95	1.5	141	16.1	212	7	
UCD2-035	18-19Oct95	18.8	332	1.5	3587	3	
UCD2-027, Zones 1-3	10/11/95	13	60	0.8	608	8	
UCD2-027, Zones 4-7	10/12/95	18.8	81	1.6	963	5	
UCD2-027, Zone 1	10/12/95	0.3	30	4.3	9	Not measured	Water visually clear, depressurized to pump intake
UCD2-027, Zone 2	10/13/95	0.5	33	10.0	17	6	Depressurized to pump intake
UCD2-027, Zone 3	10/13/95	1.25	43	5.7	54	5	
UCD2-027, Zone 4	10/16/95	4.6	125	6.3	523	3	
UCD2-027, Zone 5	10/16/95	5.5	93	1.2	480	2	
UCD2-027, Zone 6	10/16/95	5.2	56	0.8	291	1	
UCD2-027, Zone 7	10/19/95	5.5	110	1.4	605	5	

Static water-level measurements were taken during well development and subsequent slug testing activities and are presented in Table 2.6. Water levels were measured with a laminated electric water-level indicator according to Procedure WL-01, "Water-Level Measurement Procedure" (PNL 1995, unpublished).

2.4 Ground-Water Sampling

Following well development, ground-water samples were collected for screening purposes from wells UCD1-025, UCD2-026, UCD1-034, and UCD2-035 using either a ¾- or 3-hp submersible pump as per Procedure NHFP-GC-1, "Ground-Water Sample Collection Procedure" (PNL 1995,

Table 2.6. Static Water-Level Measurements in New Wells During Well Development and Slug Testing

Well Number	Zone(s)	Measurement Date	Time (hrs)	D/W ⁽¹⁾ (ft)
UCD2-027	1-7	10/11/95	1420	41.70
UCD2-027	1	10/17/95	0842	41.15
UCD2-027	3	10/18/95	1053	41.12
UCD2-027	3	10/18/95	1230	41.08
UCD2-027	4	10/18/95	1254	40.93
UCD2-027	4	10/18/95	1400	40.90
UCD2-027	5	10/18/95	1440	40.89
UCD2-027	5	10/18/95	1600	40.87
UCD2-027	5	10/19/95	0919	40.93
UCD2-027	5	10/19/95	1009	40.96
UCD2-027	6	10/18/95	1625	40.88
UCD2-027	6	10/19/95	0727	40.91
UCD2-027	6	10/19/95	0903	40.92
UCD2-027	7	10/19/95	1412	40.92
UCD2-027	7	10/19/95	1540	40.93
UCD2-026		10/12/95	1434	41.99
UCD2-026		10/19/95	1532	40.93
UCD1-025		10/12/95	1426	41.96
UCD1-025		10/19/95	1535	41.15
UCD1-034		10/17/95	1011	46.59
UCD2-035		10/18/95	0850	47.07
Notes:				
1. D/W = Depth to Water				
2. D/W measurements taken from or corrected to top of protective casing.				

unpublished). One-time fluid temperature, conductivity, and pH measurements were recorded immediately before sampling. Relevant procedures for these measurements include NHFP-FA-1, "Temperature Measurement Procedure"; NHFP-FA-2, "Calibration of Conductivity Meter and Measurement of Field Conductivity"; and NHFP-FA-3, "Calibration of pH Meter and Measurement of Field pH" (PNL 1995, unpublished). The seven zones in well UCD2-027 were sampled using the Westbay ground-water monitoring system per Westbay (1992) procedures.

All samples were analyzed for chloroform, tritium, hexavalent and total chromium, and nitrate-nitrogen on a rapid turnaround basis by LAS. Previous investigations have identified these constituents as the primary contaminants of concern at the LEHR site. The total chromium samples were not filtered. Sample bottles were provided by LAS. Labels and chain-of-custody forms were generated by PNNL. Chain-of-custody followed Procedure NHFP-AD-2, "Ground-Water Sample Chain-of-Custody and Field Record Form Procedure" (PNL 1995, unpublished). Purge water was discharged to the frac tank near well UCD2-027 or the poly tank near well UCD2-035.

2.4.1 Discussion of Ground-Water Sampling Results

Table 2.7 contains the analytical results for the ground-water samples collected after well development. These results have been validated in accordance with the procedures described in PNL (1995, unpublished); no problems were noted.

Chloroform concentrations ranged from < 1 to $69 \mu\text{g/L}$, with the highest concentration found in well UCD2-027, zone 5. Concentrations increased slightly with depth in HSU-1 as indicated by the results from zones 1 through 3 (Figure 2.12). Concentrations continued to increase in HSU-2 to the maximum of $69 \mu\text{g/L}$ in zone 5 at 95.9 ft. Concentrations decreased to near or below the detection limit in zones 6 and 7. Well UCD2-026 showed results similar to those for zone 4 but lower than zone 5; well UCD1-025 was slightly lower than zones 2 and 3. Chloroform was below detection in wells UCD1-034 and UCD2-035. The federal maximum contaminant level (MCL) for the four trihalomethanes summed (i.e., chloroform, bromodichloromethane, dibromochloromethane, and bromoform) is $100 \mu\text{g/L}$.

Tritium activities in all but zone 7 in well UCD2-027 were below their respective detection limits. The activity in zone 7 was 400 pCi/L . The MCL for tritium is $20,000 \text{ pCi/L}$.

Hexavalent chromium concentrations in HSU-1 ranged from < 10 to $320 \mu\text{g/L}$, with the highest concentration in well UCD1-025. The concentration in well UCD1-025 was two orders of magnitude greater than the corresponding value in zone 3 in well UCD2-027 (see Figure 2.12). Similar trends were noted for total chromium and nitrate. Currently, there is no explanation for these observations. Hexavalent chromium concentrations in HSU-2 ranged from < 10 to $16 \mu\text{g/L}$. The state MCL for hexavalent chromium is $50 \mu\text{g/L}$.

Table 2.7. Analytical Results for Ground-Water Samples Collected After Well Development

Sample ID	Pump Intake (ft bgs)	Site ID	Sample Date	HSU	Chloroform			Tritium				Hexavalent Chromium			Total Chromium			Nitrate-Nitrogen			Comments
					Conc. (µg/L)	Limit (µg/L)	Analysis Date	Activity (pCi/L)	Error (pCi/L)	MDA (pCi/L)	Analysis Date	Conc. (µg/L)	Limit (µg/L)	Analysis Date	Conc. (µg/L)	Limit (µg/L)	Analysis Date	Conc. (mg/L)	Limit (mg/L)	Analysis Date	
GWGW0225	71.53	UCD1-034	10/17/95	HSU-1	1.0 U ⁽¹⁾	1	10/28/95	30	190	250	11/8/95	<10	10	10/18/95	5.7 B	10	11/14/95	0.21	0.1	10/18/95	Screening sample
GWGW0226	115.59	UCD2-035	10/18/95	HSU-2	1.0 U	1	10/28/95	140	200	230	11/8/95	<10	10	10/19/95	9.0 B	10	11/14/95	1.2	0.1	10/19/95	Screening sample
GWGW0223	73	UCD1-025	10/20/95	HSU-1	1.4	1	10/29/95	-40	180	240	11/9/95	320 D ⁽²⁾	20	10/21/95	335	10	11/14/95	10	0.1	10/21/95	Screening sample
GWGW0227	115.6	UCD2-027	10/30/95	HSU-2	1.8	1	11/10/95	400	220	230	11/9/95	2.0 B ⁽³⁾	10	10/31/95	6.0 B	10	11/14/95	0.12	0.1	10/31/95	Screening sample, zone 7
GWGW0228	105.7	UCD2-027	10/31/95	HSU-2	1.0 U	1	11/11/95	60	190	240	11/9/95	6.0 B	10	11/11/95	6.3		11/14/95	0.81	0.1	11/11/95	Screening sample, zone 6
GWGW0229	95.9	UCD2-027	10/31/95	HSU-2	69	1	11/10/95	-20	190	240	11/9/95	2.0 B	10	11/11/95	6.4		11/14/95	2.0	0.1	11/11/95	Screening sample, zone 5
GWGW0230	86.0	UCD2-027	10/31/95	HSU-2	17	1	11/10/95	60	190	240	11/9/95	6.0 B	10	11/11/95	7.4		11/14/95	0.039 B	0.1	11/11/95	Screening sample, zone 4
GWGW0231	72.9	UCD2-027	10/31/95	HSU-1	12	1	11/10/95	-30	180	240	11/9/95	15	10	11/11/95	6.5		11/14/95	0.0010 B	0.1	11/11/95	Screening sample, zone 3
GWGW0232	63.0	UCD2-027	10/31/95	HSU-1	9.5	1	11/10/95	-30	180	240	11/9/95	22	10	11/11/95	4.7		11/14/95	0.0030 B	0.1	11/11/95	Screening sample, zone 2
GWGW0233	53.2	UCD2-027	10/31/95	HSU-1	6.4	1	11/11/95	20	190	240	11/9/95	21	10	11/11/95	6.2		11/14/95	0.0020 B	0.1	11/11/95	Screening sample, zone 1
GWGW0224	94	UCD2-026	11/1/95	HSU-2	21	1	11/11/95	-10	190	260	11/28/95	16	10	11/2/95	19.3	10	11/14/95	3.1	0.1	11/2/95	Screening sample

Notes:

1. U = Below Detection Limit
2. D = Dilution Performed
3. B = Reported Value Less Than Contract Required Detection Limit but Greater Than Instrument Detection Limit

Figure 2.12. Contaminant Concentrations as a Function of Depth in Wells UCD1-025, UCD2-026, and UCD2-027

Total chromium concentrations ranged from <10 to 335 µg/L in HSU-1 and <10 to 19.3 µg/L in HSU-2. The state MCL for total chromium is 50 µg/L. Similarities between the total and hexavalent chromium concentrations measured in each sample indicate most of the chromium present in the ground water exists in the +6 oxidation state.

Nitrate-nitrogen concentrations were at or near the detection limit of 0.1 mg/L in all of the wells, with the exception of UCD1-025. Concentrations ranged from <0.1 to 10 mg/L. The MCL for nitrate-nitrogen is 10 mg/L. Additional details on the distribution of these and other constituents in the ground water can be found in Stewart et al. (1996).

2.5 Slug Testing

Slug testing was conducted during October and November 1995 at existing and new well installations to provide information on the range and possible spatial variation of hydraulic properties for HSU-1 and HSU-2 at the LEHR site. In total, 11 existing HSU-1 wells (UCD1-010, -011, -012, -013, -018, -019, -020, -021, -022, -023, -024) and 4 existing HSU-2 wells (UCD2-007, -015, -016, -017) were characterized using the slug test method. Slug testing was also conducted at the five new wells (UCD1-025, 2-026, 2-027, 1-034, and 2-035). Static water-level measurements taken in the new and existing wells during slug testing are shown in Tables 2.6 and 2.8, respectively. Water levels were measured with a laminated electric water-level indicator according to Procedure WL-01, "Water-Level Measurement Procedure" (PNL 1995, unpublished).

Slug tests conducted at well UCD2-027 were performed on each of the seven monitoring zones before installing the Westbay ground-water monitoring system. The monitoring zones were isolated during testing using a downhole inflatable straddle packer system. Slug test responses were monitored using a Campbell Scientific, Inc. datalogger (model CR-10) and Keller pressure transducers (0-10 psig, 0-20 psig, or 0-30 psig).

Slug tests at the existing well sites were conducted using slugging rods of known displacement volume. At most of these locations, two slugging rods were used (i.e., a 2-in.-dia. rod with a displacement volume of 0.124 ft³ and a 3-in.-dia. rod with a displacement volume of 0.323 ft³) to impart different initial stress levels for individual tests. A minimum of two tests were conducted at each well site with at least one test for each of the slugging rods. Comparing the test responses for slug tests conducted at different stress levels provides information on possible hydraulic property scale dependence, well installation effects (e.g., ground-water flow turbulence), and lateral variation of hydraulic properties in the immediate vicinity of the well site.

Table 2.8. Static Water-Level Measurements in Existing Wells During Slug Testing

Well Number	Measurement Date	Time (hrs)	D/W ⁽¹⁾ (ft)
UCD2-007	11/6/95	1530	40.98
UCD1-010	11/1/95	0750	40.60
UCD1-011	11/2/95	0725	40.85
UCD1-012	11/1/95	1515	42.02
UCD1-013	11/3/95	0943	41.83
UCD2-014	11/3/95	1242	41.26
UCD2-015	10/31/95	1428	40.65
UCD2-016	11/3/95	1521	38.69
UCD2-017	10/31/95	1156	40.71
UCD1-018	10/31/95	1645	38.60
UCD1-019	11/6/95	0755	40.56
UCD1-020	11/2/95	1520	38.80
UCD1-021	11/6/95	0943	37.72
UCD1-022	11/6/95	1147	37.77
UCD1-023	11/6/95	1353	37.79
UCD1-024	11/2/95	1139	38.22
Notes:			
1. D/W = Depth to Water			
2. D/W measurements taken from top of PVC casing.			

Slug tests at the new well sites were performed using compressed air supplied by air cylinders to depress the water column a prescribed distance within the sealed well. After allowing sufficient time for equilibration of the water column depression, the compressed air within the sealed well was released by opening valves mounted on the well head assembly, thereby initiating the slug test. Two to four slug tests were conducted at each of the new well sites, with each test using a different stress level magnitude. As previously mentioned, comparing the test responses for slug tests conducted at various stress levels provides a variety of information on possible variations in hydraulic properties and well site conditions.

2.5.1 Slug Test Analysis Methods

Depending on the test formation properties and influence of inertial/friction effects, slug tests can respond either as an overdamped (i.e., an exponential decay pattern) or underdamped (i.e., oscillatory) test response. A number of analytical methods are available for analyzing overdamped and underdamped slug tests. The preferred analytical methods for the respective slug tests are discussed in Sections 2.5.1.1 and 2.5.1.2.

Inherent assumptions with all slug test analysis methods are that laminar (nonturbulent) flow conditions exist (Bouwer 1996), and that homogeneous test formation conditions exist. For the slug test analyses performed, laminar/turbulent flow conditions were assessed by determining the Reynolds number from flow velocity calculations within the well casing/fluid column. Test data indicative of laminar flow conditions (i.e., Reynolds number ≤ 2000) were the focus of the slug test analyses. In only a few cases (i.e., well UCD2-027, zones 5, 6, and 7) did turbulent flow conditions dominate $> 90\%$ of the test response record. In those cases, only minimum value estimates could be assigned for the test interval.

The homogeneous test formation condition assumes that the test formation penetrated by the test well (either fully or partially) is uniform throughout. The net effect is that individual layer characteristics within an actual test formation are "averaged" and an "equivalent" hydraulic property value is assigned for the entire formation thickness. For the case of equivalent hydraulic conductivity, it should be recognized that layers of higher and lower hydraulic conductivity exist within the test formation; however, taken as a whole, the test formation would have the indicated equivalent hydraulic conductivity based on the observed slug test response characteristics.

Section 2.5.2 summarizes the results of hydraulic property determinations based on the individual slug test analyses. Results of individual well site slug test analyses, including test discussion and supporting analysis plots, are provided in Appendix D. Generally, quantitative estimates for transmissivity (T) and equivalent hydraulic conductivity (K_e) were obtained for a majority of the test sites. As discussed below, slug test responses are rather insensitive to vertical anisotropy (K_v) and storativity (S) and, therefore, values used to facilitate the slug test analysis should not be viewed as actual quantitative estimates derived from the type-curve analysis method.

2.5.1.1 Overdamped Tests

Analytical methods used in analyzing slug tests exhibiting overdamped responses (i.e., exponential decay pattern) include the type-curve matching method for unconfined and confined aquifers, as presented in Hyder et al. (1994), Hyder and Butler (1995), Spane and Wurster (1993), and Spane (1996). Because these analytical methods can use all or any part of the slug test response in the analysis procedure, they are particularly useful in analyzing unconfined aquifer tests (e.g., HSU-1 wells). They also do not have any of the inherent analytical weaknesses of the commonly used Bouwer and Rice method (e.g., assumption of steady-state flow, isotropic conditions, etc.), as originally described in Bouwer and Rice (1976) and Bouwer (1989) for unconfined aquifer slug tests. These analytical limitations are discussed in Hyder and Butler (1995), Brown et al. (1995), and Bouwer (1996).

Because of the ease of application, the analytical method described in Spane (1996) was used to analyze overdamped slug tests. The method presented pertains to the analysis of slug interference tests; however, the general procedure of converting available pumping test type curves to an equivalent slug test response also applies. As shown in Figure 2.13, a comparison of predicted slug test responses for the analytical methods presented in Spane (1996) and Hyder and Butler (1995) for the given test/aquifer

Figure 2.13. Comparison of Analytical Unconfined Aquifer Slug Test Models: Spane (1996) and Hyder and Butler (1995)

conditions provided similar results. It should be noted that both type-curve analysis methods account for the effects of well partial penetration, anisotropy, wellbore storage, and aquifer elasticity effects (storativity).

Several analytical assumptions were made to facilitate analysis of the overdamped slug test results. These assumptions include the following:

- Only test data reflective of laminar flow conditions were the focus of the type-curve analysis.
- A vertical anisotropy (K_D) value of 0.1 was assumed.

- A storativity value of 0.0001 was used in most cases.
- The sandpack (for HSU-1 test sites) and the well screen interval (for HSU-2 test sites) were assumed to be equivalent to the test interval sections.

All standard methods for hydrologic test analysis assume that laminar flow conditions exist within the aquifer and well during testing. Laminar flow conditions during testing were determined by calculating flow velocities within the well casing (based on timed/fluid pressure measurements obtained in the well column), and then determining the Reynolds number based on standard fluid mechanics relationships. Laminar flow conditions were assumed to exist when Reynolds numbers $\leq 2,000$ were indicated. It should be noted that the Reynolds number calculations are based on steady flow conditions and therefore, some uncertainty exists as to what threshold Reynolds number value is indicative of laminar flow for test responses, with exponentially decreasing flow rate characteristics.

To standardize the slug test type-curve matching analysis for all overdamped slug test responses, a vertical anisotropy (K_D) of 0.1 was assumed. Figure 2.14 shows predicted slug test responses for a

Figure 2.14. Sensitivity Analysis of the Effects of Vertical Anisotropy on Unconfined Aquifer Slug Test Response

well that partially penetrates the upper 50% of an unconfined aquifer, for the given test formation conditions. As indicated, only a slight variation and offset in test response is indicated for the range of vertical anisotropy ($K_D=0.01-0.5$) that encompasses the commonly reported values in stratified alluvial formations (e.g., Weeks [1969]). This effect would be expected to increase slightly with smaller aquifer penetration ratios, and to become barely perceptible with full aquifer penetration. Because of the relative insensitivity of slug test response to vertical anisotropy, the use of an assumed (constant) value of 0.1 is not expected to have any significant impact in the determination of T and K_e from the type-curve matching analysis.

To facilitate the unconfined aquifer slug-test type-curve analysis, an elastic storage value of 0.0001 was used for all initial analysis runs. In some cases, slight modifications were made to input storativity values to improve the final analysis matches. Figure 2.15 shows the effect of storativity on predicted slug-test response. As indicated for the range of storativity commonly exhibited by shallow unconfined aquifers (i.e., $S=0.005-0.0001$), higher storativity values are associated with “flatter” test recovery curves. This characteristic of storativity allows for better type-curve matches through slight modifications of the input storativity value. It should be noted, however, that other factors influence

Figure 2.15. Sensitivity Analysis of the Effects of Storativity on Unconfined Aquifer Slug Test Response

the shape of the slug test curve (e.g., skin effects, vertical anisotropy). For this reason, storativity values used in the final slug test analyses are considered to be of qualitative value, and should not be used (as in the case for T) for quantitative applications.

For HSU-1 slug tests, the sand pack interval (rather than the screened interval) was used to represent the test interval for all analyses. This approach is based on the assumed higher transmissive properties of the sand pack (in comparison to the test formation), which are considered to be more representative in conveying test responses to the surrounding formation over the sand pack interval. In contrast, for HSU-2 overdamped slug tests, the screened interval (rather than the sand pack interval) was used to represent the test interval for the analyses. This approach is based on the assumption that the formation materials within HSU-2 have a higher permeability than the sand pack, and therefore, test response transmission is expected to propagate faster laterally from the well screen to the surrounding test formation, than vertically within the sand pack interval. In reality, only small differences exist between individual screened and sand pack intervals (i.e., in comparison to the aquifer thickness). Subsequently, no significant differences in analysis results would be expected.

2.5.1.2 Underdamped Tests

Several analytical methods are available for analyzing underdamped slug tests exhibiting oscillatory test responses. They include methods from Van der Kamp (1976, 1984), Kipp (1985), and Kabala et al. (1985). Because of the ease of application and frictional head loss considerations, the analytical methods described by Van der Kamp (1976, 1984) were used for analyzing slug tests exhibiting underdamped responses. Recently, a spreadsheet modeling of slug tests has been published by Wylie and Magnuson (1995) using the nonfrictional analysis method published in Van der Kamp (1976). This spreadsheet method does not provide for a frictional effect analysis or account for the modification to the original nonfrictional analysis method as presented in Van der Kamp (1984). For these reasons, it was not used in the slug test analysis.

Several analytical assumptions were made to facilitate analysis of the underdamped slug test results using the methods presented in Van der Kamp (1976, 1984). These assumptions include the following:

- Only test data reflective of laminar flow conditions were the focus of the type-curve analysis.
- Isotropic aquifer conditions were assumed (i.e., $K_D = 1.0$).
- A storativity value of 0.0001 was used for determining T.
- The well was assumed to fully penetrate the aquifer.

As in the case for analysis of overdamped tests, the analysis of underdamped slug tests is dependent on the existence of laminar flow conditions. Laminar flow conditions during testing were determined by calculating flow velocities within the well casing (based on timed/fluid pressure measurements obtained in the well column), and then determining the Reynolds number based on standard fluid mechanics relationships. As discussed previously for overdamped slug test analysis, laminar flow

conditions were assumed to exist when Reynolds numbers $\leq 2,000$ were indicated. It should be noted that the Reynolds number calculations are based on steady flow conditions and therefore, some uncertainty exists as to their validity for determining oscillatory flow behavior.

All available methods for underdamped slug test analysis assume isotropic formations (i.e., $K_D = 1.0$). The effects of anisotropy on underdamped slug test response are uncertain. However, if effects similar to those for overdamped slug test response are assumed, then the effects may be small and become inconsequential with full aquifer penetration.

The analytical methods presented in Van der Kamp (1976, 1984) in reality can only be used to determine the hydraulic diffusivity (i.e., transmissivity/storativity ratio, T/S). It is only in assuming a value for storativity that an estimate for T can be obtained. However, as indicated in Van der Kamp (1976), the sensitivity of the solution to storativity variation is small for the range of conditions anticipated for confined sedimentary aquifers (i.e., $S = 0.0005$ - 0.00005). For the HSU-2 underdamped slug test analyses listed in Appendix D, the calculated T range remained within a factor of 1.5 for this storativity range. To facilitate the calculation of a best estimate value from the underdamped slug-test analysis, a storativity of 0.0001 was used. This approach is consistent with analysis recommendations on storativity as listed in Kabala et al. (1985).

All available methods for underdamped slug test analysis assume that the well fully penetrates the aquifer. None of the HSU-2 wells exhibiting underdamped test responses fully penetrate the aquifer. They range in penetration from 26% to 80%. The effects of partial penetration on underdamped slug test response are uncertain. However, it may be anticipated that partial penetration effects will cause the oscillatory response to be damped back to static conditions more rapidly because of the presence of vertical flow components.

For a similar situation that confronted the use of fully penetrating well analysis-type curves for partially penetrating overdamped confined aquifer test responses, Cooper et al. (1967) stated:

"Few wells completely penetrate an aquifer, but it is nevertheless possible under some circumstances for a hydrologist to derive useful information from a test on a partially penetrating well. Since the vertical permeabilities of most stratified aquifers are only small fractions of the horizontal permeabilities, the induced flow within the small radius of the cone that develops during the short period of observation is likely to be essentially 2-dimensional. Therefore, the determined value of T would represent approximately the transmissibility of that part of the aquifer in which the well is screened..."

Because of the low stress levels used and reasons provided above, it was assumed that wells exhibiting underdamped slug test responses were fully penetrating, with an aquifer thickness equal to the well screen length.

2.5.2 Analysis Results

Table 2.9 shows the hydraulic conductivity range and mean values for HSU-1 and HSU-2 slug tests. Summaries of the individual analysis results (presented in Appendix D) are contained in Tables 2.10 and 2.11.

Table 2.9. Hydraulic Conductivity Ranges and Mean Values for HSU-1 and HSU-2

Hydrogeologic Unit	Hydraulic Conductivity	
	Range (ft/s)	Mean (ft/s)
HSU-1	$2.2 \times 10^{-5} - 1.3 \times 10^{-4}$	4.2×10^{-5}
HSU-2	$1.4 \times 10^{-3} - 7.2 \times 10^{-3}$	4.3×10^{-3}

HSU-2 exhibits a range and mean value nearly two orders of magnitude higher than HSU-1. These analysis values are slightly higher when compared with the hydraulic conductivity values previously reported for HSU-1 (7.1×10^{-6} to 8.3×10^{-5} ft/s), and significantly higher than the range previously cited for HSU-2 (3.1×10^{-4} to 9.4×10^{-4} ft/s), in DOE (1993). There are a number of reasons for the lower range values reported in DOE (1993). With respect to HSU-1 values, DOE (1993) states that these tests were analyzed using the Bouwer and Rice (1976) analytical method. As discussed in Section 2.5.1.1, many recent technical papers have shown that use of the Bouwer and Rice method can cause the actual formation hydraulic conductivity conditions to be significantly underestimated (up to 30% to an order of magnitude). This is attributed in part to the assumptions of aquifer inelasticity, isotropic conditions, and the semi-empirical basis of the Bouwer and Rice method.

With respect to the significantly lower HSU-2 values reported in DOE (1993), the cause is attributed to the improper application of overdamped slug test analytical methods (e.g., Bouwer and Rice [1976], Cooper et al. [1967]) for slug tests that exhibit underdamped (oscillatory) test response behavior. For these reasons, the range and mean values obtained from the slug test characterization investigation conducted in October and November 1995 and presented in this report are considered to provide the best available estimates for hydraulic properties within HSU-1 and HSU-2 on the LEHR site. It should be noted that the range and mean values listed for HSU-2 are based only on four quantitative test results (Table 2.11), of which wells UCD2-016 and UCD2-017 are considered to provide the most representative results.

Results obtained from the Westbay ground-water monitoring system in well UCD2-027 also suggest several vertical distribution patterns for hydraulic conductivity within HSU-1 and HSU-2. Generally, the results suggest that hydraulic conductivity increases with depth within HSU-1, as indicated by comparing zone 1, 2, and 3 results. Also, qualitative comparison of multilevel zone test results suggest that the highest hydraulic conductivity condition occurs within the middle section of HSU-2 (i.e., zones 5 and 6), with the lowest occurring near the top of the aquifer (i.e., zone 4). These apparent vertical patterns of hydraulic conductivity (if reflective of conditions across the LEHR site) provide valuable insight into the possible vertical distribution and transport of contaminants within HSU-1 and HSU-2, and provide useful information for the proper design and selection of remediation technologies for the site.

Table 2.10. Analysis Summary of Hydraulic Property Estimates for HSU-1 Slug Tests

HSU-1 Well	Transmissivity (ft ² /d) Spane (1996)	Hydraulic Conductivity (ft/s)	
		Spane (1996)	Bouwer & Rice (1976)
UCD1-010	62	0.0000222	0.0000278
UCD1-011	250	0.0000728	0.0000521
UCD1-012	90	0.000025	0.000023
UCD1-013	105	0.0000299	0.0000218
UCD1-018	490	0.0001253	0.0001042
UCD1-019	105	0.0000315	0.0000194
UCD1-020	110	0.0000325	0.0000266
UCD1-021	190	0.0000557	0.0000412
UCD1-022	155	0.0000412	0.0000284
UCD1-023	290	0.0000753	0.0000706
UCD1-024	290	0.0000797	0.0000573
UCD1-025	110	0.0000302	0.0000214
UCD2-027, Zone 1	14 ⁽¹⁾	0.0000040 ⁽¹⁾	0.0000024 ⁽¹⁾
UCD2-027, Zone 2	38 ⁽¹⁾	0.0000108 ⁽¹⁾	0.0000066
UCD2-027, Zone 3	(2)	NA ⁽³⁾	0.0000358 ⁽²⁾
UCD1-034	35	0.0000131	0.0000104
Range ⁽⁴⁾	14 - 490	0.0000040 - 0.0001253	
Mean ⁽⁴⁾	142.4	0.0000421	

Notes:

1. Analysis method assumes that the aquifer is homogeneous over the entire aquifer thickness. Because the test interval represents only a small percentage of the aquifer thickness (i.e., well screen = only 2 ft in length) and the fact that slug tests are most affected by aquifer materials in proximity of the well screen, the results may not be indicative of average aquifer conditions.
2. Test response indicates composite formational test response, with a higher permeability zone extending 4 to 5 ft from the well (i.e., T1=160 ft²/d), which is surrounded by a formation of low permeability (i.e., T2=75 ft²/d).
3. NA = Analytical Method Not Applicable
4. Based on results obtained using the analytical method described in Spane (1996); mean values include both the inner and outer zone permeability results indicated for well UCD2-027, Zone 3.

Table 2.11. Analysis Summary of Hydraulic Property Estimates for HSU-2 Slug Tests

HSU-2 Well	Transmissivity ft ² /d		Hydraulic Conductivity ft/s	
	Van der Kamp (1984)	Spane (1996)	Van der Kamp (1984)	Spane (1996)
UCD2-007	1220	NA	0.00141	NA
UCD2-015	6250	NA	0.00289	NA
UCD2-016	12285	NA	0.00569	NA
UCD2-017	15450	NA	0.00715	NA
UCD2-026	NA ⁽¹⁾	> 1200	NA	> 0.00032
UCD2-027, Zone 4	NA	1100	NA	0.000289 ⁽²⁾
UCD2-027, Zone 5	NA	> 3000	NA	> 0.000789 ⁽²⁾
UCD2-027, Zone 6	NA	> 3000	NA	> 0.000789 ⁽²⁾
UCD2-027, Zone 7	NA	> 2400	NA	> 0.000631 ⁽²⁾
UCD2-035	NA	> 2000	NA	> 0.000429
Range ⁽³⁾	1220 - 15450		0.000141 - 0.00715	
Mean ⁽³⁾	8801		0.00429	

Notes:

1. NA = Analytical Method Not Applicable
2. Analysis method assumes that the aquifer is homogeneous over the entire aquifer thickness. Because the test interval represents only a small percentage of the aquifer thickness (i.e., well screen = only 2 ft in length) and the fact that slug tests are most affected by aquifer materials in proximity of the well screen, the results may not be indicative of average aquifer conditions.
3. Does not include > analysis results or results from well UCD2-027, due to the limited well screen interval as explained in (2).

2.6 Westbay System Installation

A Westbay MP55 Multi-Level Ground-Water Monitoring System (referred to hereafter as the "MP55 system") was installed in well UCD2-027 in October 1995 to 1) monitor fluid pore pressures in each zone during hydraulic tests using a second well as a source well and 2) obtain ground-water samples from discrete horizons within HSU-1 and HSU-2. The MP55 system is a modular, multi-level ground-water sampling and pressure monitoring system with a single, hydraulically sealed access casing and various valved and unvalved couplings. It allows access to multiple monitoring zones in a single borehole. The system consists of permanently installed casing components, portable sampling and monitoring probes, and specialized tools. Casing components include 2.25-in.-ID casing sections and inflatable packers linked by regular couplings, measurement port (i.e., sampling port) couplings, or pumping port couplings. The packers isolate the annulus of the stainless steel casing between each monitoring zone.

Work performed during installation of the MP55 system included the following:

- Installation of the MP55 system, comprised of seven monitoring zones, in well UCD2-027 with a completed depth of 128 ft.
- Training of PNNL personnel to use a MOSDAX sampler probe, a MOSDAX datalogger, and eight pressure probes.
- Training of PNNL personnel to use a pumping port open/close tool.

All system materials, purging equipment, sampler probe equipment, and MOSDAX pressure probe equipment were supplied by Westbay. The system includes MP55 casing blanks and seven 2-ft monitoring zones. Five of the monitoring zones (i.e., 1, 2, 5, 6, 7) consist of two inflatable packers and one measurement port. The other two monitoring zones (i.e., 3, 4) consist of two inflatable packers, one measurement port, MP55 casing, and one pumping port. Note that measurement ports are required between packers in nonscreened zones to bleed off water as the upper packer is inflated, so that the upper packer will seat correctly as it inflates. Six such quality assurance (QA) zones were installed in well UCD2-027.

Three 2-ft screened intervals were completed in HSU-1 and four 2-ft screened intervals were completed in HSU-2 using 5-in.-dia. stainless steel screens and casing. Placement of the screened intervals was determined based on the MP55 system configuration before completing the well, and then corroborated by interpretation of lithologic and geophysical logs, such that these intervals and the corresponding measurement ports were adjacent to permeable zones within the formation. Figure 2.16 shows a schematic diagram of the completed well with the MP55 system installed. Appendix E provides additional details on the components and tools in the MP55 system.

2.6.1 MP55 System Installation

Installation of the MP55 system commenced on October 23, 1995, with Westbay onsite to install the system and train PNNL personnel to use the sampling and monitoring tools and the data-logging software. Installation of the system's permanent components was completed on October 25, 1995.

2.6.1.1 Layout of MP55 Casing Components

All installation equipment and MP55 system components were factory cleaned before being shipped to the LEHR site. Each individual component was factory sealed in a plastic bag and placed in a sturdy cardboard container for shipping. During vehicle transport onsite, all materials were enclosed in the containers in which they were shipped to keep them clean and to protect them from damage. The MP55 system materials were stored off the ground and covered with plastic while awaiting placement in the well.

A Casing Installation Log for the MP55 system was prepared by Westbay as a guide to system installation. To prepare for installation, couplings were attached to packers and the casing, and these casing components were laid out in sequence and numbered according to the installation log. Serial numbers of components were recorded and nominal casing lengths were verified.

2.6.1.2 Lowering MP55 System Casing Components

The MP55 system casing components were lowered into the well in the sequence indicated on the installation log. Lowering the casing components involved using a slip plate to hold the top of the casing string while adding the next component and inserting the shear wire. The slip plate was then removed and the string was lowered. In instances where the slip plate was too thick to be used with the packers, pipe wrenches were used to hold the casing string. A geotextile sleeve was attached to the QA zone ports as a barrier to fine-grained material.

Two people were needed to lower the first four packers. One person lowered the string, while the other positioned the slip plate and inserted the shear wire. After the fourth packer was added, the casing string was too heavy for one person to lower. A tripod and pulley was set up over the well and a rope was used to hold the casing string as a third person helped lower it.

As the casing string was lowered, each casing joint was tested with a minimum internal hydraulic pressure of 100 psi for one minute to confirm the seal. The joint testing tool consisted of two packers, positioned in the casing on either side of the coupling, and a center section having a valve for pumping deionized water into the space between the tool's packers.

The hydraulic sealing capability of the completed MP55 system casing string was confirmed by noting that buoyancy was maintained overnight, and that the depth to water in the MP55 system casing remained steady with respect to the depth to water in the stainless steel casing.

2.6.1.3 Inflation of MP55 System Packers

The packers were inflated individually with deionized water using the packer inflation tool. The lowermost packer was inflated first with the rest inflated in ascending order. A target internal pressure of 200 psi above ambient pressure at the packer was used during inflation. Inflation of the packers was completed on October 25, 1995. All packers were confirmed to be inflated and sealing correctly.

2.6.2 MP55 System Training

Training in the operation and maintenance of MP55 system probes and tools was completed on October 26 and 27, 1995. A PNNL staff member was trained as a qualified operator for unsupervised operation of the following equipment:

1. Model 2531 MOSDAX Sampler Probe System - used for collection of fluid samples and pressures.
2. Model 6012 Pumping Port Open/Close Tool System - used for monitoring zone purging and hydraulic conductivity testing.
3. MP55 MOSDAX Automated Data Logging System - used for installation and removal of MOSDAX pressure probes and for operation of Mlog32 software for datalogger operation, data collection, and data storage.

2.6.3 Ground-Water Sampling With the MP55 System

Following installation of the MP55 system, ground-water samples were collected for screening purposes from the seven measurement ports using the MOSDAX sampler probe. The probe was lowered to each measurement port valve and samples collected in a pre-evacuated stainless steel sampling container attached to the lower end of the probe. Decontamination of the stainless steel sampling container was performed before and after each measurement port. The samples were transferred at the surface to bottles provided by LAS. Labels and chain-of-custody forms were generated by PNNL. Chain-of-custody followed Procedure NHFP-AD-2, "Ground-Water Sample Chain-of-Custody and Field Record Form Procedure" (PNL 1995, unpublished). Purge water was discharged into the frac tank adjacent to well UCD2-027. All samples were analyzed for chloroform, tritium, hexavalent and total chromium, and nitrate-nitrogen on a rapid turnaround basis by LAS. Analytical results for these samples are discussed in Section 2.4.1.

2.7 Continuous Water-Level Monitoring

Continuous water-level monitoring equipment was installed in selected wells to monitor diurnal and seasonal water-level trends and response patterns. Initially, four wells are being monitored, two in HSU-1 (UCD1-025 and UCD1-034) and two in HSU-2 (UCD2-026 and UCD2-035). These wells were selected for two reasons: 1) the wells provide spatially distributed aquifer response data for both HSU-1 and HSU-2, and 2) surface completions at the wells were specifically designed to provide secure environments for the monitoring equipment. Pressure response data (i.e., water-level fluctuations) are being measured in each well with Keller PSI series 30S strain gauge pressure transducers. Barometric pressure is also being measured. Pressure data is being recorded using a Campbell Scientific Inc. CR10 datalogger.

Water-level data from the continuous water-level monitoring network will be used to refine the conceptual understanding of the hydrogeology beneath the LEHR site. The data will be evaluated with respect to the dynamic response of HSU-1 and HSU-2 to external stresses (e.g., barometric effects, natural recharge from areal infiltration, pumping from off-site wells, etc.). A time equivalent comparison of HSU-1 and HSU-2 responses will also be performed for determining a time scale associated with site water-level fluctuations. This information will be used to improve interpretation of discrete historical water-level measurements, and to determine if additional continuous water-level data are required for assessing the hydrologic interconnection between the HSUs across the site.

2.8 Cone Penetrometer Testing and Hydropunch Installation

CPT and Hydropunch ground-water sample collection were performed by Gregg In Situ, Inc. in October 1995, in November and December 1995, and in March 1996. CPT provided detailed stratigraphic delineations and measurement of dynamic and dissipation aquifer pore pressures. These tests aided in understanding site-specific geologic and hydrogeologic parameters directly relevant to the collection of ground water with the Hydropunch and its variations (i.e., miniature temporary wells). They also served to expand site-wide knowledge.

The Hydropunch and its variations provided tools for collecting ground-water samples for screening purposes without having to construct traditional monitoring wells. This capability facilitated a rapid delineation of ground-water contamination associated with the LEHR site. One-hundred seventeen ground-water samples were collected from 61 Hydropunch locations, 7 of which were subjected to CPT. These procedures were overseen by a California Registered Geologist. The Solano County Department of Environmental Health reported that no permits were required to conduct these activities at and adjacent to the LEHR site. Ground-water samples were analyzed for chloroform, tritium, hexavalent and total chromium, and nitrate-nitrogen on a rapid turnaround basis.

2.8.1 Cone Penetrometer Testing

CPT was undertaken at locations HPL00200, HPL00203, HPL00211, HPL00213, HPL00219, HPL00252, and HPL00254 (see Figures 1.2 and 1.3). The resultant data outputs are included in Appendix F. The majority of the tests were conducted from ground surface to approximately 85 ft bgs. Two of the CPTs were driven to approximately 100 ft bgs. Tests were performed by driving a 1.75-in.-OD stainless steel rod with strain gauges mounted directly behind and on the sleeve above the drive point (i.e., cone). The CPT industry standard drive rate of 2 cm/s was used, and strain gauge measurements were transmitted by wire to a computer that logged these values at 5-cm intervals. Soil identifications were made by measuring the stresses on the cone tip (QC) and friction sleeve (FS) during advancement into the subsurface. The ratio, QC/FS, was also used in combination with these measurements to interpret the soil type.

Piezocone (CPTu) testing to determine aquifer pore pressure was accomplished simultaneously with CPT soil classification. The integrated pore pressure element located within the cone consists of an external, saturated porous ring and an internal, fluid-filled (i.e., glycerin) chamber pressure transducer. The transducer measures the pore water pressure in the formation immediately adjacent to the element during CPT advancement. Its signal is logged in the same manner as the signal from the strain gauges. Readings obtained during cone advancement are dynamic excess pore pressures (u). In saturated soils, cone penetration changes porosity by shear and compression which, in turn, changes pore water pressure. Pore pressure effects caused by cone advancement are referred to as excess pore pressures. In general, an increase in porosity causes a negative excess pore pressure and a decrease in porosity causes a positive excess pore pressure. Negative excess pore pressures are typically associated with sandy soils. Hence, u is an indicator of whether or not an area within the aquifer will easily yield water, which is essential with sampling devices of the Hydropunch genre.

CPTu was also used to perform brief aquifer dissipation tests. In these tests, piezocone advancement would be temporarily halted to allow the dissipation of u to be observed. In this manner, the rate that u approached formation hydrostatic pressure (u_0) provided an indication as to whether or not an area within the aquifer would readily yield water.

To verify CPT "calibration" at the LEHR site, location HPL00200 was deliberately placed immediately adjacent to monitoring well UCD1-012 to compare the CPT output to the borehole log for this well.

2.8.2 Hydropunch Sample Collection

Ground-water sample collection using the Hydropunch and its variations was undertaken at locations HPL00200 through HPL00217 in October 1995 (Phase I) (Table 2.12 and Figure 2.17). The initial sample locations were in the vicinity of existing monitoring well UCD1-012. Subsequent locations, based on chloroform results from on-site gas chromatography/mass spectrometry (GC/MS) analysis, were placed in a grid pattern radially outward from well UCD1-012 to facilitate the delineation of the ground-water contaminant plumes. Predetermined sampling intervals were 55, 75 and 85 ft bgs.

Hydropunch locations HPL00218 through HPL00236, HPL00238, and HPL00239 were extended eastward to delineate the extent and depth of the chloroform plume east of the LEHR site in November and December 1995 (Phase II) (Table 2.13 and Figure 2.17). Computer modeling indicated that the chloroform would be concentrated at a depth of approximately 95 ft away from the source area. Therefore, Hydropunch samples were collected at depths of approximately 85 and 95 ft for these locations. Two locations, HPL00207 and HPL00222, were sampled at additional depths of 89 and 75 ft, respectively, because of their location along the centerline of the plume.

Hydropunch locations HPL00240 through HPL00261 were sampled in March 1996 to determine if Landfill 3 serves as a contaminant source east of the LEHR site and to further characterize the eastward trending chloroform plume offsite (Phase III) (Table 2.14 and Figures 2.18 and 2.19). Sample collection depths were set at 85 and 95 ft bgs to characterize chloroform distributions in the upper and middle portions of HSU-2. Initial locations were predetermined, however, subsequent sample locations were based on results generated through on-site analyses.

The Hydropunch is a 1.5 to 3-ft-long, slotted, cylindrical chamber, sheathed in a 1.5-in.-OD hollow rod, that is driven into the subsurface. The sheath is retracted at the desired sampling depth to expose the 0.75-in.-OD slotted water accumulation chamber. Once formation water has charged the Hydropunch chamber, grab samples may be collected using a 0.5-in.-OD stainless steel bailer. Bailers of several lengths ranging from 1.5 to 3 ft were available for this purpose.

CPT, CPTu, and experience were used to determine whether the formation would readily yield water at each specific location and whether the application of additional procedures would be necessary to obtain samples. Additional procedures that facilitated sample collection at the specific locations included the following:

1. Applying a vacuum to the Hydropunch hollow rod string to overcome interstitial pore pressure.
2. Raising the Hydropunch above the target sample collection depth to create a void.
3. Deliberately overdriving the Hydropunch beyond the desired sample collection depth to create a void, and then setting it at the desired depth.
4. Allowing the Hydropunch sampling string to remain in the ground for an extended period (i.e., 2 to 14 hr).
5. Substituting the commercially supplied Hydropunch with a 1-in.-OD, 10-slot, polyvinyl chloride (PVC) well screen.

Table 2.12. Hydropunch Ground-Water Sample Locations, Depths, and Analytical Results (Phase I)

Sample Location	Sample Depth (ft bgs)	Sample ID	Sample Date	Chloroform			Chloroform			Trilium			Hexavalent Chromium			Total Chromium			Nitrate-Nitrogen			CPT	Comments	
				Field ⁽³⁾ Conc. (µg/L)	Detection Limit (µg/L)	Analysis Date	Lab ⁽⁴⁾ Conc. (µg/L)	Detection Limit (µg/L)	Analysis Date	Activity (pCi/L)	Error (pCi/L)	MDA (pCi/L)	Analysis Date	Conc. (µg/L)	Detection Limit (µg/L)	Analysis Date	Conc. (µg/L)	Detection Limit (µg/L)	Analysis Date	Conc. (mg/L)	Detection Limit (mg/L)	Analysis Date		
HPL00200	73.5 - 76.5	HPGW0201	10/3/95	8015.2 E ⁽⁵⁾	0.5	10/3/95	7200	1	10/9/95	0	190	250	10/12/95	< 1	1	10/5/95	430	7	10/5/95	87.7	0.1	10/9/95	X	
	84 - 87	HPGW0202	10/3/95	17019.3 E	0.5	10/3/95				-70	190	260	10/12/95	93.4	1	10/5/95	190	7	10/5/95	127.9	0.1	10/10/95		
HPL00201	71 - 74	HPGW0204	10/5/95	944	0.3	10/5/95	6400	1	10/9/95	-20	200	260	10/24/95	< 1	1	10/9/95	840	7	10/9/95	65.7	0.1	10/9/95		
	83 - 86	HPGW0205	10/3/95	317.5	0.5	10/3/95				-60	190	260	10/12/95	8.2	1	10/4/95	210	7	10/4/95	9.4	0.1	10/5/95		
HPL00202	52 - 55	HPGW0206	10/4/95	0.1 J ⁽⁶⁾	0.3	10/4/95				-100	190	260	10/24/95	22	1	10/5/95	50	7	10/5/95	26.4	0.1	10/5/95		
	72 - 75	HPGW0207	10/4/95	0.7	0.3	10/4/95				-20	190	250	10/24/95	< 1	1	10/5/95	410	7	10/5/95	11.9	0.1	10/5/95		
	83 - 86	HPGW0208	10/4/95	5.7	0.3	10/4/95				0	200	260	10/24/95	< 1	1	10/5/95	680	7	10/5/95	11.8	0.1	10/5/95		
HPL00203	68 - 75	HPGW0210	10/10/95	259.9	0.3	10/10/95				-130	160	230	10/26/95	122	1	10/12/95	270	7	10/12/95	32.3	0.1	10/12/95	X	
	82 - 85	HPGW0211	10/4/95	1.6	0.3	10/4/95								< 1	1	10/5/95	210	7	10/5/95	12.2	0.1	10/5/95		
HPL00204	82 - 85	HPGW0214	10/4/95	10.8	0.3	10/4/95				-10	190	260	10/24/95	4.1	1	10/6/95	1030	7	10/6/95	31.6	0.1	10/11/95		
HPL00205	70 - 75	HPGW0216	10/10/95	140.8	0.3	10/10/95				-10	190	260	11/28/95											VOAF, VOA, H ¹ only (245 ml)
	82.5 - 85.5	HPGW0217	10/5/95	81.1	0.3	10/5/95				-10	190	260	10/24/95	< 1	1	10/9/95	880	7	10/9/95	10.7	0.1	10/10/95		
HPL00206	70 - 76	HPGW0219	10/10/95	2952.5 E	0.3	10/10/95				-40	180	230	10/26/95	< 1	1	10/12/95	100	7	10/12/95	32.5	0.1	10/12/95		
	82 - 85	HPGW0220	10/5/95	1122.8	0.3	10/5/95				70	200	250	10/24/95	3	1	10/9/95	470	7	10/9/95	21.5	0.1	10/9/95		
HPL00207	73 - 76	HPGW0222	10/10/95	7949 D ⁽⁵⁾ , E	0.3	10/10/95				60	200	260	10/24/95	< 1	1	10/9/95	320	7	10/9/95	16.4	0.1	10/9/95	VOAF only (20 ml)	
	82 - 85	HPGW0223	10/5/95	844	0.3	10/5/95																		
HPL00208	70 - 76	HPGW0225	10/9/95	6366 E	0.3	10/9/95				-20	190	260	10/24/95	< 1	1	10/10/95	333	7	10/10/95	120.0	0.1	10/11/95		
	83 - 86	HPGW0226	10/5/95	361	0.3	10/5/95				-50	190	260	10/24/95	< 1	1	10/9/95	510	7	10/9/95	19.0	0.1	10/9/95		
HPL00209	83 - 86	HPGW0229	10/5/95	84.3	0.3	10/5/95				-30	190	260	10/24/95	3.5	1	10/6/95	670	7	10/6/95	29.8	0.1	10/11/95		
HPL00210	73 - 76	HPGW0231	10/9/95	925.9 E	0.3	10/9/95				-400	230	250	10/24/95	< 1	1	10/10/95	7	7	10/10/95	35.7	0.1	10/11/95		
	82 - 85	HPGW0232	10/5/95	2327.5 E	0.3	10/5/95				120	180	230	10/26/95	3.5	1	10/9/95	130	7	10/9/95	31.0	0.1	10/10/95	Broken H ¹ bottle, substitute leftover Cr ⁶⁺ /NO ₃ ⁻ sample	X
HPL00211	81 - 84	HPGW0235	10/6/95	10.3	0.3	10/6/95				10	200	260	10/24/95	< 1	1	10/9/95	90	7	10/9/95	18.0	0.1	10/10/95		
HPL00212	82 - 85	HPGW0238	10/6/95	0.8	0.3	10/6/95				570	220	220	10/26/95	< 1	1	10/9/95	280	7	10/9/95	346.0	0.1	10/10/95	Broken H ¹ bottle, substitute leftover Cr ⁶⁺ /NO ₃ ⁻ sample	X
HPL00213	67.5 - 75	HPGW0240	10/10/95	211.5	0.3	10/10/95				3470	410	230	10/26/95	64	1	10/12/95	390	7	10/12/95	29.1	0.1	10/12/95		
	82 - 85	HPGW0241	10/6/95	117.9	0.3	10/6/95				810	270	260	10/24/95	< 1	1	10/16/95	< 7	7	10/16/95					
HPL00214	82 - 85	HPGW0244	10/6/95	1.0	0.3	10/6/95				830	280	260	10/24/95	< 1	1	10/9/95	710	7	10/9/95	3.8	0.1	10/10/95		
HPL00215	82 - 85	HPGW0247	10/6/95	27.8	0.3	10/6/95				100	210	260	10/24/95	< 1	1	10/10/95	140	7	10/10/95	14.6	0.1	10/11/95		
HPL00216	82 - 85	HPGW0250	10/9/95	4.1	0.3	10/9/95	3.6	1	10/11/95	210	220	260	10/24/95	< 1	1	10/10/95	400	7	10/10/95	22.8	0.1	10/11/95		
HPL00217	71 - 75	HPGW0252	10/10/95	1831.6 E	0.3	10/10/95				30	170	230	10/26/95	146	1	10/12/95	150	7	10/12/95	29.1	0.1	10/12/95		
	82 - 85	HPGW0253	10/10/95	143.0	0.3	10/10/95				20	170	220	10/26/95	57	1	10/12/95	40	7	10/12/95	23.5	0.1	10/12/95		

Notes:

1. Information reflects sampling conducted from 3-10 Oct 95.
2. Samples were analyzed by GC/MS in the field.
3. E = Calibration Range Exceeded
4. J = Estimated Value
5. D = Constituent Detected in Diluted Sample
6. Duplicates were analyzed for approximately 10% of the chloroform samples at the PNNL Richland office.

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Figure 2.17. Chloroform Concentrations at Hydropunch Locations, October-December 1995 (Phases I and II)

Table 2.13. Hydropunch Ground-Water Sample Locations, Depths, and Analytical Results (Phase II)

Sample Location	Sample Depth (ft bgs)	Sample ID	Sample Date	Chloroform			Chloroform			Tritium				Hexavalent Chromium			Total Chromium			Nitrate-Nitrogen			CPT	Comments	
				Field ⁽⁴⁾ Conc. (µg/L)	Detection Limit (µg/L)	Analysis Date	Lab ⁽⁵⁾ Conc. (µg/L)	Detection Limit (µg/L)	Analysis Date	Activity (pCi/L)	Error (pCi/L)	MDA (pCi/L)	Analysis Date	Conc. (µg/L)	Detection Limit (µg/L)	Analysis Date	Conc. (µg/L)	Detection Limit (µg/L)	Analysis Date	Conc. (mg/L)	Detection Limit (mg/L)	Analysis Date			
HPL00218	72 - 75	HPGW0254	11/15/95	128.3	0.3	11/16/95				1400	310	260	11/29/95	1.1	0.2	11/15/95	<10			NA ⁽⁶⁾				X	VOAF, VOA only
	85	HPGW0255	11/15/95	309.3	0.3	11/16/95				110	200	260	11/29/95	<0.2	0.2	11/15/95	<10			NA					
	95	HPGW0256	11/15/95	28.9	0.3	11/16/95																			
HPL00219	85	HPGW0258	11/16/95	35.8	0.3	11/16/95				30	190	260	11/29/95	7.3	0.2	11/20/95	<10			8.7		11/20/95			
	95	HPGW0259	11/16/95	60.6	0.3	11/16/95				40	190	260	11/29/95	0.4	0.2	11/20/95	<10			3.9		11/20/95			
HPL00220	85	HPGW0261	11/16/95	16.0	0.3	11/16/95								<0.2	0.2	11/20/95	<10			26.4		11/20/95			
	95	HPGW0262	11/16/95	0.8 B ⁽¹⁾	0.3	11/16/95				160	200	260	11/29/95	<0.2	0.2	11/19/95	<10			5.6		11/20/95			
HPL00221	85	HPGW0265	11/17/95	124.7	0.3	11/17/95				-10	180	250	11/29/95	<0.2	0.2	11/19/95	<10			33.4		11/20/95			
	95	HPGW0266	11/17/95	156.0	0.3	11/17/95								0.7	0.2	11/19/95	<10			8.7		11/20/95			
HPL00222	85	HPGW0267	11/17/95	76.5	0.3	11/17/95				20	190	260	11/29/95	<0.2	0.2	11/19/95	<10			11.1		11/20/95			
	95	HPGW0268	11/17/95	139.8	0.3	11/17/95								<0.2	0.2	11/19/95	<10			10.3		11/17/95			
HPL00223	85	HPGW0270	11/20/95	3.7	0.3	11/20/95				20	160	210	12/8/95	<0.2	0.2	11/25/95	<10	10		5.7		11/27/95			
	95	HPGW0271	11/20/95	4.0	0.3	11/20/95				-40	160	210	12/8/95	<0.2	0.2	11/25/95	<10	10		4.5		11/27/95			
HPL00224	85	HPGW0273	11/20/95	9.9	0.3	11/20/95				20	160	210	12/8/95	1.3	0.2	11/25/95	<10	10		6.6		11/27/95			
	95	HPGW0274	11/20/95	28.1	0.3	11/20/95				-150	140	210	12/8/95	1.3	0.2	11/25/95	<10	10		5.1		11/27/95			
HPL00225	85	HPGW0276	11/20/95	30.2	0.3	11/20/95				20	160	210	12/8/95	<0.2	0.2	11/25/95	<10	10		14.7		11/27/95			
	95	HPGW0277	11/21/95	62.4	0.3	11/21/95				-70	150	210	12/8/95	13	0.2	11/22/95	21			6.6		11/22/95			
HPL00226	85	HPGW0279	11/21/95	68.0	0.3	11/21/95				30	160	210	12/8/95	<0.2	0.2	11/22/95	16			14.7		11/22/95			
	95	HPGW0280	11/21/95	48.3	0.3	11/21/95				-10	160	210	12/8/95	1.3	0.2	11/22/95	10			11.2		11/21/95			
HPL00227	85	HPGW0282	11/21/95	11.9	0.3	11/21/95				60	170	210	12/8/95	<0.2	0.2	11/22/95	<10			8.3		11/21/95			
	95	HPGW0283	11/21/95	1.5	0.3	11/21/95				30	160	210	12/8/95	<0.2	0.2	11/22/95	<10			4.5		11/22/95			
HPL00228	85	HPGW0285	11/27/95	10.6	0.3	11/27/95	10.3	0.5	12/19/95	120	170	210	12/8/95	3.4	0.2	11/28/95	<10			5.4		1/5/96			
	95	HPGW0286	11/27/95	5.9	0.3	11/27/95	6.8	0.5	12/19/95	20	160	210	12/8/95	<0.2	0.2	11/28/95	30			5.1		1/5/96			
HPL00229	85	HPGW0288	11/27/95	28.9	0.3	11/27/95				90	170	210	12/8/95	<0.2	0.2	11/28/95	<10			5.5		1/5/96			
	95	HPGW0289	11/27/95	32.0	0.3	11/27/95				20	160	210	12/8/95	<0.2	0.2	11/28/95	15			6.6		1/5/96			
HPL00230	85	HPGW0291	11/28/95	2.2	0.3	11/28/95				260	180	210	12/9/95	2.8	0.2	12/1/95	<10	10		4.0		12/11/95			
	95	HPGW0292	11/28/95	1.5	0.3	11/28/95				190	180	210	12/9/95	<0.2	0.2	11/30/95	<10	10		2.1		12/11/95			
HPL00231	85	HPGW0294	11/28/95	209.6	0.3	11/28/95				40	160	210	12/9/95	<0.2	0.2	12/1/95	<10	10		15.0		12/11/95			
	90	HPGW0295	11/28/95	283.3	0.3	11/28/95				30	160	210	12/9/95	0.4	0.2	11/30/95	<12	10		10.8		12/11/95			
HPL00232	85	HPGW0297	11/28/95	<0.3 U ⁽⁴⁾	0.3	11/28/95				-40	160	210	12/9/95	1	0.2	11/30/95	<10	10		7.3		12/11/95			
	95	HPGW0298	11/28/95	<0.3	0.3	11/28/95				-20	160	210	12/9/95	1	0.2	11/30/95	<10	10		5.6		12/11/95			
HPL00233	85	HPGW0300	11/29/95	1.2	0.3	11/29/95	1.2	0.5	12/19/95	70	170	220	12/12/95	<0.2	0.2	12/1/95	<10								
	95	HPGW0301	11/29/95	1.0	0.3	11/29/95				70	160	210	12/12/95	<0.2	0.2	12/1/95	<10	10		26.9		12/11/95			
HPL00234	85	HPGW0303	11/29/95	1.0	0.3	11/29/95				20	160	220	12/12/95	<0.2	0.2	12/1/95	<10	10		7.5		12/11/95			
	95	HPGW0304	11/29/95	3.6	0.3	11/29/95	4.5	0.5	12/19/95	80	170	210	12/12/95	1	0.2	12/1/95	<10	10		6.9		12/11/95			
HPL00235	85	HPGW0233	11/29/95	0.3	0.3	11/29/95				-40	150	220	12/12/95	<0.2	0.2	12/1/95	<10	10		10.9		12/11/95			
	95	HPGW0234	11/30/95	<0.3 U	0.3	11/30/95				-110	150	220	12/12/95	8.3	0.2	12/1/95	14	10		5.4		12/12/95			
HPL00236	85	HPGW0236	11/30/95	<0.3 U	0.3	11/30/95	<0.5	0.5	12/19/95	-40	150	220	12/12/95	<0.2	0.2	12/1/95	<10	10		12.3		12/12/95			
	90	HPGW0237	11/30/95	0.4	0.3	11/30/95				-10	160	220	12/12/95	<0.2	0.2	12/1/95	<10	10		6.9		12/12/95			
HPL00239	85	HPGW0239	11/30/95	0.9	0.3	11/30/95	0.6	0.5	12/19/95	530	210	210	12/12/95	<0.2	0.2	12/1/95	<10	10		10.6		12/12/95			
	88	HPGW0248	11/30/95	0.5	0.3	11/30/95				410	200	220	12/12/95	3.9	0.2	12/1/95	11	10		6.5		12/12/95			
HPL00238	85	HPGW0245	11/30/95	0.5	0.3	11/30/95	<0.5	0.5	12/20/95	50	170	220	12/12/95	<0.2	0.2	12/4/95	<10	10		6.5		12/12/95			
	95	HPGW0246	11/30/95	0.3	0.3	11/30/95				-40	160	220	12/12/95	<0.2	0.2	12/4/95	<10	10		3.0		12/12/95			
HPL00207	89	HPGW0242	12/1/95	2729.5	0.3	12/1/95				-20	160	220	12/12/95	<0.2	0.2	12/4/95	<10	10		15.9		12/12/95			
HPL00222	75	HPGW0228	12/1/95	37.3	0.3	12/1/95	32.0	0.5	12/19/95	-10	160	220	12/12/95	<0.2	0.2	12/4/95	<10	10		12.7		12/12/95			

Notes:

- Information reflects sampling conducted from 15Nov95 through 1Dec95.
- Samples were analyzed by GC/MS in the field.
- B = Constituent Detected In Associated Blank
- U = Below Detection Limit
- Duplicates were analyzed for approximately 10% of the chloroform samples at the PNNL Richland office.
- NA = Not Analyzed

Table 2.14. Hydropunch Ground-Water Sample Locations, Depths, and Analytical Results (Phase III)

Sample Location	Sample Depth (ft bgs)	Sample ID	Sample Date	Chloroform			Hexavalent Chromium			Nitrate-Nitrogen			Specific Conductance (EC)		CPT	Comments	
				Conc. ⁽²⁾ (µg/L)	Limit (µg/L)	Analysis Date	Conc. ⁽⁴⁾ (µg/L)	Limit (µg/L)	Analysis Date	Conc. ⁽⁵⁾ (mg/L)	Limit (mg/L)	Analysis Date	Conc. ⁽⁶⁾ µmhos/cm	Analysis Date			
HPL00240Z1	85	HPGW0320	3/11/96	0.4	0.3	11-Mar-96	<	U	0.5	3/11/96	0.828	0.3	11-Mar-96	883	3/11/96		
HPL00240Z2	91	HPGW0321	3/11/96	0.5	0.3	11-Mar-96	<	U	0.5	3/11/96	0.713	0.3	11-Mar-96	855	3/11/96		
HPL00241Z1	85	HPGW0323	3/11/96	<	U ⁽³⁾	0.3	6.1	0.5	3/11/96	0.161	0.3	11-Mar-96	827	3/11/96			
HPL00241Z2	92	HPGW0324	3/11/96	<	U	0.3											
	92	HPGW0324R	3/12/96	<	U	0.3	<	U	0.5	3/12/96	0.345	0.3	12-Mar-96	821	3/11/96		Replicate sample
HPL00242Z1	86	HPGW0326	3/12/96	<	U	0.3	<	U	0.5	3/12/96	0.391	0.3	12-Mar-96	757	3/12/96		
HPL00242Z2	92	HPGW0327	3/12/96	<	U	0.3	<	U	0.5	3/12/96	0.437	0.3	12-Mar-96	767	3/12/96		
HPL00243Z1	85	HPGW0329	3/12/96	<	U	0.3	<	U	0.5	3/12/96	0.46	0.3	12-Mar-96	777	3/12/96		
HPL00243Z2	95	HPGW0330	3/12/96	<	U	0.3	<	U	0.5	3/12/96	0.414	0.3	12-Mar-96	811	3/12/96		
HPL00244Z1	85	HPGW0332	3/13/96	<	U	0.3	<	U	0.5	3/13/96	0.368	0.3	13-Mar-96	903	3/13/96		
HPL00244Z2	93	HPGW0333	3/13/96	<	U	0.3	<	U	0.5	3/13/96	0.391	0.3	13-Mar-96	902	3/13/96		
HPL00245Z1	86	HPGW0335	3/13/96	<	U	0.3	<	U	0.5	3/13/96	1.518	0.3	13-Mar-96	943	3/13/96		
HPL00245Z2	95	HPGW0336	3/13/96	<	U	0.3	<	U	0.5	3/13/96	0.736	0.3	13-Mar-96	885	3/13/96		
HPL00246Z1	85	HPGW0338	3/14/96	<	1.4	0.3	5.2	0.5	3/14/96	2.806	0.3	14-Mar-96	1108	3/14/96			
HPL00246Z2	95	HPGW0339	3/14/96	<	U	0.3	<	U	0.5	3/14/96	0.943	0.3	14-Mar-96	831	3/14/96		
HPL00247Z1	85	HPGW0341	3/14/96	<	0.7	0.3	1.8	0.5	3/14/96	2.622	0.3	14-Mar-96	1029	3/14/96			
HPL00247Z2	95	HPGW0342	3/14/96	<	U	0.3	<	U	0.5	3/14/96	0.575	0.3	14-Mar-96	798	3/14/96		
HPL00248Z1	85	HPGW0344	3/15/96	<	0.5	0.3	<	U	0.5	3/15/96	2.093	0.3	15-Mar-96	959	3/15/96		
HPL00248Z2	90	HPGW0345	3/15/96	<	0.4	0.3	<	U	0.5	3/15/96	1.564	0.3	15-Mar-96	911	3/15/96		
HPL00249Z1	85	HPGW0347	3/15/96	<	4.9	0.3	<	U	0.5	3/15/96	2.599	0.3	15-Mar-96	967	3/15/96		
HPL00249Z2	95	HPGW0348	3/15/96	<	60	0.3	4.1	0.5	3/15/96	1.173	0.3	15-Mar-96	754	3/15/96			
HPL00250Z1	85	HPGW0350	3/18/96	<	U	0.3	<	U	0.5	3/18/96	0.391	0.3	18-Mar-96	684	3/18/96		
HPL00250Z2	94	HPGW0349A	3/14/96	<	U	0.3	<	U	0.5	3/18/96	0.529	0.3	18-Mar-96	783	3/18/96		
HPL00251Z1	83	HPGW0353	3/18/96	<	0.3	0.3	5.3	0.5	3/18/96	2.553	0.3	18-Mar-96	1022	3/18/96			
HPL00251Z2	95	HPGW0351	3/18/96	<	U	0.3	<	U	0.5	3/18/96	0.437	0.3	18-Mar-96	747	3/18/96		
HPL00252Z1	85	HPGW0356	3/19/96	<	0.8	0.3	<	U	0.5	3/19/96	3.266	0.3	19-Mar-96	1143	3/19/96	X	
HPL00252Z2	95	HPGW0357	3/19/96	<	13.8	0.3	<	U	0.5	3/19/96	2.185	0.3	19-Mar-96	981	3/19/96		
HPL00253Z1	85	HPGW0359	3/19/96	<	36.1	0.3	1.4	0.5	3/19/96	2.323	0.3	19-Mar-96	978	3/19/96			
HPL00253Z2	94	HPGW0360	3/19/96	<	35.5	0.3	<	U	0.5	3/19/96	2.691	0.3	19-Mar-96	893	3/19/96		
HPL00254Z1	85	HPGW0362	3/20/96	<	8.4	0.3	3.8	0.5	3/20/96	2.07	0.3	20-Mar-96	958	3/20/96	X		
HPL00254Z2	94	HPGW0363	3/20/96	<	7.7	0.3	<	U	0.5	3/20/96	1.38	0.3	20-Mar-96	855	3/20/96		
HPL00255Z1	85	HPGW0365	3/20/96	<	U	0.3	<	U	0.5	3/20/96				1313	3/20/96		
HPL00255Z2	95	HPGW0366	3/20/96	<	1.7	0.3	<	U	0.5	3/20/96	1.081	0.3	20-Mar-96	863	3/20/96		
HPL00256Z1	89	HPGW0367	3/21/96	<	7	0.3	<	U	0.5	3/21/96	1.15	0.3	21-Mar-96	352	3/21/96		
HPL00256Z2	99	HPGW0368	3/21/96	<	3.6	0.3	<	U	0.5	3/21/96	1.725	0.3	21-Mar-96	949	3/21/96		
HPL00257Z1	85	HPGW0369	3/21/96	<	1.4	0.3	0.9	0.5	3/21/96	2.599	0.3	21-Mar-96	1208	3/21/96			
HPL00257Z2	95	HPGW0370	3/21/96	<	4.9	0.3	<	U	0.5	3/21/96	1.219	0.3	21-Mar-96	845	3/21/96		
HPL00258Z1	88	HPGW0371	3/21/96	<	U	0.3	21.5	0.5	3/21/96	4.393	0.3	21-Mar-96	1151	3/21/96			
HPL00259Z1	87	HPGW0375	3/22/96	<	U	0.3	4.8	0.5	3/22/96	0.966	0.3	22-Mar-96	817	3/22/96			
HPL00259Z2	97	HPGW0377	3/22/96	<	0.3	0.3	<	U	0.5	3/22/96	0.598	0.3	22-Mar-96	378	3/22/96		
HPL00260Z1	85	HPGW0364	3/22/96	<	3	0.3	6.3	0.5	3/22/96	1.472	0.3	22-Mar-96	933	3/22/96			
HPL00260Z2	95	HPGW0374	3/22/96	<	1.1	0.3	2.9	0.5	3/22/96	1.495	0.3	22-Mar-96	861	3/22/96			
HPL00261Z1	95	HPGW0373	3/22/96	<	0.4	0.3	4.7	0.5	3/22/96	1.955	0.3	22-Mar-96	897	3/22/96			
Notes:																	
1. Information reflects sampling conducted from 11-22Mar96.																	
2. Samples were analyzed by GC/MS in the field.																	
3. U = Below Detection Limit																	
4. Samples were analyzed by adsorptive stripping voltammetry in the field.																	
5. Samples were analyzed using a colorimetric kit.																	
6. Samples were analyzed using a field screening instrument.

SG96050205.1

Figure 2.18. Chloroform Concentrations at Hydropunch Locations Near Landfill 3, March 1996 (Phase III)

SG96050205.2

Figure 2.19. Chloroform Concentrations at Off-Site Hydropunch Locations, March 1996 (Phase III)

If water from the formation was relatively free-flowing following the application of a vacuum on the sample string, then purging would ensue to better assure sample integrity. This was not possible with every rod string subjected to a vacuum because of very low yield at selected sample locations.

The PVC well screen provided a significantly greater amount of open area and length than the Hydropunch. Although the well screen could be nearly any length, exposed screen length was generally limited to approximately 5 ft to maintain control over the depth from which the water sample was recovered. In only one especially difficult application did the screen length approach 7.5 ft.

Combinations of the various procedures described above were required to obtain ground-water samples at some of the desired locations. Combining procedures was particularly important for collecting water samples at 75 ft bgs. Even so, in some cases an insufficient volume of water was recovered to perform all of the specified laboratory analyses. In Phases I and II, ground water generally rapidly charged the Hydropunch chamber at 85 and 95 ft bgs, but little could be done to collect ground water from 55 ft bgs. These phenomena corroborate the CPT and CPTu data. Ground water in Phase III most often did not rapidly charge the Hydropunch chamber. This, in addition to noted ram pressure required to drive the Hydropunch to the desired sample collection depth, suggest a higher clay content within HSU-2 than in the areas investigated in Phases I and II.

It should be noted that the well screen and the stainless steel drive point used with it cannot be recovered from the subsurface. These materials are relatively inert and pose no risk to human health or the environment. Each CPT and ground-water sample collection hole were backfilled to the surface with bentonite grout tremied into the hole.

2.8.3 Contamination Prevention and Decontamination Procedures

All CPT, Hydropunch, and temporary miniature well rods were driven into and removed from the subsurface through the floor of a cargo van using a hydraulic ram. As the CPT rods were withdrawn from the subsurface, they passed through a contained, sealed, steam cleaner. The cleaned rods were dismantled and stored on racks within the van. The hollow rod strings used with the Hydropunch or temporary miniature well were manually steam cleaned once they were withdrawn from the subsurface. Steam cleaning was necessary to assure that ground-water contaminants that may have adhered to the interior of the rods when collecting water samples did not remain inside the rods. Metal troughs and equipment located on a support truck associated with the van were used in steam cleaning the rods, stainless steel bailers, and other tools between uses at each location. All rods for the CPT, Hydropunch, temporary miniature well, and other related equipment were cleaned as described above before they were removed from the site. Cleaning and decontamination efficacy were verified with radiation test wipes and portable screening instruments before allowing the van and support truck to vacate the site.

2.8.4 Hydropunch Sample Analyses

In Phases I and II, ground-water samples were analyzed for chloroform, tritium, hexavalent and total chromium, and nitrate-nitrogen on a rapid turnaround basis. Previous investigations have identified these constituents as the primary contaminants of concern at the LEHR site. Chloroform analyses were performed onsite by PNNL using a GC/MS, such that the selection of subsequent Hydropunch locations was based on analytical results from initial locations. PNL Procedure NHFP-FA-6, "Sample Collection and Analysis of Hydropunch Water Samples for Volatile Organic Compounds," was used. Duplicate chloroform analyses were performed at the PNNL Richland office on approximately 10% of the samples. Hexavalent and total chromium and nitrate-nitrogen samples were also shipped back to PNNL for analysis. The total chromium samples from Phase I were not filtered before analysis, although the Phase II samples were. Tritium analyses were performed by LAS.

In Phase III, on-site analyses were performed for chloroform, hexavalent chromium, nitrate, and specific electrical conductance by PNNL. Chloroform analyses, which included numerous other organic compounds, were conducted with GC/MS. An adsorptive stripping voltametry (ASV) method was used to perform hexavalent chromium analysis and a commercially available colorimetric kit was used to perform nitrate analysis. Specific electrical conductance was measured with a commercially available meter designed for this purpose. No tritium analysis were necessary in this phase.

2.8.5 Discussion of Hydropunch Installation Results

Tables 2.12, 2.13, and 2.14 contain the analytical results from the Hydropunch locations. Low formation yields prevented samples from being routinely collected at the 55-ft depth. Therefore, this discussion focuses on results from the 75-, 85-, and 95-ft samples. In addition, it has been recognized that contaminant depth increases with distance from the suspected source area(s). Consequently in Phases II and III, which encompass areas substantially east of the suspected source area(s), sample collection depths were predetermined to be 85 to 95 ft bgs to account for this condition.

2.8.5.1 Phase I Results

Chloroform concentrations at the 75-ft depth ranged from 0.7 to 8015 $\mu\text{g/L}$, with the highest concentration approximately 7 ft east of well UCD1-012. Chloroform concentrations at the 85-ft depth ranged from 0.8 to 17,019 $\mu\text{g/L}$, again with the highest concentration 7 ft east of well UCD1-012. The federal MCL for the four trihalomethanes summed is 100 $\mu\text{g/L}$. Results for two of the three duplicate analyses were in close agreement with the on-site analyses. The third analysis was almost seven times the on-site result.

Tritium activities at the 75-ft depth ranged from less than detection to 3470 pCi/L, with the highest activity approximately 229 ft southeast of well UCD1-012. Tritium activities at the 85-ft depth ranged from less than detection to 830 pCi/L, with the highest activity approximately 177 ft east of well UCD2-014. The MCL for tritium is 20,000 pCi/L.

Hexavalent chromium concentrations at the 75-ft depth ranged from <1 to $146\text{ }\mu\text{g/L}$, with the highest concentration approximately 43 ft northwest of well UCD1-012. Hexavalent chromium concentrations at the 85-ft depth ranged from <1 to $93.4\text{ }\mu\text{g/L}$, with the highest concentration approximately 7 ft east well UCD1-012. The state MCL for hexavalent chromium is $50\text{ }\mu\text{g/L}$.

Total chromium concentrations at the 75-ft depth ranged from 7 to $840\text{ }\mu\text{g/L}$, with the highest concentration approximately 102 ft east of well UCD1-012. Total chromium concentrations at the 85-ft depth ranged from <7 to $1030\text{ }\mu\text{g/L}$, with the highest concentration approximately 93 ft northwest of well UCD1-012. Of note, the total chromium samples were preserved but not filtered in the field. The nitric acid likely extracted chromium into solution from the particulates, resulting in higher concentrations. The state MCL for total chromium is $50\text{ }\mu\text{g/L}$.

Nitrate-nitrogen concentrations at the 75-ft depth ranged from 11.9 to 120 mg/L , with the highest concentration approximately 40 ft southwest of well UCD1-012. Nitrate-nitrogen concentrations at the 85-ft depth ranged from 3.8 to 346 mg/L , with the highest concentration approximately 7 ft east of well UCD1-012. The MCL for nitrate-nitrogen is 10 mg/L .

2.8.5.2 Phase II Results

Chloroform concentrations at the 85-ft depth ranged from <0.3 to $2730\text{ }\mu\text{g/L}$, with the highest concentration approximately 50 ft southeast of well UCD1-012. Chloroform concentrations at the 95-ft depth ranged from <0.8 to $156\text{ }\mu\text{g/L}$, with the highest concentration along the centerline of the plume, approximately 525 ft east of well UCD1-012. Results for the duplicate analyses were in close agreement with the on-site analyses.

Tritium activities at the 85-ft depth ranged from less than detection to 530 pCi/L , with the highest activity approximately 350 ft southeast of well UCD1-012. Tritium activities at the 95-ft depth ranged from less than detection to 190 pCi/L , with the highest activity approximately 450 ft east/southeast of well UCD1-012.

Hexavalent chromium concentrations at the 85-ft depth ranged from <0.2 to $7.3\text{ }\mu\text{g/L}$, with the highest concentration approximately 375 ft northeast of well UCD1-012. Hexavalent chromium concentrations at the 95-ft depth ranged from <0.2 to $13\text{ }\mu\text{g/L}$, with the highest concentration along the eastern boundary of the UC Davis property, approximately 1200 ft east/northeast of well UCD1-012.

Total chromium concentrations at the 85-ft depth ranged from <10 to $16\text{ }\mu\text{g/L}$. Total chromium concentrations at the 95-ft depth ranged from <10 to $30\text{ }\mu\text{g/L}$.

Nitrate-nitrogen concentrations at the 85-ft depth ranged from 4.0 to 33.4 mg/L , with the highest concentration approximately 525 ft east of well UCD1-012. Nitrate-nitrogen concentrations at the 95-ft depth ranged from 2.1 to 26.9 mg/L , with the highest concentration approximately 1125 ft east/southeast of well UCD1-012.

2.8.5.3 Phase III Results

Chloroform concentrations at the 85-ft depth ranged from below detection ($0.3 \mu\text{g/L}$) to $36 \mu\text{g/L}$. Chloroform concentrations at the 95-ft depth ranged from below detection to $60 \mu\text{g/L}$. Reported chloroform concentrations did not exceed $0.3 \mu\text{g/L}$ in the ground-water samples collected from locations in the vicinity of Landfill 3 and the southwest corner of the Hamel/Rust property offsite.

Reportable concentrations of hexavalent chromium were found in 15 of the 47 ground-water samples analyzed. Reported concentrations above the detection limit range from about 1 to $21.5 \mu\text{g/L}$. All but 2 of these samples were collected from the 85-ft depth.

Forty-five samples contained detectable concentrations of nitrate as N. Concentrations ranged from 0.5 to nearly 20 mg/L. The distribution and concentration ranges are similar to those observed with previous data.

All samples were tested for specific electrical conductance. Specific electrical conductance concentrations average approximately 900 umhos/cm.

2.8.5.4 Summary of Phase I, II, and III Results

Results from the Phase I, II, and III Hydropunch sampling indicate that high chloroform concentrations are found trending from west/southwest to east/northeast in the lower portion of HSU-1 and the upper and middle portions of HSU-2. These results correspond well with the screening samples collected from the five new wells following well development. The chloroform appears to originate in the vicinity of Landfill 2. Concentrations above the MCL can be found approximately 800 ft east/northeast of well UCD1-012 in HSU-1 and approximately 900 ft in HSU-2. Of note, trichloroethene (TCE) and tetrachloroethene (PCE) and their breakdown products were found at selected locations.

Tritium was not found above the MCL at any of the Hydropunch installations. The highest activity was 3470 pCi/L in HSU-1. Hexavalent chromium was found at three Hydropunch locations above the MCL in HSU-1 and one location in HSU-2. Total chromium samples from Phase I were not filtered, resulting in relatively high concentrations. Concentrations were at or near the detection limit in the Phase II samples. Nitrate-nitrogen samples were all above the MCL in HSU-1. All but two of the Phase I samples and approximately 35% of the Phase II samples were above the MCL in HSU-2. Additional details on the distribution of these and other constituents in the ground water can be found in Stewart et al. (1996).

2.9 Surveying

Five existing wells, located in high traffic areas, were completed with flush-to-ground, locking, water-tight, Kilman Electriloc well cover systems in October and November 1995. The well numbers

are UCD1-005, UCD1-021, UCD1-022, UCD1-023, and UCD1-024. These wells, the five new wells, and the Phase I and II Hydropunch locations were surveyed for horizontal and vertical control in January 1996. The permanent casing, protective casing, and top-dead-center of the well cover were surveyed. In addition, a survey stamp (X) was imprinted on the north side of the protective casing. Phase III Hydropunch locations were surveyed for horizontal and vertical control and three off-site wells were surveyed for horizontal control in March 1996. Table 2.15 provides the State plane coordinates and elevations in feet above mean sea level (msl).

Table 2.15. Survey Data for Wells and Hydropunch Locations

Wells

Well Number	Coordinates		Elevation (ft above msl)			
	Northing	Easting	Well Cover	Protective Casing	Permanent Casing	Westbay Casing
UCD1-005	1951113.02	6631453.57	48.42	48.44	47.92	
UCD1-021	1951099.81	6631478.49	48.75	48.77	48.01	
UCD1-022	1951043.57	6631257.33	49.07	49.06	48.40	
UCD1-023	1950761.52	6631387.22	49.38	49.39	48.60	
UCD1-024	1950879.02	6631636.90	48.91	48.91	48.22	
UCD1-025	1951145.77	6632484.43	48.78	48.80	47.92	
UCD2-026	1951146.05	6632479.37	48.77	48.79	48.23	
UCD2-027	1951146.73	6632499.66	48.76	48.78	47.79	48.02
UCD1-034	1950452.03	6631692.18	55.69	55.70	54.94	
UCD2-035	1950454.48	6631696.24	55.70	55.71	55.03	

Hydropunch Locations (Phase I and II)

Sample Location	Coordinates		Elevation (ft above msl)
	Northing	Easting	Ground Surface
HPL00200	1950998.95	6631943.60	48.72
HPL00201	1950980.50	6632037.45	47.54
HPL00202	1951093.54	6631957.55	48.76
HPL00203	1951018.76	6631841.07	49.18
HPL00204	1951076.18	6631882.29	48.79
HPL00205	1951052.86	6632025.94	48.06
HPL00206	1951026.13	6631985.57	48.62
HPL00207	1950964.23	6631976.10	48.07
HPL00208	1950957.79	6631884.37	49.13
HPL00209	1950944.23	6631741.92	49.10
HPL00210	1950906.60	6632029.76	48.05
HPL00211	1950631.47	6631916.69	47.64
HPL00212	1950570.83	6631910.49	47.85
HPL00213	1950814.79	6632067.81	47.28
HPL00214	1950618.90	6632066.83	47.48
HPL00215	1950833.19	6632187.26	47.00
HPL00216	1950815.93	6632266.32	47.68
HPL00217	1951037.89	6631915.96	48.77
HPL00218	1950961.30	6632193.83	47.55
HPL00219	1951099.61	6632302.73	48.27
HPL00221	1951041.22	6632468.14	47.45
HPL00222	1951110.39	6632684.75	47.24
HPL00223	1951189.46	6632479.72	48.73
HPL00224	1951218.09	6632798.39	46.79
HPL00225	1951223.51	6633096.65	46.03
HPL00226	1951100.65	6633099.01	46.37
HPL00227	1950964.57	6633099.05	47.47
HPL00228	1950910.65	6632666.00	47.94
HPL00229	1950948.50	6632471.77	49.06
HPL00230	1950816.13	6632377.65	48.66
HPL00231	1950998.67	6632384.21	48.34
HPL00232	1951342.99	6632582.09	48.76
HPL00233	1950803.68	6633003.57	48.09
HPL00234	1951340.16	6633031.81	46.21
HPL00235	1951342.22	6632766.68	47.76
HPL00236	1951208.78	6632320.46	50.18
HPL00238	1950773.16	6632603.35	49.25
HPL00239	1950727.28	6632180.72	48.24

Notes:

1. HPL00220 was not surveyed due to access restrictions.
2. HPL00237 was not installed.

Hydropunch Locations (Phase III)

Sample Location	Coordinates		Elevation (ft above msl)
	Northing	Easting	Ground Surface
HPL00240	1950715.8	6632765.4	47.71
HPL00241	1950506.5	6632884.2	48.51
HPL00242	1950582.4	6632701.8	48.36
HPL00243	1950648.7	6632845.1	47.53
HPL00244	1950562.5	6632562.1	48.46
HPL00245	1950648.9	6632556.0	48.18
HPL00246	1950726.8	6632461.7	48.47
HPL00247	1950717.1	6632609.5	48.20
HPL00248	1950616.5	6632290.2	45.64
HPL00250	1950508.9	6633214.6	46.20
HPL00251	1950739.7	6633213.6	45.65
HPL00252	1951423.8	6633616.8	45.34
HPL00253	1951428.2	6633383.8	45.36
HPL00254	1951414.0	6634088.5	45.35
HPL00255	1951405.2	6634747.9	44.92
HPL00256	1951692.0	6634748.7	43.99
HPL00257	1951536.2	6634404.1	44.38
HPL00258	1951570.5	6633615.9	44.97
HPL00259	1950627.5	6633416.2	45.92
HPL00260	1951175.6	6634745.6	45.71
HPL00261	1951560.2	6633384.7	45.26

Note:

1. HPL00249 was not surveyed.

Off-Site Wells

Sample Location	Coordinates	
	Northing	Easting
NW-1	1951392.2	6633278.8
NW-2	1951491.3	6634779.4
NW-3	1950660.0	6634853.5

3.0 Data Management

Analytical results produced for the August to December 1995 field activities were generated by LAS and PNNL. Results were received from LAS initially via fax, followed by hard copy and electronic format. These results have been validated in accordance with the procedures described in PNL (1995, unpublished). Two problems were noted: Because the holding times were exceeded, the hexavalent chromium results for the sediment sample from 95 to 100 ft in well UCD2-035 was rejected, as was the hexavalent chromium result for the ground-water sample from 90 ft in well UCD2-027.

Results provided by PNNL have been entered into the LEHR database and verified against the hard copy spreadsheet or data report. Analytical results provided by PNNL will not be validated by the data management staff in accordance with the procedures identified in PNL (1995, unpublished). The technical staff have reviewed and validated these results. The remainder of this section provides a general overview of the PNNL data management system for the LEHR project, including data receipt, storage, validation, and reporting.

3.1 Data Receipt

In addition to original deliverables from the laboratories, a computer database has been maintained to store results of field measurements, laboratory chemical and radiological analyses, and water-level measurements. The results of these field investigations and analyses were received primarily on standardized data forms, designed to fulfill the needs of both the technical and data management staff. These data forms are illustrated in the Quality Assurance Project Plan (QAPjP) (PNL 1995, unpublished). The completed forms were sent to the PNNL Richland office with copies retained by the originators. When the data forms were received, they were stamped with the date of receipt, copied, and filed. A log has been maintained to document the progress and status of the data from receipt through storage in the computer database. Each entry has been dated and initialed by the individual performing the particular task described on the form.

3.1.1 Sample Tracking

Sample tracking procedures were used to indicate whether analytical samples collected at the LEHR site were contained, transported, and analyzed according to methods and holding times specified. Sample tracking also verified that analyses requested for each sample listed on the chain-of-custody were performed by the analytical laboratories and that results have been received. Tracking has been performed electronically and printouts have been generated for any outstanding results or discrepancies. The computer database automatically calculated laboratory turnaround times and sample holding times to aid in the data validation process.

3.1.2 Data Entry

Data from PNNL have been entered into the database manually or by directly downloading laboratory-supplied electronic data. Data from LAS were entered by directly downloading laboratory-supplied electronic data. Regardless of the method of entry, data entry quality control was maintained through several types of data checking. Data checking was carried out before merging the temporary input file with the master database file. This checking system involved directly comparing hardcopy listings of the temporary input database to the hardcopy laboratory or field reports. Any necessary corrections were written directly on the printout. Once a correction was made, a revised printout was placed with the original to document the change. Notations were made of the date and the initials of the reviewer. After the corrections were completed, the log was dated and initialed. Following correction of any inconsistencies in either the data file or the laboratory reports, the temporary input file was merged to a proxy master file. This proxy file was used as a daily working file, and backups of it as well as the master file were maintained.

All field analytical data, including temperature, conductivity, pH, and Eh, were entered by hand, and the original field sampling water-level data have been entered into the ground-water elevation module of the database. This subsystem provided listings for quality assurance checks.

3.2 Data Storage

Following data entry, the data have been stored in the Database Management System. This system is comprised of database modules that can be linked relationally to obtain information and status of samples. The desktop computer-based system is being maintained on a Paradox platform. All recent and past data are stored in this system. Features of the system include management of chemical and physical data for soils, ground water, surface water, and the flexibility to generate a variety of reports. Other general features include data sorting, querying, and statistical analyses. Data subsets maybe exported to other applications for graphical and specialized computational needs. Chemical distribution maps may be prepared by directly exporting data into AutoCad, or via intermediate contouring packages.

3.3 Data Validation

Data validation was performed on analytical results received from the laboratory for ground-water and Hydropunch samples upon receipt from LAS. The purpose of the data validation was to identify data that meet the quality required for the RI/FS program and risk assessment, and to identify data that do not meet data quality objectives (DQOs) or quality assurance criteria that are set forth in the QAPjP and agreed to by the laboratory. The QAPjP provides specific procedures and descriptions of data validation flags.

Data received from the laboratory were reviewed with respect to the PARCC parameters (precision, accuracy, representativeness, comparability, and completeness). PARCC parameters are indicators of data quality, and apply to the field program and analytical results as well as to the laboratory procedures. The PARCC parameters for water monitoring at the LEHR site are specified below. Analyte-specific precision and accuracy objectives are listed in the Quality Assurance Program Plan (QAPP) for the LEHR site.

A U.S. Environmental Protection Agency (EPA) Contract Laboratory Program (CLP) or CLP-equivalent data package was provided for ground-water laboratory results. When received, a detailed validation of 10% of the analytical data was performed, based on EPA National Functional Guidelines. The remaining 90% of the data set was reviewed for a limited set of validation criteria. Specific procedures for data validation are presented as part of the QAPjP.

The objective of the detailed data evaluation according to EPA National Functional Guidelines is to randomly select 10% of the data packages and then to completely regenerate the data values based on the original raw data (e.g., chromatograms, instrument values), standards, instrument calibration runs, GC/MS tuning, etc. This level of data validation allows an appropriately trained person outside the project to independently validate a data package at any later date.

The remaining 90% of the data had the same CLP or equivalent data package; however, a limited validation was performed. Holding times were checked, and surrogate recovery, blanks, matrix spikes, and matrix spike duplicates were also checked against the quality control guidelines.

3.4 Data Reporting

The database format allows numerous types of data reports to be produced. Raw data tables can be generated showing either samples or analytical parameters as column headings with the other variables listed vertically down the page. Laboratory data qualifiers, data validation qualifiers, detection limits, and regulatory criteria can be included as desired. Summary tables of detected compounds, compounds exceeding regulatory criteria, and comparisons of recent data to historical values can be generated. All tables can be organized by parameter class, date ranges, locations sampled, purpose of sampling, etc. In addition, customized table formats can be easily developed as specific requirements dictate. Tabular reports can be printed or exported as needed for use with other software programs.

4.0 Hydrogeologic Conceptual Model

The hydrogeology in the vicinity of the LEHR site was initially characterized during the Phase II Site Characterization work (DOE 1993). In 1995, the five new monitoring wells were installed and the five additional CPTs were performed as part of the RI/FS program. This section summarizes the regional setting and presents a refined hydrogeologic conceptual model for the LEHR site, based primarily on interpretation of the borehole logs and, to a lesser extent, on the CPT logs.

4.1 Regional Setting

The LEHR site is located in the southern portion of the Sacramento Valley on the relatively flat-lying Putah Plain (DWR 1978). Average site elevation is approximately 50 ft above msl. Relief across the site is approximately 2 ft, with the lowest point near the Cobalt-60 field. The land surface slopes gently east/northeast toward the Sacramento River at approximately 5 ft/mi.

The Sacramento Valley is a large, asymmetrical physiographic basin bordered by the Coast Ranges to the west, the Klamath Mountains and Cascade Range to the north, and the Sierra Nevada Mountains to the east. Marine and continental sedimentary deposits occur within the basin, ranging in age from Jurassic to Recent. Norris and Webb (1976) suggest that the sediments are over 30,000 ft thick near the valley axis. Deformation of these deposits during uplift of the surrounding mountains resulted in a regional dip of the sediments from the sides of the valley toward its axis.

The LEHR site is located east of the valley axis on the geomorphic unit termed "low alluvial plains and fans" or Putah Plain (DWR 1978). This surface represents distal portions of alluvial fan deposits associated with Putah Creek, referred to as the Putah Creek Fan (Mann 1992). Sediments within these alluvial fan deposits consist primarily of silts and clays, with coarse-grained sediments occurring locally. Over geologic time, Putah Creek changed course frequently throughout this area, resulting in ribbon-like strips of coarse, main-channel deposits, flanked by overbank silts and clays. The age of these deposits ranges from late Pleistocene to Recent. Thickness of the alluvial fan deposits is reported to be between 140 ft (Mann 1992) and 180 ft (DWR 1978).

Underlying the Putah Creek Fan is the Plio-Pleistocene age Tehama Formation. The Tehama Formation consists of fine-grained sands and silts with discontinuous lenses of coarse sand and gravel. It is the principal water-bearing formation on the west side of the Sacramento Valley. This unit is thought to be coeval with the Laguna Formation on the east side of the Sacramento Valley (DWR 1978, Olmsted and Davis 1961).

Locally, both unconfined and confined aquifers occur in the upper 3,000 ft of sediments in the Sacramento Valley. No regionally continuous confining units exist (DWR 1978). Ground water generally flows toward the Sacramento River from the west and east sides. At various depths beneath

the valley floor, saline water is found, as a result of entrapment during deposition of the marine sediments. The depth to the base of the fresh water varies from as little as 400 to over 3,000 ft.

The major ground-water sources for public and private water supplies in the Sacramento Valley are the unconsolidated sediments of Pliocene and Pleistocene age, and older alluvium. The younger alluvium and stream channel deposits are less frequently tapped. Ground water is recharged through leakage from streams and rivers, and direct infiltration from precipitation and irrigation.

4.2 LEHR Site Hydrogeology

Consistent with DOE (1993), four hydrogeologic units were encountered during drilling operations in 1995. They are, in descending order, the vadose zone, HSU-1, HSU-2, and the unnamed aquitard beneath HSU-2. In this report, a hydrogeologic unit is defined as a laterally continuous geologic unit with hydrologic significance. Hydrologic significance is indicated by hydraulic conductivity or hydrochemistry contrasts between units. Hydrogeologic units depicted here correspond to hydrostratigraphic units referenced in previous reports (DOE 1993, 1994, 1995). In a strict sense, a hydrostratigraphic unit, as proposed by Maxey (1964), is defined as a body of rock having considerable lateral extent and composing a geologic framework for a reasonably distinct hydrologic system.

Figure 4.1 is a generalized hydrogeologic column showing the order and average elevations of these units, and their relationships to the regional stratigraphy and hydrostratigraphy. Table 4.1 lists the unit depths and thicknesses in the LEHR site wells as interpreted from borehole logs, CPT logs, or as extrapolated from these logs. Figure 4.2 indicates the location of two cross sections, one west to east and one north to south. The cross sections are provided in Figures 4.3 and 4.4 and incorporate portions of previously presented cross sections in DOE (1993). Cross section A-A' extends existing information through the new well cluster of UCD1-025, UCD2-026, and UCD2-027. Note that HSU-2 appears to thin beneath this cluster. Information further east on the contact between HSU-1 and HSU-2 was interpreted from CPT logs. Cross section B-B' is oriented north to south through the second well cluster of UCD1-034 and UCD2-035. HSU-2 appears to thicken locally beneath Putah Creek.

The vadose zone is comprised primarily of unsaturated clays and silts with sands and gravels intermixed, indicative of a relatively low-energy depositional environment. HSU-1 is lithologically similar to the vadose zone. The contact between HSU-1 and HSU-2 ranges from approximately 76 to 88 ft bgs. HSU-2 is comprised primarily of sands in the upper portion of the unit and gravels in the middle to lower portions of the unit, suggesting a relatively high-energy depositional environment. Thickness ranges from approximately 31 to 54 ft. Flowing sand conditions were encountered in the upper portion of HSU-2.

Collectively, sediments from the vadose zone, HSU-1, and HSU-2 comprise the Putah Creek Fan beneath the LEHR site. Thicknesses range from 118 ft (UCD2-015) to 138 ft (UCD2-017). DOE (1993) further subdivided the Putah Creek Fan into two lithofacies: an upper lithofacies consisting of

Figure 4.1. Generalized Hydrogeologic Column

Table 4.1. Hydrogeologic Contacts in the LEHR Site Wells

Well Number	Former Well Number	Coordinates		Elevations			Drill		Casing		Screen			Date Completed	Depth to		Depth to Top of		Thickness of HSU-2 (ft)	
				Ground Surface	Top of Pro. Casing	Top of Perm. Casing	Method	Depth (ft bgs)	Size (in.)	Type	Interval (ft bgs)	Slot Size	Type		Top of HSU-2 (ft bgs)	Drill Log (X-Section)	Unnamed Aquitard (ft bgs)	Drill Log (X-Section)	Drill Log (X-Section)	Drill Log (X-Section)
UCD1-001	UCD-01	1951329.71	6631236.04	47.9	50.05	49.53	HSA ⁽¹⁾	56.5	2	PVC ⁽²⁾	46.5-56.5	20	PVC	10/9/87	ND ⁽⁴⁾	(86)	ND	(117)		(31)
UCD1-002	UCD-02	Abandoned		Abandoned			HSA	60.0	Abandoned		Abandoned			10/9/87	ND		ND			
UCD1-003	UCD-03	1951078.26	6631651.85	48.2	50.05	49.43	HSA	51.5	2	PVC	39-49	20	PVC	10/23/87	ND	(77)	ND	(115)		(38)
UCD1-004	UCD-04	1950651.45	6631315.64	49.4	51.69	51.20	HSA	56.5	2	PVC	45-55	20	PVC	10/14/87	ND	(83)	ND	(117)		(34)
UCD1-005	UCD-05	1951113.02	6631453.57	48.4	48.44	47.92	HSA	48.5	2	PVC	38-48	20	PVC	10/22/87	ND	(80)	ND	(117)		(37)
UCD1-006	UCD-06	1951048.00	6631270.45	49.0	50.94	50.50	HSA	52.5	2	PVC	40-50	20	PVC	10/21/87	ND	(82)	ND	(118)		(36)
UCD2-007	UCD-07	1951086.35	6631684.02	49.3	51.65	51.25	HSA	90.0	2	PVC	80-90	20	PVC	11/5/87	78	(77)	>90	(116)	>12	(39)
UCD1-008	UCD-08	1950694.34	6631902.08	49.2	51.51	51.05	HSA	56.0	2	PVC	43.5-53.5	20	PVC	11/3/87	ND		ND			
UCD1-009	UCD-09	1950989.69	6631932.52	49.0	51.39	51.00	HSA	51.5	2	PVC	40-50	20	PVC	11/4/87	ND		ND			
UCD1-010	UCD-10	1950805.37	6633117.83	47.4	49.87	49.34	HSA	70.0	4	PVC	54-69	10	PVC	10/11/89	ND	(71)	ND			
UCD1-011	UCD-11	1950855.20	6632272.51	47.6	50.67	50.19	HSA	66.5	4	PVC	50-65	10	PVC	10/17/89	ND	(78)	ND			
UCD1-012	UCD-12	1951000.90	6631936.63	48.8	51.76	51.42	HSA	65.0	4	PVC	49.5-64.5	10	PVC	10/19/89	ND	(81)	ND	(117)		(36)
UCD1-013	UCD-13	1950684.47	6631899.88	49.2	52.19	51.65	HSA	65.0	4	PVC	50-65	10	PVC	10/26/89	ND	(80)	ND			
UCD2-014	UCD-14	1950661.72	6631894.94	49.0	51.72	51.29	HSA	86.0	4	PVC	75-85		PVC	11/15/89	80	(80)	>86		>6	
UCD2-015	UCD-15	1950663.47	6631326.11	49.4	51.49	50.94	Air Rotary	120.5	4	PVC	91-116	20	SS	3/30/90	85	(83)	118	(117)	33	(34)
UCD2-016	UCD-16	1951437.57	6631291.46	48.2	49.95	49.18	Air Rotary	122.0	4	PVC	92-117	20	SS	4/4/90	88	(87)	119	(118)	31	(31)
UCD2-017	UCD-17	1950946.59	6630689.15	49.6	51.83	51.48	Air Rotary	143.0	4	PVC	88-113	20	SS	4/10/90	85	(84)	138	(139)	53	(55)
UCD1-018	UCD-18	1950715.24	6630679.76	46.7	48.56	47.75	HSA	70.0	4	PVC	54-69	10	SS	10/4/90	ND	(81)	ND			
UCD1-019	UCD-19	1951333.01	6631882.93	49.3	51.33	50.49	HSA	74.5	4	PVC	56.6-71.5	10	SS	10/1/90	ND	(78)	ND			
UCD1-020	UCD-20	1951079.65	6631641.81	48.0	49.78	48.94	HSA	71.5	4	PVC	57-72	10	SS	10/9/90	ND	(77)	ND	(115)		(38)
UCD1-021	UCD-21	1951099.81	6631478.44	48.7	48.73	48.00	HSA	73.5	4	PVC	57-72	10	SS	10/11/90	ND	(80)	ND	(117)		(37)
UCD1-022	UCD-22	1951043.57	6631257.33	49.0	49.06	48.40	HSA	71.5	4	PVC	57-72	10	SS	10/25/90	ND	(82)	ND	(118)		(36)
UCD1-023	UCD-23	1950761.52	6631387.22	49.2	49.39	48.60	HSA	76.5	4	PVC	56.5-71.5	10	SS	10/17/90	ND	(83)	ND	(117)		(34)
UCD1-024	UCD-24	1950879.02	6631636.90	48.8	48.91	48.22	HSA	71.5	4	PVC	57-72	10	SS	10/22/90	ND	(81)	ND			
UCD1-025		1951145.77	6632484.43		48.80	47.92	Air Rotary	75.0	4	SS ⁽³⁾	60-75	10	SS	10/6/95	ND	(82)	ND	(126)		(44)
UCD2-026		1951146.05	6632479.37		48.79	48.23	Air Rotary	102.0	4	SS	87-102	20	SS	10/6/95		(82)	ND	(126)		(44)
UCD2-027		1951146.73	6632499.66		48.78	47.79	Air Rotary	136.0	5	SS	Westbay	10/20	SS	10/6/95	82		126		44	
UCD1-034		1950452.03	6631692.18		55.70	54.94	Air Rotary	80.0	4	SS	61-76	10	SS	10/6/95		(76)	ND	(130)		(54)
UCD2-035		1950454.48	6631696.24		55.71	55.03	Air Rotary	130.0	4	SS	107-122	20	SS	10/6/95	76		130		54	

Notes:

1. HSA = Hollow Stem Auger
2. PVC = Polyvinyl Chloride
3. SS = Stainless Steel
4. ND = Not Determined
5. (86) = Extrapolated Value

SG96030293.1a

Figure 4.2. Location of West to East and North to South Cross Sections

Explanation

▽ 4/10/91 HWL: High Groundwater Level

▼ 8/14/91 LWL: Low Groundwater Level

Screened Interval

Stratigraphic Lithology

Interbedded Clay, Silty Clay and Silt

Fine-Grained Sand and Silty Sand

Well-Rounded Cobbles and Gravel with Some Sand

Boring Log Lithology

Silty Clay, Sandy Clay

Clayed Silt, Sandy Silt

Silty Sand, Sand with Silt

Clayey Sand, Sand with Clay

Clayey Gravel, Gravel with Clay

Silty Gravel, Gravel with Silt

Sandy Gravel, Gravel with Sand

Gravelly Sand, Sand with Gravel

Figure 4.3. West to East

CPT Tip Resistance

, Gravelly Clay
 , Gravelly Silt
 Silt
 h Clay
 with Clay
 h Silt
 with Sand
 ith Gravel

: Cross Section A-A'

Figure 4.4 North to S

SG96030293.2a

Lithology

Clay, Sandy Clay, Gravelly Clay
 Red Silt, Sandy Silt, Gravelly Silt
 Sand, Sand with Silt
 Grey Sand, Sand with Clay
 Grey Gravel, Gravel with Clay
 Gravel, Gravel with Silt
 Sandy Gravel, Gravel with Sand
 Gravelly Sand, Sand with Gravel

CPT Tip Resistance

the interbedded clays and silts, with some sand and gravel deposits (i.e., the vadose zone and HSU-1), and a lower lithofacies consisting primarily of the sands and gravels (i.e., HSU-2).

The upper portion of the unnamed aquitard is comprised of light brown silty clay to clay with some caliche. Depth of penetration into this aquitard in all wells ranged from 2.5 ft (UCD2-015) to 10 ft (UCD2-027). The maximum depth penetrated in all of the investigations was 143 ft bgs in well UCD2-017. Thickness of the unnamed aquitard is thought to be approximately 90 ft in the vicinity of the LEHR site (DOE 1994). This unit corresponds to the Tehama Formation (DOE 1993).

Because of the generalized nature of the hydrogeologic column (see Figure 4.1) and cross sections (see Figures 4.3 and 4.4), and the difficult task of identifying and correlating small-scale subsurface features from drill cuttings, details other than those described above are not shown on these figures. However, a good indication of the small-scale features that may be present was interpreted from the geophysical logs in well UCD2-027. Details of the Σ measurements from the neutron-neutron porosity log suggest that HSU-1 is composed of a series of fining-upward beds (see Section 2.2.2.3). Meandering stream deposits are characterized by fining-upward sequences that are commonly capped by clay. The Σ log response strongly suggests that HSU-1 was deposited in the meander belt of a small stream (6 to 10 ft deep, as suggested by the thickness of the meander packages) that had traversed a region of low relief (high clay content in water). Putah Creek is a good analog for the size and depositional environment of the ancient stream that may have deposited HSU-1.

Several aquifers underlie the LEHR site. The shallow (uppermost) ground-water system is comprised of two hydrologically communicative hydrogeologic units, HSU-1 and HSU-2. Because of the predominantly fine-grained character of HSU-1, hydraulic properties are considerably lower in comparison to HSU-2. The discontinuous, intercalated, depositional pattern of sediments within HSU-1 causes ground-water conditions to vary from unconfined to locally semi-confined within this unit. Also, the preponderance of overlapping fine-grained layers within HSU-1 serves as a leaky confining layer for the underlying HSU-2. Dynamic elastic response conditions, characteristic of highly transmissive confined aquifers, are reflected in the rapid water-level changes exhibited by HSU-2 wells to off-site pumping. The seasonal effect of off-site pumping also imposes a pronounced cumulative impact within both HSU-1 and HSU-2, and causes hydraulic head conditions to fluctuate annually up to 30 ft beneath the LEHR site.

Regionally, HSU-2 is referred to as the first aquifer. Wells completed in HSU-2 are reported to have high specific capacities. At greater depths (i.e., approximately 230 to 280 ft), Mann (1992) indicates that there are sand and gravel aquifers within the Tehama Formation, jointly referred to as the second aquifer. Areal drillers' logs show the presence of a gravel unit below the unnamed aquitard. This gravel unit is identified as HSU-3 in DOE (1994). HSU-2 and HSU-3 are naturally isolated from each other by layers of silt and clay. However, several wells may artificially interconnect the two aquifers. Sediments of HSU-3 are reported to be less permeable than HSU-2 (DOE 1995). In addition, wells completed in these sediments have lower specific capacities than wells completed in HSU-2.

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Appendix A

**As-Built Diagrams, Well Completion Summaries,
Daily Borehole Logs, and Daily Borehole/Well
Completion Logs for the Five Monitoring Wells**

AS-BUILT DIAGRAM

Boring or Well Number UCD2-027

Sheet 1 of 2

Location Univ. of California-Davis

Project LEHR RI/FS

Logged by Steve Teel and Terry Liikala (PNL), Bill Schaal (IT)

Date Well Started 08-29-95

Reviewed by _____ Date _____

Date Well Completed 10-06-95

Drill Bit / Sample Method Used:

☐ Rotary
 ☒ Air Rotary
 ☒ Mud Rotary
 ☒ Air Percussion
 ☒ Back Hoe
 ☒ Auger
 ☒ Grab Sample
 ☒ Continuous Core Sampler
 ☒ Drive Sampler
 ☒ Hard Tool
 ☒ Split-Barrel

AS-BUILT DIAGRAM

Boring or Well Number UCD2-027

Sheet 2 of 2

Location Univ. of California-Davis

Project LEHR RI/FS

Logged by Steve Teel and Terry Liikala (PNL), Bill Schaal (IT)

Date Well Started 08-29-95

Reviewed by _____ Date _____

Date Well Completed 10-06-95

Well Construction Data

Geologic / Hydrologic Data

Well Construction Data			Geologic / Hydrologic Data		
Depth (ft)	Description	Construction Diagram	Depth in Feet	Sample Method	Lithologic Description
90-94.5	PEL-PLUG Bentonite Pellets, 3/8"		90	○	90-92 Sand
94.5-100	RMC Lonestar Sand, #2/12		95		92-95 No Recovery
96-98	5-in dia., 20-slot SS Screen				95-120 Sandy Gravel
98-106	5-in dia., 304, Sch 10 SS Casing		100		
100-104.5	PEL-PLUG Bentonite Pellets, 3/8"		105		
104.5-109.5	RMC Lonestar Sand, #2/12		110	+	
106-108	5-in dia., 20-slot SS Screen		115	+	
108-116	5-in dia., 304, Sch 10 SS Casing		120	+	120-126 Gravelly Sand
109.5-114.5	PEL-PLUG Bentonite Pellets, 3/8"		125	+	126-131.5 Silty Clay
114.5-119	RMC Lonestar Sand, #2/12		130	+	131.5-136 No Recovery
116-118	5-in dia., 20-slot SS Screen		135		
118-128	5-in dia., 304, Sch 10 SS Casing		140		
119-135	PEL-PLUG Bentonite Pellets, 3/8"				
135-136	Slough	TD = 136 feet			

NOTES: 1) All casing is flush threaded.
2) Couplings are 304, Sch 40 Stainless Steel.
3) Depth of screen placement was determined by examination of lithologic and geophysical logs.

NOTE: 1) Samples from 105'-131.5' are Grab Samples from cyclone.

Drill Bit / Sample Method Used:

☐ Rotary

☒ Air Rotary

☐ Mud Rotary

☐ Air Percussion

☐ Back Hoe

☐ Auger

☒ Grab Sample

☒ Continuous Core Sampler

☐ Drive Sampler

☐ Hard Tool

☐ Split-Barrel

WELL COMPLETION SUMMARY

Page 1 of 2

Project RJ/FS
 Location LEHR, Univ. of CA - Davis
 Drilling Co. Water Development Corp.
 Driller Jason Layton, Chuck Webber, Jon Fischer, Erin Thompson
 Other (companies) Schlumberger Well Services, Harris Concrete
 Geologist(s) Terry Liikala (PNL), Bill Schaal (IT)

Well No. UCD2-027 Temp. Well No. _____
 Coordinates _____
 Elevation: Casing _____ Survey Marker _____

DRILLING METHOD

Drilling Method(s) Air Rotary
 Drilling Fluid Air, Water
 Other _____

COMPLETION DATA

Drilled Depth 136'
 Completed Depth 128'
 Date Started 08-29-95
 Date Completed 10-06-95
 Static Water Level/Date 41.70' (a) / 10-11-95

OTHER (check if performed)

Well Abandonment _____ Manhole Cover _____
 X Well Development _____ Pad w/Manhole Cover _____
 X Aquifer Testing _____ X Protective Casing w/Pad _____
 X Geophysical Log(s) _____ X Locking Cap _____

SCREEN

Type	Outer Diameter	Length	Slot Size	Interval
304 Stainless Steel, flush threaded	5"	2'	20	116' - 118'
304 Stainless Steel, flush threaded	5"	2'	20	106' - 108'

TEMPORARY CASING

Type	Nominal Diameter	Max. Outer Diameter	Interval
Carbon Steel (flush threaded)	8 5/8" ID	9 5/8"	+4' - 136'
			- -
			- -

PERMANENT CASING

Type	Nominal Diameter	Max. Outer Diameter	Interval
304 Stainless Steel, SCH 10, flush threaded	5"		118' - 128'
304 Stainless Steel, SCH 10, flush threaded	5"		108' - 116'

ANNULAR SEAL/FILL

Type	Interval	Quantity	Volume
PEL-PLUG Bentonite Pellets, 3/8", 30 min	128' - 135'	4 50-lb buckets	
PEL-PLUG Bentonite Pellets, 3/8", 30 min	119' - 128'	3 50-lb buckets	
RMC Lonestar Sand, #2/12	114.5' - 119'	1 100-lb bag	
PEL-PLUG Bentonite Pellets, 3/8", 30 min	109.5' - 114.5'	1.5 50-lb buckets	
RMC Lonestar Sand, #2/12	104.5' - 109.5'	1.25 100-lb bags	
PEL-PLUG Bentonite Pellets, 3/8", 30 min	100' - 104.5'	0.5 50-lb bucket	
RMC Lonestar Sand, #2/12	94.5' - 100'	1.25 100-lb bags	
PEL-PLUG Bentonite Pellets, 3/8", 30 min	90' - 94.5'	1 50-lb bucket	

PUMP

Type Westbay MP55 Measurement Port (b) Depth to Inlet 53.32' (Zone 1) Date Set 10-25-95

ACCEPTANCE

Completed Well: Accept _____ Conditionally Accept _____
 Reject _____

COMMENTS

- (a) Static water level measured from lip of well vault.
 (b) Depth to inlet of measurement port is in feet below the top of stainless steel casing.

Reviewed by _____ Date _____ Depths are below land surface unless noted.

A.3

WELL COMPLETION SUMMARY - CONTINUED

Page 2 of 2

Project RI/FS
Location LEHR, Univ. CA - Davis

Well No. UCD2-027 Temp. Well No. _____
Geologist(s) Terry Liikala (PNL), Bill Schaal (IT)

SCREEN

Type	Outer Diameter	Length	Slot Size	Interval	
304 Stainless Steel, flush threaded	5"	2'	20	96'	- 98'
304 Stainless Steel, flush threaded	5"	2'	20	86'	- 88'
304 Stainless Steel, flush threaded	5"	2'	10	73'	- 75'
304 Stainless Steel, flush threaded	5"	2'	10	63'	- 65'
304 Stainless Steel, flush threaded	5"	2'	10	53'	- 55'

TEMPORARY CASING

Type	Nominal Diameter	Max. Outer Diameter	Interval	

PERMANENT CASING

Type	Nominal Diameter	Max. Outer Diameter	Interval	
304 Stainless Steel, SCH 10, flush threaded	5"		98'	- 106'
304 Stainless Steel, SCH 10, flush threaded	5"		88'	- 96'
304 Stainless Steel, SCH 10, flush threaded	5"		75'	- 86'
304 Stainless Steel, SCH 10, flush threaded	5"		65'	- 73'
304 Stainless Steel, SCH 10, flush threaded	5"		55'	- 63'
304 Stainless Steel, SCH 10, flush threaded	5"		1.63'	- 53'

ANNULAR SEAL/FILL

Type	Interval		Quantity	Volume
RMC Lonestar Sand, #2/12	84.9'	- 90'	1 100-lb bag	
PEL-PLUG Bentonite Pellets, 3/8", 30 min	76.5'	- 84.9'	2.75 50-lb buckets	
RMC Lonestar Sand, #1/20	71.5'	- 76.5'	4 100-lb bags	
PEL-PLUG Bentonite Pellets, 3/8", 30 min	66.5'	- 71.5'	2.5 50-lb buckets	
RMC Lonestar Sand, #1/20	61.5'	- 66.5'	2.5 100-lb bags	
PEL-PLUG Bentonite Pellets, 3/8", 30 min	57.5'	- 61.5'	2.5 50-lb buckets	
RMC Lonestar Sand, #1/20	51.5'	- 57.5'	2.25 100-lb bags	
PEL-PLUG Bentonite Pellets, 3/8", 30 min	49'	- 51.5'	2.25 50-lb buckets	
Pure Gold Grout	3'	- 49'	8 50-lb bags	
PEL-PLUG Bentonite Pellets, 3/8", 30 min	2'	- 3'		

PUMP

Type	Westbay MP55 Measurement Port (a)	Depth to Inlet	63.17' (Zone 2)	Date Set	10-25-95
Type	Westbay MP55 Measurement Port	Depth to Inlet	73.03' (Zone 3)	Date Set	10-25-95
Type	Westbay MP55 Measurement Port	Depth to Inlet	86.14' (Zone 4)	Date Set	10-25-95
Type	Westbay MP55 Measurement Port	Depth to Inlet	95.99' (Zone 5)	Date Set	10-25-95
Type	Westbay MP55 Measurement Port	Depth to Inlet	105.68' (Zone 6)	Date Set	10-25-95
Type	Westbay MP55 Measurement Port	Depth to Inlet	115.71' (Zone 7)	Date Set	10-25-95

COMMENTS

(a) Depth to inlet of measurement port is in feet below the top of stainless steel casing.

DA BOREHOLE LOG

Boring or Well Number UCP-2-2 Depth 0 Sheet 1 of 1
Location _____ Project LEHR RIFS

Logged by SS Teel SS Teel Date 8/23/95
Print Sign
Reviewed by _____ Date _____
Print Sign
Lithologic Classification Scheme N/A Procedure _____ Rev No. _____
Measuring Equipment N/A

Drilling Contractor Water Development (Woodland)
Driller Jason Layton, Charles Webber, Jon Fischer
Rig/Method Speedstar 1b, AR

[illegible]

W = wet, M = moist, D = dry

DAILY BOREHOLE LOG

Boring or Well Number UCD 2-027

Depth 0 Sheet 1 of 1

Location

Project LEHR RIFS

Logged by SS Teel Print

SS Tool
Sign

Date 8/24/95

Drilling Contractor Water Development

Reviewed by _____ Print _____

Sign

Date

Driller Jason Layton, Charles Webber, Jon Fischer

Lithologic Classification Scheme N/A

Procedure

Rev No.

Rig/Method Speedstar 16, Air RotaryMeasuring Equipment N/A[illegible]

W = wet, M₁ = moist, D = dry

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DAILY BOREHOLE LOG

Boring or Well Number UCD-2- Depth 0' Sheet 1 of 2
 Location _____ Project _____

Logged by SS Teel SS Teel Date 8/25/95
 Print Sign
 Reviewed by _____ Date _____
 Print Sign
 Lithologic Classification Scheme N/A Procedure _____ Rev No. _____
 Measuring Equipment N/A

Drilling Contractor Water Development
 Driller Jason Layton, Jon Fischer, Chuck Webber
 Rig/Method Speedstar 16, Air rotary

DEPTH	SAMPLES		CONTAMINATION		MOISTURE	GRAPHIC LOG	LITHOLOGIC DESCRIPTION (PARTICLE SIZE DIST., SORTING, MINERALOGY, ROUNDNESS, COLOR, REACTION TO HCL, ETC.)	TIME	H ₂ O ADDED	DRILLING COMMENTS (DRILLING RATE, DOWN TIME, BLOW COUNTS, WATER LEVEL, DRILL FLUID, ETC.)	
	TYPE	NO.	INSTRUMENT	READING						CASING	
								0700			Drillers on site, begin set up.
							After raising mast, driller has realized that access line to pipetruck will be too close to power lines. Will have to move well locations. Suggested location is 40' South of present.	0815			
								0830			Drillers read safety plan, wait for decision on next location.
							R. Schalk has talked to S. Alliga - consensus that RPM's approved 100' square area - OK to drill as long as utility OK. Unable to reach Dawn Mitchell.	1020			RCT surveys new location.
							Begin setting-up drill rig.	1040			RCT OK's location.
							Notified by TCU that utilities will have to be resurveyed (as per discussion with Dawn). Tell drillers to take an early lunch until utility survey is complete. Rig is moved to accommodate utility survey.	1100			

W = wet, M = moist, D = dry

DAILY BOREHOLE LOG

Boring or Well Number UCD-2-27 Depth 0' Sheet 2 of 2
 Location _____ Project _____

Logged by SS Teel SS Teel Date 2/25/95
 Reviewed by _____ Date _____
 Lithologic Classification Scheme N/A Procedure _____ Rev No. _____
 Measuring Equipment N/A

Drilling Contractor Water Development
 Driller Jason Layton, Jon Fischer, Chuck Webber
 Rig/Method Speedstar 16, Air Rotary

DEPTH	SAMPLES		CONTAMINATION		MOISTURE	GRAPHIC LOG	LITHOLOGIC DESCRIPTION (PARTICLE SIZE DIST., SORTING, MINERALOGY, ROUNDNESS, COLOR, REACTION TO HCL, ETC.)	TIME	H ₂ O ADDED	DRILLING COMMENTS (DRILLING RATE, DOWN TIME, BLOW COUNTS, WATER LEVEL, DRILL FLUID, ETC.)	
	TYPE	NO.	INSTRUMENT	READING						CASING	
							S. Atiga, D. Mitchell, J. Aborn, and of itti's utility surveyor on site - Utility survey is complete except for telecommunications. J. Aborn & D. Mitchell concur that drillars can set up and prepare pending telecommunications OK. This will be performed by 8:15 AM 8/28/95.	1337			
								1400	8/28/95		
							Meeting with S. Atiga, D. Mitchell, TL Liikala, SS Teel, and Don Motaiko (Water Development).	1400- 1530			
								1630	8/28/95		
							Setting-up zone.	1530			
							D. Mitchell inspects zone, recommends several improvements & additions.	1630			
								1700			End of Day

W = wet, M = moist, D = dry

U.S. GEOLOGICAL SURVEY

[illegible]

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DAILY BOREHOLE LOG				Boring or Well Number <u>UCD-2-27</u>		Depth <u>0-20'</u>		Sheet _____ of _____	
Location _____				Project _____					
Logged by <u>W. SCHAM</u> Print _____ Sign _____ Date <u>8/29/90</u>				Drilling Contractor <u>WATER DEVELOP</u>					
Reviewed by _____ Print _____ Sign _____ Date _____				Driller <u>Jason</u>					
Lithologic Classification Scheme <u>modified ASTM/FOLK</u> Procedure <u>VISUAL</u> Rev No. _____				Rig/Method <u>Air Rotary / Cont. Core</u>					
Measuring Equipment _____									

DEPTH (ft)	SAMPLES		CONTAMINATION <i>Recovery %</i>		MOISTURE	GRAPHIC LOG	LITHOLOGIC DESCRIPTION (PARTICLE SIZE DIST., SORTING, MINERALOGY, ROUNDNESS, COLOR, REACTION TO HCL, ETC.)	TIME	H ₂ O ADDED	COMMENTS (DRILLING RATE, DOWN TIME, BLOW COUNTS, WATER LEVEL, DRILL FLUID, ETC.)
	TYPE	NO.	INSTRUMENT	READING						
X X X X X					dry	ml	Sandy, clayey, SILT; 10YR 6/3 (pale br); dry; low plastic; 15% sand; 40% clay; 55% silt; plant matter (5%).	8:30		WCS 70 ft Casing 11' Hole Safety Briefing @ 0800 NONE Begin drilling @ 0815 NONE MINOR v. good
						NR				
					dry	SP	clayey, sandy gravel; dry; angular grains; 10YR 4/2 (dk gr-br). Grades into			
					moist	ch	clay; 10YR 4/1 (dk grey); high plastic; 100% clay.			
					moist	SP	poorly graded sand; dry; 10YR 4/2 (br to lte br), 80% med sand fne, k-sand; bluish, plug rotary; moist; 20% silt grades into			
15-16.5					moist	SW	v. fine sand; 10YR 4/3 (br); well graded; silt moist; 100% sand	9:15		
					moist	ch/cl	sandy CLAY; 10YR 4/3 (br); med-thin plastic; 35% sand; 10% silt; 55% clay			
							sand & clay vary w/ depth			
							high plastic; 10YR 4/4 (dk yell br); 10% sand; 90% clay;			
16.5-20					dry	sp	100% recovery; 15-20 ft core	11:30	1020	25 ft Take Break Begin drilling 11:40 am: Auger flight caked w/ clay - pulled off by hand. For 20-25 ft drill was dry. From 24-25 ft dr was hard. Core barrel stuck 12:10 core barrel free
							15-16.5'; sp; poorly graded sand; 10YR 4/2;	11:00		
							80% sand; 10% gravel; 5% silt; dry; NO HCL rxn grades into:			
					moist	ch	16.5-20; ch; CLAY; 10YR 4/2; thin plastic moist; 100% clay; mostly w/ depth (decayed organic matter AND organic-soil textures); NO HCL rxn. 10YR 6/3 (pale br). Lower 3 ft of core barrel moist. Silt increases w/ depth to ~15%			
							What? perched zone near 20 ft			

A.10

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DAILY BOREHOLE LOG

Boring or Well Number UCD-2-2

Depth 20-30'

Sheet 2 of 2

Location _____

Project _____

Logged by W. Schaal

Print

Sign

Date 8/29/95

Reviewed by _____

Print

Sign

Date _____

Lithologic Classification Scheme Modified Folk/ASTM

Procedure NHFP-DO-1

Rev No. N/A

Drilling Contractor Water Development

Driller Jason Layton, Jon Fitcher, Chuck Webber

Rig/Method Speedstar 16, Air Rotary

Measuring Equipment _____

DEPTH	SAMPLES		CONTAMINATION		MOISTURE	GRAPHIC LOG	LITHOLOGIC DESCRIPTION (PARTICLE SIZE DIST., SORTING, MINERALOGY, ROUNDNESS, COLOR, REACTION TO HCL, ETC.)	TIME	H ₂ O ADDED	DRILLING COMMENTS (DRILLING RATE, DOWN TIME, BLOW COUNTS, WATER LEVEL, DRILL FLUID, ETC.)	
	TYPE	NO.	INSTRUMENT	READING						CASING	
20-25					moist.	20	no moisture on cor barrel	12:10		12:15	DRILLER LUNCH
						Ch	100% recovery			1:15	RE-COMMENCE DRILLING
							silty clay; ; 20-21 ft v. moist;			1:50	(required pulling off more clay from drill stem)
						25	high plasticity; 10-15% silt (increases w/ depth); 85-90% clay; high plasticity; brown staining especially in upper v. moist zone, (decoloring mineral) - No HCL REACT.			2:00	Salmon reading
							22.5 to 25 caliche (immature) + increasing organic matter (1/4 in square). Caliche reaction w/ HCL			2:55	No H ₂ O
30-35											hole depth 30ft
										2:25	delayo sampler disconnected at bottom of hole. Driller off P/E to consider "fishing" options
											BREAKE
										3:10	Driller return to rig to recover tool
										4 pm	tool recovered - drilling resumes
											NOTE 0-25ft core is probably 0-30ft compressed. will have driller measure hole depth following each sample.
											Drillers have correctly digression about how to use log conditioner

W = wet, M = moist, D = dry

DAILY BOREHOLE LOG

Boring or Well Number UCD 2-027
Location _____

Depth 0-10' Sheet 1 of _____
Project LEHR RIFS

Logged by W. Schaefer SS Teel Date 8/29/95
Print _____ Sign _____
Reviewed by _____ Date _____
Print _____ Sign _____
Lithologic Classification Scheme _____ Procedure _____ Rev No. _____

Drilling Contractor Water Development
Driller Jason Layton, Jon Fischer, Chuck Webber
Rig/Method Speedstar 16 / Air Rotary

Measuring Equipment

DEPTH	SAMPLES		CONTAMINATION		MOIS- TURE	GRAPHIC LOG	LITHOLOGIC DESCRIPTION (PARTICLE SIZE DIST., SORTING, MINERALOGY, ROUNDNESS, COLOR, REACTION TO HCL, ETC.)	TIME	H ₂ O ADDED	DRILLING COMMENTS (DRILLING RATE, DOWN TIME, BLOW COUNTS, WATER LEVEL, DRILL FLUID, ETC.)	
	TYPE	NO.	INSTRUMENT	READING						CASING	
0-2.5'	Core	2.5'					Borehole size is 9 5/8"	0800			Safety Briefing
							(Note: archive core in core boxes - collecting continuous core).	0815			Begin drilling
							Clayey Silt (ml), dry, low plasticity,				
0-2.5'	Core	2.5'	GM	25-50 gpm			15% sand, 85% clay, 45% silt - 55% silt	0830			0-2.5' 100% recovery
2.5-5'	NR	2.5'	PAM	5-6 gpm			3% plant matter (of clay portion), 30% clay				2.5-5' No recovery
			PID	0 ppm			45% silt. No rxn to 10% HCL, pale brown (10YR 6/3)				
							Clayey, sandy Gravel (5-6') grad st	0845			100% Recovery
5-10'	Core	5'	PID	0.0 ppm	D		dry, gravels are 2-5 mm and coarse				
			GM	25-60 gpm			angular, 10YR 4/2 (dark gray) ; grades				
			PAM	0.1 gpm			into clay (10YR 4/1, dark gray) high				
							plasticity (100% clay) (6'-9').				
					M		Sand (9'-9.5') poorly graded, dry,				
							10YR 4/2 (brown to light brown) 80% med.				
							sand, 20% silt. (Sand) → 9/2, Kspar,				
							biotite, plag. grades into Sand (SW)				
							rfs, 10YR 4/3 (brown), well graded				
							slightly moist, 100% sand, (9.5-10')				
							No reaction to 10% HCL.				

W = wet, M = m P = dry

100% recovery

DAIRY HOLE LOG

Boring or Well Number UCD2-027 Location

Depth 10' - 25' Project

Sheet 2 of 3

Logged by W. Schaal Print Sign Date 8/29/95

Reviewed by Print Sign Date

Lithologic Classification Scheme Procedure Rev No.

Measuring Equipment

Drilling Contractor Water Development
 Driller Jason Layton, Chuck Webber, Jan Fishel
 Rig/Method Speedstar 5516 Air Rotary

DEPTH	SAMPLES		CONTAMINATION		MOIS- TURE	GRAPHIC LOG	LITHOLOGIC DESCRIPTION (PARTICLE SIZE DIST., SORTING, MINERALOGY, ROUNDNESS, COLOR, REACTION TO HCL, ETC.)	TIME	H ₂ O ADDED	DRILLING COMMENTS (DRILLING RATE, DOWN TIME, BLOW COUNTS, WATER LEVEL, DRILL FLUID, ETC.)	
	TYPE	NO.	INSTRUMENT	READING						CASING	
10-15'	Core	5'	PAM	0-15gpm	M		Sandy clay (CH/CL) (10-15')	0917			10-15' sample
			GM	20-70cpm			10YR 4/3 (brown), med-high plasticity, 35% sand, 10% silt, 55% clay (sand + clay vary w/ depth)				100% recovery
			Borehole				Lower portion of core → highly plastic, 10YR 4/4 (dark yellowish brown), 10% sand, 90% clay.	0953			
			PID	0.0ppm				1020			Take Break
			core					1100			Begin drilling
			GM	30-50cpm	D		Sand (SP) (15-16.5') Poorly graded sand, 10YR 4/2, 80% sand, 10% gravel, 5% silt, No reaction to 10% HCL, grades into:	1128			Sample 15-20', 100% recovery
			PAM	0-15cpm			Clay (CH) (16.5-20') clay, 10YR 4/2, med-high plasticity, 100% clay, some mottling w/ depth, (possibly some organic matter / organic soil textures), No HCL reaction, Silt increases w/ depth (up to 15%).	1140			Auger flight caked w/ clay Driller says 20-24' drilling was easy; drilling from 24-25' was harder. Core barrel stuck.
			PID	0.0ppm	M						
			cell diff + borehole zone								
			PID	0.0ppm							
								</			

W = wet, M = moist, D = dry

Sheet 3 of 3

Project LEHR RIFs

Driller Jason Layton, Jon Fischer, Chuck Webber

Rig/Method Speedstar SS16 / Air Rotary

Measuring Equipment

A/ 1 007 105 201

DAI COREHOLE LOG

Booring or Well Number 11CD2-027

Depth 30'-40'

Sheet 1

2

Location

Project

Logged by SS Teel, TL Lili Kalua

Print

Date 8/30/95

Sign

Reviewed by

Print

Date

Sign

Lithologic Classification Scheme Modified Folk/ASTM

NHFP - DO-1

Rev No. N/A

Measuring Equipment

Drilling Contractor Wesler Development

Driller Jason Laydon, Jon Fischer, Chuck Webber

Rig Method Speedstar 16, Air Rotary

DEPTH	SAMPLES	CONTAMINATION	MOISTURE	GRAPHIC LOG	LITHOLOGIC DESCRIPTION PARTICLE SIZE DIST., SORTING, MINERALOGY, ROUNDNESS, COLOR, REACTION TO HCL, ETC.	TIME	H ₂ O ADDED	DRILLING COMMENTS (DRILLING RATE, DOWN TIME, BLOW COUNTS, WATER LEVEL, DRILL FLUID, ETC.)	
								CASING	
						0715			Drillers on site. Tailgate
					Calibrate PID. Response = 96.7 ppm (same as).	0720			safety meeting.
					gas and instrument as previous (see cal. log).	0730			Dress-out to enter zone.
					Bottom = 30' (drillers tape)	0800			Warning-up equipment -
					Total casing = 22' 21' (includes 1' shoe)				preparing to drill.
					Add 10' casing	0855			Drilling w/ Air Rotary
					(Check source on GM = 1.47 - 1.77 mR/H)	0908			
					Silty Clay (30-32' M ¹ /Ch. same as	0920			Recover 30-35' sample
					previous (~ 30% silt), low-med plasticity				100% Recovery
					Clay (32-35') less silt content,				No readings above background
					plastic, < 5% silt, (CH), high plasticity				
					(2.5X 4/4 olive brown).				
					Entire core still contains organic partings				
					and caliche nodules. Core appears to				
					be slightly compressed due to affect from				
					sampler.	0945			Drillers have lost sampler
									down hole, drillers dress-out
									and call their shop.
									Re-enter zone
					(Zone entry was safety only for DOE	1030			
					site visit				
					parameters. Drillers now on standby.)	1045			
									Wet Bulb = 78.4
									(Work time to break = 1 hr.)

W = wet, M = moist, D = dry

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DAILY BOREHOLE LOG

Boring or Well Number UCD 2-027 Depth 40-45' Sheet 2 of 2
 Location _____ Project LEHR RIFS

Logged by SS Teel SS Teel Date 8/30/95
 Print _____ Sign _____

Reviewed by _____ Date _____
 Print _____ Sign _____

Lithologic Classification Scheme Modified Folk / USC Procedure NHFP - DO-1 Rev No. N/A

Measuring Equipment _____

Drilling Contractor Water Development

Driller Jaron Layton, Jon Fischer, Chuck Webber,

Rig/Method Speedstar SS16

DEPTH	SAMPLES		CONTAMINATION		MOISTURE	GRAPHIC LOG	LITHOLOGIC DESCRIPTION (PARTICLE SIZE DIST., SORTING, MINERALOGY, ROUNDNESS, COLOR, REACTION TO HCL, ETC.)	TIME	H ₂ O ADDED	DRILLING COMMENTS (DRILLING RATE, DOWN TIME, BLOW COUNTS, WATER LEVEL, DRILL FLUID, ETC.)	
	TYPE	NO.	INSTRUMENT	READING						CASING	
								1130			Exit zone. Remove sampler
								1230			Enter zone - fishing for sampler
								1230	SST		Break for lunch
								1430	SST		Fishing for sampler
								2:30			Recovered sampler. Take
								1445			Break
				8/30/95				1530			Enter zone.
				SST	SI-M		Sl. Sandy, Clayey Silt (CL/MH)	8/30/95			Removing sampler.
35.40'			PAM	0-1 cpm			10% sand, trace fine pebble, ^{SST} 40% clay, 50% silt. Slightly mottled - still				100% recovery
			GM	70 cpm max			see organic partings and evidence for caliche				
			PID (core)	0.0 ppm			Strong reaction to 10% HCL. Sl. to med toughness, low to medium plasticity.				
							WXR 4/4 (dark yellowish brown).				
			PID	0.0	(borehole)			1435			
			^{SST} PID	0.0	(roll-off)			1645			Exit Zone. Ready to collect sample A.M. tomorrow.

W = wet, M = dry, D = dry

1111

uck Webber

Rotary

ter assist)

[illegible][illegible]

DAILY BOREHOLE LOG

Boring or Well Number VCD2-027

Depth 45-55' Sheet 2 of 4

Location _____

Project _____

Logged by SSteel, TL Liikala
Print _____

Sign _____

Date 8/31/95

Reviewed by _____
Print _____

Sign _____

Date _____

Lithologic Classification Scheme _____

Procedure _____

Rev No. _____

Measuring Equipment _____

Drilling Contractor Water Development

Driller Jason Layton, Jon Fischer, Chuck Webber

Rig/Method Speedstar SS16 / Air (water assist)
Rotary

DEPTH	SAMPLES		CONTAMINATION		MOISTURE	GRAPHIC LOG	LITHOLOGIC DESCRIPTION (PARTICLE SIZE DIST., SORTING, MINERALOGY, ROUNDNESS, COLOR, REACTION TO HCL, ETC.)	TIME	H ₂ O ADDED	DRILLING COMMENTS (DRILLING RATE, DOWN TIME, BLOW COUNTS, WATER LEVEL, DRILL FLUID, ETC.)	
	TYPE	NO.	INSTRUMENT	READING						CASING	
45-50'	Core	5'					Silty Clay (ML/CL) 50% silt, 50% clay (45-49'). Mottled texture, low-med plasticity and toughness, None-slight reaction to 10% HCL. 2.5Y 4/4 (olive brown)	0945	0915		Pulling 50' sample (100% Recovery)
											Driller thinks he might be just barely into water table.
										51'	Adding casing. Total = 51'
							Sl. Silty Calcareous Clay (49-50'), med-high plasticity, med-high toughness, (CH), 30% silt, 20% clay, abundant calcite and MP sized well-cemented caliche nodules. Still has mottled texture				
							2.5Y 5/6 (lt. olive brown), 5GY 5/1 (greenish gray)				
			Core								
			PID	0.0 ppm					0945		Recover 50-55' sample
50-55'	Core	5'	PAM	0-6	cpm		Mottled Silty Clay (CH-ML)				100% recovery
			GM	29-66	cpm		70% clay, 30% silt, very hard (well consolidated) med-high toughness				Note: according to Doug (IT rad tech) background w/GM is 60-80 cpm.
							low-high plasticity, None-slight reaction to 10% HCL. Trace gravel (FP)				
							10YR 4/4 (dark yellowish brown)				
							5Y 4/1 (dark gray).				

W = wet, M = moist, D = dry

11

Date 8/31/95

Date _____

Rev No. _____

DEPTH	SAMPLES		CONTAMINATION		MOIS- TURE	GRAPHIC LOG	LITHOLOGIC DESCRIPTION (PARTICLE SIZE DIST., SORTING, MINERALOGY, ROUNDNESS, COLOR, REACTION TO HCL, ETC.)	TIME	H ₂ O ADDED	CASING	DRILLING COMMENTS (DRILLING RATE, DOWN TIME, BLOW COUNTS, WATER LEVEL, DRILL FLUID, ETC.)
	TYPE	NO.	INSTRUMENT	READING							
55-60'	Core	5'	core		M		Gravelly clay (first 0.8' of core) 20% VFP-EP, VCS; 10% (?) sand, 20% (?) silt, 50% clay. Med toughness, low plasticity, no reaction to 10% HCL. Well-defined 0.5-1.5 mm laminations Silty clay (remainder of core) 30% silt; 70% clay, med. plasticity, med toughness, lower upper 0.5' is very mottled - gray portions are calcareous, brown portions are not. Lower portion of core is only slightly mottled, no reaction to 10% HCL. Contains occasional MP calciche nodules.	1000			Pulling 55-60' sample D/Bottom = 61' Recover Drill 6' Recover 5' (100% recovery) Adding casing Total = 61' Drillers exit to take break.
61-66'	Core	5'	core		W		Silty clay, same as lower portion of previous core. Still contains occasional calciche nodules. 2.5Y 4/4 (olive brown).	1115			Enter zone. Now wearing poly-tyvek. Recover 61-66' core Core is saturated. 100% recovery

100-201,000-201,000

DAILY BUREHOLE LOG

Location _____

Date 8/31/95

Drilling Contractor Water Development

Logged by SS Teel, TL Liikala

Sign _____

Date _____

Driller Jason Layton, Jon Fischer, Chuck Webber

Reviewed by _____

Sign _____

Rev No. _____

Rig/Method Speedstar 5516, Air Rotary

Lithologic Classification Scheme _____

Procedure _____

Measuring Equipment _____

DEPTH	SAMPLES	CONTAMINATION		MOISTURE	GRAPHIC LOG	LITHOLOGIC DESCRIPTION (PARTICLE SIZE DIST., SORTING, MINERALOGY, ROUNDNESS, COLOR, REACTION TO HCL, ETC.)	TIME	H ₂ O ADDED	DRILLING COMMENTS (DRILLING RATE, DOWN TIME, BLOW COUNTS, WATER LEVEL, DRILL FLUID, ETC.)	
	TYPE	INSTRUMENT	READING						CASING	
66-71'		PID	0.0 ppm			silty clay (66-70') same as previous, lower 2.5' contains 10% VFS, 20-30% silt, 2.5% 1/4 (olive brown).	1135			Pulling sample
		PAM	0 cpm							
		GM	37-52 cpm							
		(gone)								
71-76.7		PID	0.0 ppm			Silty Sandy Clay (71-76.7)	1405			Pulling Sample (71-76.7)
		PAM	0-4 cpm			15% VFS, 15% silt, 70% clay	1200			P/Bottom c 76.7' (Drillers tape)
		GM	27-54 cpm			10% 1/4 dark yellowish brown	1330			Exit Zone
										Enter Zone
										1/2 water = 47.85
										Exit zone - lexan liners
										will not fit.
										Drillers leave site to get supplies.
										Enter zone 76.7-81.7
						76.7-77.8 8/31/95	1600			Recover Sample, 76-81' 50'
						78' 81' → 85 CL 1003 2-902 jars	1610			71' Adj 10' casing, Total = 71'
						76.7-77.7 8/31/95 1-1' core	1615			76-81' collected in lexan
										Recover sample 81.7-86.7
81.7-86.7						81.7-82.7 1-1' core SCL 1004	1700			
						83' 2-902 jars				Note: will describe 76.7-81.7' and 81.7-86.7' samples tomorrow.
						Note: see Conf. #5				

W = wet, M = moist, D = dry

DAILY OREHOLE LOG

Boring or Well Number 042-001 Depth 11 Sheet 1 2
 Location _____ Project _____

Logged by SS Teel, TL Lijakala SS Teel Date 9/1/95
 Print Sign
 Reviewed by _____ Date _____
 Print Sign
 Lithologic Classification Scheme _____ Procedure _____ Rev No. _____
 Measuring Equipment _____

Drilling Contractor Water Development
 Driller Jason Layton, Jon Fischer, Chuck Webber
 Rig/Method Speedstar SS16, Air Rotary

DEPTH	SAMPLES		CONTAMINATION		MOISTURE	GRAPHIC LOG	LITHOLOGIC DESCRIPTION (PARTICLE SIZE DIST., SORTING, MINERALOGY, ROUNDNESS, COLOR, REACTION TO HCL, ETC.)	TIME	H ₂ O ADDED	DRILLING COMMENTS (DRILLING RATE, DOWN TIME, BLOW COUNTS, WATER LEVEL, DRILL FLUID, ETC.)	
	TYPE	NO.	INSTRUMENT	READING						CASING	
							D/BOTTOM = 71' (w/E-tape)	0700			Drillers on site. Tailgate
							Hole has heaved approx. 15' (heaving sand)				safety Meeting.
							D/water = 46.9' (may not be accurate due to heaving sand.)	0730			Prepare to enter zone
								0750			Enter zone, warm up equipment
								0800			Tap Tag hole
											(Heave D/BOTTOM; w/water)
								0900			Drillers leave to get additional
											tools to use in heaving sands.
							(Drillers report that additional tools were steam-cleaned at shop. Look visibly clean. HPT takes wipe samples of tools and surveys.)	1100			Drillers return. Enter zone.
							Description of 76.7 - 81.7' core:				
						76.7					
						CH	Silty Clay (H st CH) (76.7 - 78.5')				
						78.5	Mod - high plasticity, 20% silt, 80% clay.				
						CL/SP	(10 YR 4/4 dk yellowish brown for entire core)				
						81.1	Clayey Sand (78.5 - 81.1') 30% clay, 70% sand (VFS - MS, occasional ES)				
							low-medium plasticity, Mottled size dist. (patches or lenses of clay sep. by sand rich, very very faintly bedded (5-8 mm))				

W = wet, M = moist, D = dry

Sheet 2 of 2

Project

Drilling Contractor Water Development

Sign

Sign

Date

Driller Jason Layton, Jon Fischer, Chuck Webber

Rev No. N/A

Rig/Method	Speedstar SS16, Air Rotary
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Measuring Equipment

W = wet, M = , D = dry

$$\begin{array}{r} \text{sheet} \quad 1 \\ 5 \overline{) 5} \\ \underline{5} \end{array}$$

Drilling Contractor Water Development

Driller Chuck Webber, John Fischer

RigMethod Speedstar SS16 / Air Rotary

DEPTH	SAMPLES	CONTAMINATION
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DEPTH	SAMPLES		CONTAMINATION		MOISTURE	GRAPHING LOG	LITHOLOGIC DESCRIPTION PARTICLE SIZE DIST., SORTING, MINERALOGY, ROUNDEDNESS, COHESION, REACTION TO HCL, ETC.	TIME	H ₂ O ADDED	DRILLING COMMENTS (PUMPING RATE, DOWN TIME, BLOW COUNTS, WATER LEVEL, DRILL FLUID, ETC.)	
	TYPE	NO.	INSTRUMENT	READING						CASING	
							Source check GM (1.53-1.70 mL/H)	1605			Drillers enter zone
							Calibrate PID - reads 974ppm	1605			Drillers were on site @ 0200 - delay was safety briefing, badging for Erin Thompson).
							Erin Thompson not in zone (waiting until bioassay sample has been collected).				
			PID	0.0 ppm			D/Bottom = ~ 79' from land surface	1035			Check roll-off/borehole w/ PID
			roll-off				(Drillers tape)	1040			Recover sampler - Sample fell out
			PID	0.0 ppm				1100			Lowering vacuum system to clean-out borehole,
			PID	0.0 ppm				1125			Check roll-off w/ PID
							(85-90' sample lost from sampler, Next sample will be 90-95')	1140			(while vacuuming)
								1250			Drillers enter zone.
							Sandy Gravel 35% gravel, 65% sand, no silt or clay (may have been lost - segregated during vacuuming), 10% MP, 10% FP, 5% VFP, 15% VS, 15% CS, 15% MS, 10% FS, 10%	1300			Collect grab sample from ~ 89-90' while vacuuming. (Grain sizes may not be representative).
							VS; SA-R; unconsolidated, 30% basalt/mafic, 70% quartzite, qtz, si-rich (Appears like > basalt/mafic content than	1322			Removing vacuum system

Boring or Well Number 0002001 Depth 0 - 10 Sheet 1 of 1
Location _____ Project _____

Drilling Contractor Water Development

Driller Chuck Webber, Jon Fischer

Rig/Method Speedstar, SS16 - Air rotary

[illegible]

W = wet, M = , D = drv

DAILY DREHOLE LOG

Boring or Well Number UCD-0217
 Location LEHR

Depth 10 - 16 Sheet 1 of 4

Project RIFS

Logged by SS Teel Print SS Teel Date 9/6/95

Reviewed by _____ Sign _____ Date _____

Lithologic Classification Scheme _____ Procedure _____ Rev No. _____

Measuring Equipment _____

Drilling Contractor Water Development
 Driller Chuck Webber, Jon Fischer, Erin Thompson
 Rig/Method Speedstar SS16, Air Rotary

DEPTH		SAMPLES		CONTAMINATION		MOISTURE	GRAPHIC LOG	TIME	H ₂ O ADDED	LITHOLOGIC DESCRIPTION PARTICLE SIZE DIST., SORTING, MINERALOGY, ROUNDNESS, COLOR, REACTION TO HCL, ETC.)	DRILLING COMMENTS (DRILLING RATE, DOWN TIME, BLOW COUNTS, WATER LEVEL, DRILL FLUID, ETC.)
TYPE	NO.	INSTRUMENT	READING								
								0700		(Still wearing poly-tyvek today)	Drillers on site. Tailgate
											safety meeting.
								0730			Prepare for work
								0800			Enter zone.
								0815			D/water
								0830			Collect water sample
Water	VOC	2								Collect samples for VOC and possible other analyses (1 of the VOC vials had an air-bubble in it - won't use this one) - 9/6/95	
Water	250ml plastic	2						0845			Lower sampler
										P/bottom after sample recovery =	Recover disturbed grab
										101.6' - 9.4 = 92.2' (drillers tape)	sample from 90-95' interval
90-95' Core	1.5'	PAM	0-50ppm	W			90' - SW			Sand (100% sand) 60-92.2' (SW)	45 blows for 1.5' (2" core)
		GM	20-50ppm							trace VEP + VES, 20% CS, 50% MS,	(Background PID = 0-1 ppm)
		PID	0-1ppm				92' - NR			20% FS, 10% VFS, no silt or clay.	
								0905		10% mafic/basalt, 90% gfa, gfaite, + Si-rich. A-R. Sample is disturbed -	Sampling w/ Continuous core
										- depths may not be totally accurate.	3.5" dia. core (Drilling)
								0915		Unconsolidated. No dry strength.	Retrieving sampler
								0920			Sample recovered. Sampler
										No recovery 92-95'.	plugged - no sample recovered
											except for a little bit in the
											shoe. P/Bottom = 96.3 (Drillers tape)

Depth 96' Sheet 2 of 4
Project RIFS

Drilling Contractor Water Development
Driller Chuck Webber, Jon Fiskler, Erin Thompson
Rig/Method Speedstar SS16, Air Rotary

DEPTH	SAMPLES		CONTAMINATION		MOIS- TURE	GRAPHIC LOG	LITHOLOGIC DESCRIPTION (PARTICLE SIZE DIST., SORTING, MINERALOGY, ROUNDNESS, COLOR, REACTION TO HCL, ETC.)	TIME	H ₂ O ADDED	DRILLING COMMENTS (DRILLING RATE, DOWN TIME, BLOW COUNTS, WATER LEVEL, DRILL FLUID, ETC.)	
	TYPE	NO.	INSTRUMENT	READING						CASING	
							LEHR Environmental Restoration	0923			Preparing to run 2" dia. drive sampler.
						95'	Sample ID: SSCL1005				
95-100'	8oz Glass	2	PAM	0-1cpm	W		COC: COC2038 95-100'	0931			Recover sampler, collect samples
			GM	40-78cpm		GW		0945			Exit zone for break.
			PID	0.0ppm				1035			Enter zone
							Sand (95-100'?) Disturbed	1050			Fixing air seal.
						100'	sample from 2" core barrel, grain sizes may not be representative.	1110			Drilling w/ Air Rotary
							Description same as previous sample.				
							Grab sample consists of sandy gravel. Grabs	1115			Collect grab sample from cyclone while cleaning-out hole w/air.
							- up to CP sized (20%). Predominantly				
							MP size gravels - 30% basalt/mafic,				
							70% quartz / Si-rich rock fragments.				
							Unbroken gravels are SA-R.				
							(No description on fine portion - lost through sieve).				
							(Therefore 95-100' interval probably consists of sandy gravel (GW).)				
								1130			Attempting to recover 100-105' sample

DAILY COREHOLE LOG

Boring or Well Number 000 Depth 100 Sheet 4
 Location LEHR Project RIFS

Logged by SS Steel SS Steel Date 9/6/95
 Print Sign
 Reviewed by _____ Date _____
 Print Sign
 Lithologic Classification Scheme _____ Procedure _____ Rev No. _____
 Measuring Equipment _____

Drilling Contractor Water Development
 Driller Chuck Webber, Jon Fischer, Grin Thompson
 Rig/Method Speedstar SS16 Air Rotary

DEPTH	SAMPLES		CONTAMINATION		MOISTURE	GRAPHIC LOG	LITHOLOGIC DESCRIPTION (PARTICLE SIZE DIST., SORTING, MINERALOGY, ROUNDNESS, COLOR, REACTION TO HCL, ETC.)	TIME	H ₂ O ADDED	DRILLING COMMENTS (DRILLING RATE, DOWN TIME, BLOW COUNTS, WATER LEVEL, DRILL FLUID, ETC.)	
	TYPE	NO.	INSTRUMENT	READING						CASING	
								1152			Sampler is stuck. Will have to pull entire drill-string. Will switch-over to drilling (no coring), to get back on schedule.
								1245			Break for lunch
								1245			Safety briefing on FCN to WASP and HWP regarding PPE
								1300			cleaner zone, remove core sampler
								1330			Exit zone, discover FCN noted above @ 1245 hrs w/ Dawn Mitchell
								1400			Load pipe for conventional air rotary drilling.
								1500			Run drill pipe downhole, D/B = 55' bgs, heaved 60'
								1520			Drill slough out of hole
								1530		100'	Add 10' casing, total = 100'
								1550		110'	Add 10' casing, total = 110'
110'	Grab		PID	0.0 ppm			Sandy Gravel. Grab sample collected from cyclone. Fines washed out. Gravel	1555			
			PAM	0.4 cfm							

W = wet, M = moist, D = dry

A.27

A 1000 002 105 001

[illegible]

Project RI/FS

Sheet 4 of 4

十

UBIS
Date 6 Sep 95

Sign

Date

Procedure

Measuring Equipment

LITHOLOGIC DESCRIPTION
PARTICLE SIZE DIST., SORTING, MINERALOGY,
ROUNDNESS, COLOR, REACTION TO HCL, ETC.)

(DRILLING RATE, DOWN TIME, BLOW COUNTS, W
ETC)

CASING

H₂O
ADDED

TIME

predominantly pebble sized (small to medium)

40% beahtec / natz composition, 60% quartz

ite / si - rich composition	unbroken gravels
1	1
2	2
3	3
4	4
5	5
6	6
7	7
8	8
9	9
10	10
11	11
12	12
13	13
14	14
 
85	85
86	86
87	87
88	88
89	89
90	90
91	91
92	92
93	93
94	94
95	95
96	96
97	97
98	98
99	99
100	100

ac SA + R

10

Add 10' casing, total = 120'

21

Gravelly Sand. Grb sample from

cyclone

11-20

Gravelly Sand: Increased silt content

Crab sample

Silty clay ^{thin} bedded: increased clay content

from $\sim 126' - 130'$. Minor bits of

gravel from above, 2.5Y 5/4 light olive;

Shut down $TD = 130'$ brown

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	100	101	102	103	104	105	106	107	108	109	110	111	112	113	114	115	116	117	118	119	120	121	122	123	124	125	126	127	128	129	130	131	132	133	134	135	136	137	138	139	140	141	142	143	144	145	146	147	148	149	150	151	152	153	154	155	156	157	158	159	160	161	162	163	164	165	166	167	168	169	170	171	172	173	174	175	176	177	178	179	180	181	182	183	184	185	186	187	188	189	190	191	192	193	194	195	196	197	198	199	200	201	202	203	204	205	206	207	208	209	210	211	212	213	214	215	216	217	218	219	220	221	222	223	224	225	226	227	228	229	230	231	232	233	234	235	236	237	238	239	240	241	242	243	244	245	246	247	248	249	250	251	252	253	254	255	256	257	258	259	260	261	262	263	264	265	266	267	268	269	270	271	272	273	274	275	276	277	278	279	280	281	282	283	284	285	286	287	288	289	290	291	292	293	294	295	296	297	298	299	300	301	302	303	304	305	306	307	308	309	310	311	312	313	314	315	316	317	318	319	320	321	322	323	324	325	326	327	328	329	330	331	332	333	334	335	336	337	338	339	340	341	342	343	344	345	346	347	348	349	350	351	352	353	354	355	356	357	358	359	360	361	362	363	364	365	366	367	368	369	370	371	372	373	374	375	376	377	378	379	380	381	382	383	384	385	386	387	388	389	390	391	392	393	394	395	396	397	398	399	400	401	402	403	404	405	406	407	408	409	410	411	412	413	414	415	416	417	418	419	420	421	422	423	424	425	426	427	428	429	430	431	432	433	434	435	436	437	438	439	440	441	442	443	444	445	446	447	448	449	450	451	452	453	454	455	456	457	458	459	460	461	462	463	464	465	466
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1000

1100

Clean up site

W = wet, M = dry

 

Location LEHRProject RI/FSLogged by T.L. Liikala
PrintDate 7 Sep 95Drilling Contractor Water Dev. Corp.Reviewed by _____
Print

Sign

Date _____

Driller Chuck Webber, Jon Frecher, Erin Thompson

Lithologic Classification Scheme _____

Procedure _____

Rev No. _____

Rig/Method Speedstar 16 / Air Rotary

Measuring Equipment _____

DEPTH	SAMPLES		CONTAMINATION		MOISTURE	GRAPHIC LOG	LITHOLOGIC DESCRIPTION (PARTICLE SIZE DIST., SORTING, MINERALOGY, ROUNDNESS, COLOR, REACTION TO HCL, ETC.)	TIME	H ₂ O ADDED	DRILLING COMMENTS (DRILLING RATE, DOWN TIME, BLOW COUNTS, WATER LEVEL, DRILL FLUID, ETC.)	
	TYPE	NO.	INSTRUMENT	READING						CASING	
								0700			Drillers onsite. Tailgate safety mtg.
								0730			Enter zone. Rig up to pump liquid wash from rolloff bin into free tank
							DIW = 46.8' bgs	0800			Schlumberger Well Services onsite. Complete paperwork receive TLDs from Dawn Mitchell
								0830		130'	Add 10' casing, total = 130' clean out hole, drill to 134' to allow for tailpipe below bottom screened interval
136' 135'	Th 9-7-95						Sand? Silty clay to ~ 131.5'. Sand? from 131.5' - 136', no sample - too fine, washed through grab sample catcher	0845			
								0900		140'	Add 10' casing, total = 140', remove drill tools from hole, conduct initial safety briefing with Schlumberger personnel
								1000			Rig up to clean out hole to 136', set up logging truck
								1100			Complete cleanout to 136', pull pipe

W = wet, M = moist, D = dry

Logged by T. L. Liikala
Print

Sign

Date 7 Sep 95

Drilling Contractor Wake Dev. Co., p.

Reviewed by _____ Print _____

Sign

Date _____

Driller Chuck Webber, John Fischer, Erin Thompson

Lithologic Classification Scheme _____ Procedure

Rev No.

Rig/Method Speedstar 16/ Ar Rotary

Measuring Equipment

[illegible]

W = wet, M = moist, D = dry

A

COMPLETION LOG

Location LEHRProject RE/ES

Logged by T.L. Liikala Date 8 Sep 95
 Print Sign
 Reviewed by _____ Date _____
 Print Sign
 Measuring Equipment _____ Procedure _____ Rev No. _____

Drilling Contractor Water Dev. Corp.
 Driller Chuck Webster, Jon Fischer, Erin Thompson
 Rig/Equipment Speedstar 16/ Air Rotary

Time	Casing/Screen					Annular Fill					Over-lap	Comments
	Type	Diameter	Length	Stickup	Depth	Type	Depth	Stickup	Quantity	Add-on		
1245-1551	SS casing / screen	5"	3' casing									F480 threads binding on several joints despite water and teflon tape lubricants
		5"	2' screen (20 slot)									
		5"	3' casing									
		5"	5' casing									
		5"	2' screen (20 slot)									
		5"	1' casing									
		5"	10' casing									
		5"	2' screen (10 slot)									
		5"	3' casing									defective material
1559												Removed last three pieces of SS casing / screen due to binding threads (10' casing, 2' screen (10-slot), 3' casing), total SS casing / screen in hole = 43'
1605												Pump liquid waste from roll-off bin into free tank
1645												Clean up site
1700												Ordered replacement sections from Roscoe Moss

WELL LOG

Location _____

Project _____

RI/FS _____

Logged by T.L. Likala Date 11 Sept 95 Sign [Signature]
 Reviewed by _____ Date _____ Sign _____
 Measuring Equipment _____ Procedure _____ Rev No. _____

Drilling Contractor Wah Dev. Corp. Driller Jason Layton, Chuck Weber, Jon Fischer
 Rig/Equipment Speedstar II / Air Rotary

Time	Casing/Screen					Annular Fill				Over-lap	Comments	
	Type	Diameter	Length	Stickup	Depth	Type	Depth	Stickup	Quantity			Add-on
0700												Drillers orsick
0700-0730												Tailgate safety Mtg.
0700-0721	55 casing /screen	5"	10'	10' casing								Resume completion, before tape, Wesson
		5"	2'	2' screen (10 slot)								cooking oil used as thread lubricant
		5"	5'	5' casing								
		5"	3'	3' casing								
		5"	2'	2' screen (10 slot)								
		5"	5'	5' casing								
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		5"	5'	5' casing								
		5"	3'	3' casing								

COMPLETION LOG

Location LEHRProject RT/FSLogged by T.L. Liikala
PrintSign [Signature]Date 11 Sep 95Reviewed by _____
Print

Sign _____

Date _____

Measuring Equipment _____ Procedure _____ Rev No. _____

Drilling Contractor Wale Dev. Corp.Driller Jason Layton, Chuck Webster, Jon FischerRig/Equipment Spacelab 16/Air Rotary

Time	Casing/Screen					Annular Fill					Over-lap	Comments
	Type	Diameter	Length	Stickup	Depth	Type	Depth	Stickup	Quantity	Add-on		
1445-1500	Carbon steel casing	9 5/8" OD	130'	3'	127'	Bentonite Pellets			2 Buckets			Unable to use tremie pipe riser, couplings too large for annular space, poured materials instead
	Carbon steel casing	9 5/8"	130'	5'	125'							
	Carbon steel casing	9 5/8"	130'	5.5'	124.5'							
						Bentonite Pellets			1 Bucket			
↓	Carbon steel casing	9 5/8"	130'	9'	121'							
1500												Hook up hydraulic jacks
1500-1540						Bentonite Pellets	119.8'		1 Bucket		1.2'	
↓	Carbon steel casing	9 5/8"	130'	10'	120'							
						Bentonite Pellets	118'		1 Bucket		2'	
	Carbon steel casing	9 5/8"	120'	3'	117'		117'					Remove 10' carbon steel casing, pellets did not settle - now located immediately below 116-118' screened interval, should have been 119.5', hole may have sloughed from 117-118'
↓												
1545						RMC Core-Site # 2/12 Sand	114'		1 100 lbs bag		3'	
↓ 2:11:45												
1600 -							114.5'				2.6'	Predeveloped screen @ 116-118', 50 gal bailed noted fine sand, sand pack (minor amount) in bailing bucket, pack settled to 114.4'
1625												Shut down, clean up site

A-1800-004 (05/90)

COMPLETION LOG

Location LEHR

Project RI/FS

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Measuring Equipment _____

Procedure _____

Rev No. _____

Drilling Contractor Wale Dev. Corp.

Driller Jason Layton, Chuck Webber, Jon Fischer

Rig/Equipment Speedstar 16/ Air Rotary

Time	Casing/Screen					Annular Fill					Over-lap	Comments
	Type	Diameter	Length	Stickup	Depth	Type	Depth	Stickup	Quantity	Add-on		
0700												Drillers onsite
0700-0715												Tailgate safety mtg.
0730-	Carbon steel casing	9 5/8"	120'	3'	117'	Bentonite Pellets	112'		1 Bucket			Enter zone, resume completion, tremie.
0900	Carbon steel casing	9 5/8"	120'	7'	113'		112.5'					pipe installed for placement of annular
						Bentonite Pellets	109'		1/2 Bucket			seal materials
	Carbon steel casing	9 5/8"	110'	3'	107'	Bentonite Pellets	105'					Removed 10' carbon steel casing, bentonite
												pellets bridged b/w ss and carbon steel
												casing during pull back, smearing pellets
												across 106-108' ss screened interval
0910												Test 1/2 bucket of bentonite pellets in 5 gal
												bucket of water, noted significant swelling
												after 5 min, also noted pellets can be
												crumbled by hand indicating not highly compressed,
												contact manufacturer, distributor - defective material
1000-												Rig up to remove ss casing and screen,
1115												photograph of pellets smearing adjacent to casing @
												water table and across 106-108' screened
												interval, also noted cracked welds on casing /
												screen is expended from derrick
1115												Decon ss screen / casing
1145-1215												Lunch
1400												Complete decon

A-1800-004 (05/90)

Location

LEHE

Project

RI/FS

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Date 12 Sep 95

Drilling Contractor Wake Dev. Co-p.

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Date _____

Driller Jason Layton, Chuck Webber, Jan Fischer

Measuring Equipment _____ Procedure _____ Rev No. _____

Rig/Equipment Speedstar 16 / Air Rotary

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IMPLEMENTATION LOG

Location LEH2

Project EL/CS

Logged by T.L. Little
Reviewed by _____
Measuring Equipment _____
Date 13 Sep 95
Date _____
Rev No. _____
Sign _____
Procedure _____
Sign _____

Drilling Contractor Wake Dev. Co-p.
Driller Jason Taylor, Chuck Webb, Jan Fieche
Rig/Equipment Spudco 16 / Air Rotary

Time	Casing/Screen				Annular Fill				Over-lap	Comments
	Type	Diameter	Length	Stickup	Depth	Type	Depth	Stickup	Quantity	Add-on
0700										
0700-0730										Driller to reset ss casing and screen
↑										and then move to UC02-026 per direction
										from Don Schalla, UC02-027 will be
										completed upon receipt of tremic pipe
										w/water injection system
0730-0745										Tailgate safety mfg.
0800										D/B = 123.5' bgs, hole moved ~ 4'
										over night, ss casing and screen to be
										reset in hole later when rig is moved
										back over hole to prevent further heaving
										around ss
0845-0845										Weld tab to carbon steel casing to
										prevent casing from settling
0845-1145										Tear down rig, move rig and equipment
										to down pad
1200-1230										lunch
1230-1430										Down rig, pipe, drill stem
1430-1645										Weld drive shoe, set up rig on
										UC02-026

Location LEHR

Project RI/ES

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Measuring Equipment _____ Procedure _____ Rev No. _____

Drilling Contractor Wake Dev. Corp.

Driller Jason Layton, Chuck Webber, Jon Fischer

Rig/Equipment Speedstar 16/Air Rotary

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 Print Sign
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 Measuring Equipment _____ Procedure _____ Rev No. _____

Drilling Contractor Water Dev. Corp.
 Driller Jason Layton, Chuck Welton, Jon Fisher
 Rig/Equipment Speedstar .16/Air Rotary

Time	Casing/Screen					Annular Fill					Over-lap	Comments
	Type	Diameter	Length	Stickup	Depth	Type	Depth	Stickup	Quantity	Add-on		
0700												Drillers office
0700-0720												Tailgate safety mtg.
0720-0730												Warm up equipment
0730-0840												Resume borehole cleanout to 128' using sand pump
0845-1000												Reset ss casing/screen in same configuration as previously noted, total ss casing/screen = 131'
1000-1130												Set tremie pipe, 1.5" too large to fit past 60', reset tremie pipe using 1" diameter, total = 126'
1130-1200												Lunch
1200-1300												Wait for new hopper from WDC shop
1300	Carbon steel casing	9 5/8" OD	130'	3.5'	126.5'							
1311						26L-PLVC Bentonite Pellets 3/8", 30 min			3/4 50 lb Bucket			Pour through hopper while injecting water through tremie and into annulus
1314	Carbon steel casing	9 5/8	130'	4.5'	122'							Pulled temporary casing back 4.5'
1318	Carbon steel casing	9 5/8	125'	3'	122'							Removed 5' temporary casing, total = 125'
1330						Bentonite Pellet Seal	126'				0	Tagged top of bentonite pellet seal
1332						Bentonite Pellets			1 Bucket			
1343	Carbon steel casing	9 5/8	125'	5'	120'							Pulled temporary casing back 2'
1345						Bentonite Pellet Seal	124.5'				0	Tagged top of bentonite pellet seal

Logged by T. L. Lilkala Print Print Date 24 Sep 95Reviewed by Print Sign Print Date 24 Sep 95Measuring Equipment Print Procedure Print Rev No. PrintDrilling Contractor Water Dev. Co.-P.Driller Jason Layton, Chuck Webber, Jon FischerRig/Equipment Speedster 16/A1, Polary

Time	Casing/Screen				Annular Fill				Over-lap	Comments
	Type	Diameter	Length	Stickup	Depth	Type	Stickup	Quantity		
1348	Carbon steel casing	9 5/8" OD	125'	8'	117' ^{TL} 118'	9-21-95				
1350						Bentonite Pellets		1 Bucket		Pulled temporary casing back 2'
1400						Bentonite Pellet Seal				
1403	Carbon steel casing	9 5/8	120'	3'	117'				0	Tagged top of bentonite pellet seal
1411										Removed 5' of temporary casing, total = 120'
1416										Removed 21' of trémie pipe, total = 105'
1418						Bentonite Pellets		1/4 Bucket		
1423						Bentonite Pellet Seal			0	Tagged top of bentonite pellet seal
TL 1430						REC bore - str sand 2 1/2" IL		1 100 lb bag		Pour sand through hopper, inject water through trémie pipe and into annulus simultaneously
1430	Carbon steel casing	9 5/8	120'	5'	115'					Pulled temporary casing back 2'
1431						Sand Back			0	Tagged top of sand pack
1432						Bentonite Pellets		1/2 Bucket		Unable to predevelop well - ss casing/cement string will sink w/o support from sand line
1457	Carbon steel casing	9 5/8	120'	8'	112'					Pulled temporary casing back 3'
1459	Carbon steel casing	9 5/8	115'	3'	112'					Removed 5' temporary casing, total = 115'
1500						Bentonite Pellets			0	Tagged top of bentonite pellet seal
1516						Bentonite Pellets		1/2 Bucket		
1523	Carbon steel casing	9 5/8	115'	6'	109'					Pulled temporary casing back 3'
1531						Bentonite Pellets		1/2 Bucket		
1533						Bentonite Pellets			0	Tagged top of bentonite pellet seal
1535						Sand 2 1/2" IL		1 bag		
1551	Carbon steel casing	9 5/8	115'	9'	106'					Pulled temporary casing back 3'

Project 21/ES

Rig/Equipment Speedtrak 16/Air Rotary

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COMPLETION LOG

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Measuring Equipment Procedure Rev No.

Drilling Contractor Water Dev. Corp.
Driller Jason Layton, Chuck Webber, Jon Fischer
Rig/Equipment Speedstar 16/A, Rotary

Time	Casing/Screen				Annular Fill				Over-lap	Comments
	Type	Diameter	Length	Stickup	Depth	Type	Depth	Stickup	Quantity	Add-on
0700										
0700-0720										
0730						Sand Pak	99.5'			
0740						Sand # 3/2			1/2 Bag (100 lb)	
0741						Sand Pak	95'			
0742	Carbon steel casing	9 5/8" 00	100'	6'	94'					
0744						Sand # 3/2			1/4 Bag	
0745						Sand Pak	94.5'			
0756										
0820						PEL-PAC Bentonite Pulver 3/8" 30 min	93.5'		1/4 50 lb bucket	
0834	Carbon steel casing	9 5/8	100'	0'	92'					
0839						Bentonite Pulver	93'		1/2 50 lb bucket	
0846	Carbon steel casing	9 5/8	100'	9'	91'					
0845						Bentonite Pulver	92'		1/4 50 lb bucket	
0850	Carbon steel casing	9 5/8	100'	13'	87'					
0856	Carbon steel casing	9 5/8	90'	3'	87'					
0910						Bent. Pulver Seal	90'			
0912						Sand # 3/2			1 100 lb bag	
0915						Sand Pak	84.9'			
0917	Carbon steel casing	9 5/8	90'	6'	84'					

COMPLETION LOG

Boring or Well Number UJL-01
Location LEHR

Project RI/FS

Sheet 1

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Measuring Equipment _____

Procedure _____

Rev No. _____

Drilling Contractor Wake Dev. Corp.

Driller Jason Layton, Chuck Webb, Jon Fischer

Rig/Equipment Speedstar 16 / Air Rotary

Time	Casing/Screen				Annular Fill				Over-lap	Comments
	Type	Diameter	Length	Stickup	Depth	Type	Depth	Stickup	Quantity	Add-on
0918						Sand pack	84.9'			
0920						Bentonite Pellets			1/2 50 lb bucket	
0928	Carbon steel casing	9 5/8" 00	90'	7'	83'	Bentonite Pellets	83'		1/2 50 lb bucket	
0930										
0946	Carbon steel casing	9 5/8"	90'	8'	82'	Bentonite Pellets	82'		1/2 50 lb bucket	
0948										
0950	Carbon steel casing	9 5/8"	90'	9'	81'	Bentonite Pellets	81'		1/2 50 lb bucket	
0957										
1007	Carbon steel casing	9 5/8"	90'	11'	79'	Bentonite Pellets	81'			
1009										
1009	Carbon steel casing	9 5/8"	90'	13'	77'	Bentonite Pellets	81'			
1010	Carbon steel casing	9 5/8"	80'	3'	77'					
1017										
1026										
1040						Bentonite Pellets	76'			
1050	Carbon steel casing	9 5/8"	80'	4'	76'					

A-1800-004 (05/90)

DRILL BENCH/LOG

Boring or Well Number UC02-071

Sheet 5 of 4

Project RT/FS

Drilling Contractor Water Dev. Corp.
 Driller Jason Layton, Chuck Webb, Jon Fisher
 Rig/Equipment Spectra 16/Air Rotary

Logged by T.L. Wilk
 Date 22 Sep
 Reviewed by
 Date
 Measuring Equipment
 Procedure
 Rev No.

Time	Casing/Screen				Annular Fill				Over-lap	Comments	
	Type	Diameter	Length	Stickup	Depth	Type	Depth	Stickup			Quantity
1055						Bea. Fall Seal	75'				Pellet seal has bridged b/w carbon steel and ss casings, break through bridge by adding tremic pipe, remeasure top of barbolic pellet seal @ 82'
1130 - 1200											Lunch
1200 - 1200											Cut 2' section tremic pipe to make 10'
											sections the 9-22-95
1215											1225
1228						Barbolic Pellet			1/2 50 lb bucket		
1232	Carbon steel casing	9 5/8" 00	80'	5'	75'						Pulled temporary casing back 1'
1234						Barbolic Pellet			1/4 50 lb bucket		
1237						Barbolic Pellet	76.5'		1/2 100 lb bag		Tagged top of barbolic pellet seal
1240	Carbon steel casing	9 5/8"	80'	6'	74'				1/2 100 lb bag		Pulled temporary casing back 1'
1242						Sand # 1/20			1/2 100 lb bag		Tagged top of sand pack
1247						Sand Seal	74'				
1248	Carbon steel casing	9 5/8"	80'	7'	73'				1/2 100 lb bag		Pulled temporary casing back 1'
1249						Sand # 1/20			1/2 100 lb bag		Tagged top of sand pack
1251	Carbon steel casing	9 5/8"	80'	8'	72'						Pulled temporary casing back 1'
1253						Sand pack	72.6'				Tagged top of sand pack
1255						Sand # 1/20			1/4 100 lb bag		
1256	Carbon steel casing	9 5/8"	80'	9'	71'						Pulled temporary casing back 1'

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Measuring Equipment

Date 22 Sep 95

Date _____

Rev No.

Drilling Contractor Wake Dev. C-p.

Driller Jason Layton, Chucho Webber, Jon Fischer

Rig/Equipment	Speedster 16/Air Rotary
---------------	-------------------------

Time	Casing/Screen				Annular Fill					Over-lap	Comments	
	Type	Diameter	Length	Stickup	Depth	Type	Depth	Stickup	Quantity			Add-on
1299						Sand pack	71.5'				0	Tagged top of sand pack
1300	Carbon steel casing	9 5/8" OD	80'	13'	67'							Pulled temporary casing back 4'
1301	Carbon steel casing	9 5/8"	70'	3'	67'							Removed 10' temporary casing, total = 70'
1305						Sand Pack	73'				0	Sand pack settled
1320						Sand 2' 1/2"			2 1/4 100 lb bags			
1325						Sand pack	71.5'				0	Tagged top of sand pack
1330						Bentonite Pellets			2 50 lb Buckets			
1350						Bent. Pellet Seal	67.5'					Tagged top of bentonite pellet seal
1354	Carbon steel casing	9 5/8"	70'	5'	65'							Pulled temporary casing back 2'
1357						Bentonite Pellets			1/2 50 lb bucket			
1359						Bent. Pellet Seal	66.5'				0	Tagged top of bentonite pellet seal
1401						Sand #1/20			1 1/2 100 lb bags			
1410	Carbon steel casing	9 5/8"	70'	13'	57'							Pulled temporary casing back 8'
1418	Carbon steel casing	9 5/8"	60'	3'	57'							Removed 10' of temporary casing, total = 60'
1424												Removed 21' of tritic pipe, total = 52'
1437						Sand #1/20	63'		1 100 lb bag			Tagged top of sand pack
1445						Sand pack	61.5'				0	Tagged top of sand pack
1446						Bentonite Pellets			1 50 lb Bucket			
1458						Bent. Pellet Seal	60'					Tagged top of bentonite pellet seal
1500												Shut down, clean up site

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Print	Sign	Print	Sign	Procedure	Rev No.
William Schaal (17)	William Schaal				
Date 8/25/95	Date 8/25/95				
<div> <div>Drilling Contractor</div> <div>Jayson Layton</div> <div>Spradenton 16/412 Rotary</div> </div>					
Time					
Casing/Screen		Annular Fill			
Diameter	Length	Stickup	Depth	Type	Quantity
Add-on					
Over-lap					
Comments					
<p>Arrive at field office. Review daily here</p> <p>Log generated by T. Lika on 8/22/95</p> <p>UCD-2-237 requires completion from</p> <p>0-60 ft. Includes 2 screened intervals.</p> <p>Critical advise placement of bent rod</p> <p>above filter pack (~52 ft bgs)</p> <p>collimate CID</p> <p>Taggart mty + HZUP signature from</p> <p>Case.</p>					

Logged by William Schaal (IT) William Schaal Date 9/25/95
 Print Sign
 Reviewed by _____ Date _____
 Print
 Measuring Equipment fiberglass tape measure Procedure Introduce materials w/ tremie: H₂O inject bent pellet and grout Rev No. _____

Drilling Contractor Water Dev Corp
 Driller Jayson Layton
 Rig/Equipment Speedston 16/All Rotary

Time	Casing/Screen					Annular Fill					Over-lap	Comments
	Type	Diameter	Length	Stickup	Depth	Type	Depth	Stickup	Quantity	Add-on		
0745	carbon steel	9 5/8"	60'	3'	57'	bentonite pellet	60'					Tagged top of bentonite. Agrees w/ final measurement by T. Liikala 9/23/95. Pellets carried downhole w/ water (Injection). Provides 55' pellets. Pellets = sugar-coated pellets.
0810						bentonite pellet	58'		1.5 bucket		o	
0820						↓	57.5'		↓		o	
			60'	5'	55'							Pulled casing 2 ft upward drill
0830						* 1/20 sand	54.0'		2 1/4 100lb bag			Tagged top of sand. Sand carried w/ H ₂ O inject. Pulled drill casing 2 ft upward
			60'	7'	53'	↓						
0835							51.0'					Provides 6 ft of sand. This is 1 ft more than desired! Pulled drill casing 6 ft upward
			60'	13'	47'							
0840			45'	3'	47'							Removed 15 feet of drill casing
0850							51.5'		2 1/4 buckets			Tagged top of sand. Filter pack settled * (after casing pull) to planned interval.
0858						bentonite pellet	50.0'					Pellets carried w/ H ₂ O inject.
0900						↓	49.0'					Tagged top of pellets. Provides 2.5' seal between filter pack and grout. Pellets = sugar coated
												* NOTE: this seal NOT part of original well design. T. Liikala gave instructions 9/23/95 to install this seal. PURPOSE: Assure that grout does not invade or infiltrate filter pack of top screened interval.
0905			0'	0'	0'	grout	3'		8 50lb bags			Grout mix: 8 bags (50lb/bag) + ~ 100 gal H ₂ O tremied down hole. Casing pulled increment during grouting top surface near
	permanent SS well casing	5"		3'								3' stick-up of well casing in temporary. Facilitate further construction.
												END

AS-BUILT DIAGRAM			Boring or Well Number <u>UCD2-026</u>		Sheet <u>1</u> of <u>2</u>	
			Location <u>Univ. of California-Davis</u>		Project <u>LEHR RI/FS</u>	
Logged by <u>Terry Liikala (PNL)</u>			Date Well Started <u>09-13-95</u>			
Reviewed by _____ Date _____			Date Well Completed <u>10-06-95</u>			
Well Construction Data			Geologic / Hydrologic Data			
			Sample Method			
Depth (ft)	Description	Construction Diagram	Depth in Feet	Lithologic Diagram	Depth (ft)	Lithologic Description
+4-101	Carbon Steel Casing, 9 5/8" OD - temporary		0		0	Original Ground Surface
0.4-2	Concrete w/8-in dia. well vault		5			
2-4	PEL-PLUG Bentonite Pellets, 3/8"		10			
4-79	Pure Gold Grout		15			
1-87	4-in dia., 304, Sch 10 SS Casing		20		18-19.5	Silty Clay
			25			
			30			
			35			
			40			
			45		41.99' (10-12-95)	Sample collected from 38.5'-40'. No excess core available for lithologic description.
			50			
			55			
			60		58-59.5	Silty Clay
			65			
			70			
			75			
79-84	Baroid Bentonite Pellets, 3/8"		80		78-79.5	Clayey Silty Sand
84-102	RMC Lonestar Sand, #2/12		85			
87-102	4-in dia., 20-slot SS Screen		90		88-89.5	Gravelly Sand

Drill Bit / Sample Method Used:

☐ Rotary
 ☒ Air Rotary
 ☒ Mud Rotary
 ☒ Air Percussion
 ☐ Back Hoe
 ☐ Auger
 ☐ Drive Sampler
 ☐ Hard Tool
 ☐ Split-Barrel

AS-BUILT DIAGRAM			Boring or Well Number <u>UCD2-026</u> Sheet <u>2</u> of <u>2</u>		
			Location <u>Univ. of California-Davis</u> Project <u>LEHR RI/FS</u>		
Logged by <u>Terry Liikala (PNL)</u>			Date Well Started <u>09-13-95</u>		
Reviewed by _____ Date _____			Date Well Completed <u>10-06-95</u>		
Well Construction Data			Geologic / Hydrologic Data		
Depth (ft)	Description	Construction Diagram	Depth in Feet	Sample Method	
				Lithologic Diagram	Depth (ft)
	End Cap		<div style="text-align: center;"> ☒ </div> <div style="text-align: center;">95</div> <div style="text-align: center;">100</div> <div style="text-align: center;">105</div>		
NOTES: 1) All casing is flush threaded. 2) Couplings are 304, Sch 40 Stainless Steel. 3) Depth of screen placement was determined by examination of lithologic logs.					

Drill Bit / Sample Method Used:
☐ Rotary
 ☒ Air Rotary
 ☐ Mud Rotary
 ☐ Air Percussion
 ☐ Back Hoe
 ☐ Auger
 ☐ Drive Sampler
 ☐ Hard Tool
 ☐ Split-Barrel

WELL COMPLETION SUMMARY

Page 1 of 1

Project RI/FS
 Location LEHR, Univ. of CA - Davis
 Drilling Co. Water Development Corp.
 Driller Jason Layton, Chuck Webber, Jon Fischer
 Other (companies) Harris Concrete
 Geologist(s) Terry Liikala (PNL)

Well No. UCD2-026 Temp. Well No. _____
 Coordinates _____
 Elevation: Casing _____ Survey Marker _____

DRILLING METHOD

Drilling Method(s) Air Rotary
 Drilling Fluid Air, Water
 Other _____

COMPLETION DATA

Drilled Depth 102'
 Completed Depth 102'
 Date Started 09-13-95
 Date Completed 10-06-95
 Static Water Level/Date 41.99' (a) / 10-12-95

OTHER (check if performed)

Well Abandonment _____ Manhole Cover _____
☒ Well Development _____ Pad w/Manhole Cover _____
☒ Aquifer Testing ☒ Protective Casing w/Pad _____
 Geophysical Log(s) _____ ☒ Locking Cap _____

SCREEN

Type	Outer Diameter	Length	Slot Size	Interval
304 Stainless Steel, flush threaded	4"	15'	20	87' - 102'

TEMPORARY CASING

Type	Nominal Diameter	Max. Outer Diameter	Interval
Carbon Steel (flush threaded)	8 5/8" ID	9 5/8"	+4' - 101'

PERMANENT CASING

Type	Nominal Diameter	Max. Outer Diameter	Interval
304 Stainless Steel, SCH 10, flush threaded	4"		1' - 87'

ANNULAR SEAL/FILL

Type	Interval	Quantity	Volume
RMC Lonestar Sand, #2/12	84' - 102'	8 100-lb bags	
Baroid Bentonite Pellets, 3/8"	79' - 84'	1.75 50-lb buckets	
Pure Gold Grout	4' - 79'	(b)	
PEL-PLUG Bentonite Pellets, 3/8", 30 min	2' - 4'		

PUMP

Type _____ Depth to Inlet _____ Date Set _____

ACCEPTANCE

Completed Well: Accept _____ Conditionally Accept _____
 Reject _____

COMMENTS

(a) Static water level measured from lip of well vault.
 (b) Used grout from UCD1-025 batch to top off UCD2-026 after grout had settled.

Reviewed by _____ Date _____ Depths are below land surface unless noted.

Drilling Contractor Water Dev. Corp.

Date _____

Driller Taser Layton, Chuck Webber, Jon Fischer

Rev No.

Rig/Method Speedstar 16/Air Rotary

Measuring Equipment

A.51

Depth 18 - 40 Sheet 1 of 3
Project RI/FS

Drilling Contractor Water Dev. Co.-p.

Driller Jason Layton, Chuckle Webber, Joe Fischer

Rig/Method Speeds - 16 / Air Rotary

TIME	H ₂ O ADDED	CASING	DRILLING COMMENTS (DOWLING RATE, DOWN TIME, BLOW COUNTS, WATER LEVEL, DRILL FLUID, ETC)
100			Drillers onsite
00-1220			Tailgate Safety mtg.
130-0000			Replace seal at top of drill stem
00-0830			Set up to collect drive sample
0830			4 Blows 1st 6"
			5 Blows 2nd 6"
			8 Blows 3rd 6"
			Core sample collected with drive
			Sampler (drilling jar)
0845	Water added continuously	4' set the quartz	Add 20' carbon steel casing, total casing = 40', resume drilling
0910			Set up to collect drive sample
0920			5 Blows 1st 6"
			6 Blows 2nd 6"
			14 Blows 3rd 6"
			Core sample collected with drive
			Sampler (drilling jar)
			Allow several minutes to vent (~10 minutes)
0930		60'	Add 20' carbon steel casing, total casing = 60', resume drilling

DAILY BOREHOLE LOG

Boring or Well Number UCD2-026
Location LEHRDepth 40 - 90' Sheet 2 of 3
Project RI/FSLogged by T.L. Liikala
Print [Signature] Sign [Signature] Date 14 Sep 95Reviewed by _____
Print _____ Sign _____ Date _____

Lithologic Classification Scheme _____ Procedure _____ Rev No. _____

Measuring Equipment _____

Drilling Contractor Water Dev. Corp.
Driller Tason Layton, Chuck Webber, Son Fiechal
Rig/Method Speedstar 16 / Air Rotary

DEPTH	SAMPLES		CONTAMINATION		MOIS- TURE	GRAPHIC LOG	LITHOLOGIC DESCRIPTION (PARTICLE SIZE DIST., SORTING, MINERALOGY, ROUNDNESS, COLOR, REACTION TO HCL, ETC.)	TIME	H ₂ O ADDED	DRILLING COMMENTS (DRILLING RATE, DOWN TIME, BLOW COUNTS, WATER LEVEL, DRILL FLUID, ETC.)	
	TYPE	NO.	INSTRUMENT	READING						CASING	
			Breathalyzer Spencer PID	0.0 ppm				0950			
58'								1000			Break, Ret to take small samples
								1030			Set up to collect drive sample
58-59.5' core		SSCL1001			W		silty clay, 2.5V 4/4 olive brown, mottled gray clay/silt intermixed 10YR5/1, gray, 20% silt, 80% clay	1040			4 Blows 1st 6"
			PID	0.0 ppm							12 Blows 2nd 6"
			PAM	2-6 cpm							14 Blows 3rd 6"
			GM	25-54 cpm							core sample collected with drive sampler (drilling jar)
								1050			80' Add 20' carbon steel casing, total casing ~ 80', resume drilling
	Well Head		PID	0.0 ppm				1125			Set up to collect drive
	Breathalyzer Spencer		PID	0.0 ppm				1140			sample, switch from tri-cone to drag bit
78-79.5' core		SSCL1002			W		Clayey silty sand, 10YR 4/3 brown to dark brown, 20% clay, 30% silt, 50% fine sand	1153			5 Blows 1st 6"
			PID	0.0 ppm							6 Blows 2nd 6"
			PAM	1-11 cpm							15 Blows 3rd 6"
			GM	25-44 cpm							core sample collected with drive sampler (drilling jar)
								1205			90' Add 2 5' sections of carbon steel casing, total casing ~ 90'

DAILY BOREHOLE LOG

Boring or Well Number UCD 2-026

Depth 90' - 102' Sheet 3 of 3

Location LEHR

Project RI/FS

Logged by T. L. Lilkens
Print

[Signature]
Sign

Date 14 Sep 95

Drilling Contractor Wake Dev. Corp.

Reviewed by _____
Print

Sign

Date _____

Driller Sason Layton, Chick Webber, Jan Fischer

Lithologic Classification Scheme _____

Procedure _____

Rev No. _____

Rig/Method Speedstar 16/ A. Relay

Measuring Equipment _____

DEPTH	SAMPLES		CONTAMINATION		MOIS- TURE	GRAPHIC LOG	LITHOLOGIC DESCRIPTION (PARTICLE SIZE DIST., SORTING, MINERALOGY, ROUNDNESS, COLOR, REACTION TO HCL, ETC.)	TIME	H ₂ O ADDED	DRILLING COMMENTS (DRILLING RATE, DOWN TIME, BLOW COUNTS, WATER LEVEL, DRILL FLUID, ETC.)	
	TYPE	NO.	INSTRUMENT	READING						CASING	
								1215- 1245			Lunch
								1315			Resume drilling
								1345			Set up to collect drive sample
88-89'	Core	SSCL 2004			W		Gravelly Sand. 25% Gravel, 75% Sand,	1400			3 Blows 1st 6"
			PID	0.0 ppm			gravel are small to medium pebbles, sand is				7 Blows 2nd 6"
			PAM	1-3 cpm			fine to coarse, gravel are predominantly				17 Blows 3rd 6"
			GM	30-34 cpm			subrounded, 50% matrix, 50% quartz rich,				core sample collected with
							sand color. 10YR 3/3 dark brown				drive sampler (drilling jar)
								1420		100'	Add 2 5' sections of carbon
											steel casing, total casing = 100'
											resume drilling
								1435		105'	Add 5' carbon steel casing,
											total casing = 105', resume
											drilling
102'	Bringing up		0.0 ppm					1451			Set up to collect drive sample
	PID							1525			D/B = 87' bgs, hole heaved
											when tripping out, set up to
											bail well using sand bailer, fill
											water truck
								1540- 1700			Bail well, fill ^{bottom} w/water to
											increase hydrostatic head
											D/B = 92' bgs

DIY BOREHOLE LOG

BOILING OR WELL NUMBER

546

sheet

Location LEHR

Project RI/FS

Logged by T.L. Liikala
Print

Date 15 Sep 95

Drilling Contractor Wake Dev. Corp.

Reviewed by _____ Print _____

Sign

Date _____

Lithologic Classification Scheme _____ Procedure _____ Rev No. _____

Driller Jason Layton, Chuck Webber, Jon Fischer

Rig/Method Speedstar 16 / Air Rotary

Measuring Equipment

[illegible]

W = wet, M = moist, D = dry

Logged by T.L. Little Print Sign 15 Sep 95 Date

Reviewed by _____ Print Sign _____ Date

Measuring Equipment _____ Procedure _____ Rev No. _____

Drilling Contractor W&L Dev. Corp.
Driller Jason Layton, Chuck Webster, Jon Fitcher
Rig/Equipment Specter 16 / Air Raker

Time	Casing/Screen				Annular Fill				Over-lap	Comments	
	Type	Diameter	Length	Stickup	Depth	Type	Stickup	Quantity			Add-on
1330	Carbon steel casing	9 5/8"	105'	4'	101'						Grind centralizers sufficiently such that they pass through drill collar
1348-1426	Stainless steel	4"	15'	Sum	(20 ell) + bottom cap						Make threads down, flush threads
		4"	40'	casing	w/centralizers						
		4"	20'	casing							
		4"	1'	casing	w/centralizers						
		4"	20'	casing							
		4"	20'	casing							
		4"	20'	casing							
		4"	20'	casing							
		4"	5'	casing							
		4"	5'	casing							
											Total casing = 105', temporary cleanup = 3' 10" above ground surface
											Engst water simultaneously with pouring sand
											Pull temporary casing 1'
											Pull temporary casing 1'
1439	Carbon steel casing	9 5/8"	105'	5'	100'						
1440											
1441	Carbon steel casing	9 5/8"	105'	6'	99'						
1442											
1443	Carbon steel casing	9 5/8"	105'	9'	96'						
1444	Carbon steel casing	9 5/8"	100'	4'	96'						
1445											
1446											
1447	Carbon steel casing	9 5/8"	100'	1'	94'						

Project RI/CS

Drilling Contractor Water Dev. Corp.
Driller Jason Layton, Chuck Webster, Jon Fischer
Rig/Equipment Speedstar 16 / Air Poling

A-1800-004 (05/90)

COMPLETION LOG

Boring or Well Number UCD-04 Location LEH2

Sheet 1 of 5 Project AI/PS

Logged by T. L. Little Date 10/24/95 Sign [Signature]
 Reviewed by _____ Date _____ Sign _____
 Measuring Equipment _____ Procedure _____ Rev No. _____

Drilling Contractor Walt Dev. Corp.
 Driller Jason Layton, Chris Webb, Jon Fiske
 Rig/Equipment Spudco 16/A-1 Rotary

Time	Casing/Screen					Annular Fill					Over-lap	Comments
	Type	Diameter	Length	Stickup	Depth	Type	Depth	Stickup	Quantity	Add-on		
0700-0715												Driller on site
0740	Carbon steel casing	9 5/8"	95'	4'	91'	Sand pack	89'				4'	Tailgate safety mfg.
0740	Carbon steel casing	9 5/8"	95'	6'	89'	Disc wire - 5/8" sand 1 1/2"						Pulled temporary casing back 2'
0741									1 bag			
0750						Sand pack	84'				5'	Tagged top of sand
0752	Carbon steel casing	9 5/8"	95'	9'	86'							Pulled temporary casing back 3'
0753	Carbon steel casing	9 5/8"	90'	4'	86'						1'	Removed 5' of temporary casing, total = 90'
0754						Sand pack	85'					
0755						Sand pack 1/2"			1 bag			
0759	Carbon steel casing	9 5/8"	90'	6'	84'							Pulled temporary casing back 2'
0803						Sand pack	83'				1'	
0804												Begin predevelopment using SC well valve
												barrier, bails hooked on shoulder w/
												upstream sections of stainless steel casing
												and pulled SS casing and screen partially
												out of the hole
0816-0825												Remove stainless steel casing and screen
0828												Rig up to redrill hole to 102'
0838-0900												Redrill hole to 102', add 15' temporary
0900-1130												steel casing
												clean out borehole w/ sand pump, 0/6-99'

Logged by T.L. Little
Reviewed by _____
Measuring Equipment _____
Date 18 Sep 95
Rev No. _____
Sign _____
Procedure _____
Sign _____
Date _____
Rev No. _____

Drilling Contractor Water Dev. Corp.
Driller Jason Lighter, Chuck Webber, Jon Fisher
Rig/Equipment Speedster 10/ air rotary

Time	Casing/Screen				Annular Fill				Over-lap	Comments
	Type	Diameter	Length	Stickup	Depth	Type	Stickup	Quantity	Add-on	
1140-										Lunch
1200-										
1205-										Clean out borehole w/sand pump, D/B = 102'
1215-										Reset ss casing and screen as previously described (same configuration)
1230	Carbon steel casing	9 5/8"	105'	4'	101'			2 100 lb bags		Inject water simultaneously
1240	Carbon steel casing	9 5/8"	105'	5'	100'					Pull temporary casing back 1'
1240						Sand 1/2"		2 bags		
1241	Carbon steel casing	9 5/8"	105'	6'	99'					Pull temporary casing back 1'
1241						Sand pack	90'			Tagged top of sand pack
1242	Carbon steel casing	9 5/8"	105'	9'	96'					Pull temporary casing back 3'
1242						Sand pack	93'			Tagged top of sand pack
1243	Carbon steel casing	9 5/8"	100'	4'	96'					Removed 5' of temporary casing, total = 100'
1244						Sand 1/2"		1 bag		
1247	Carbon steel casing	9 5/8"	100'	9'	91'					Pull temporary casing back 5'
1248	Carbon steel casing	9 5/8"	95'	4'	91'					Removed 5' of temporary casing, total = 95'
1251						Sand pack	88'			Tagged top of sand pack
1251						Sand 1/2"		2 bags		
1254						Sand pack	86'			Tagged top of sand pack
1256	Carbon steel casing	9 5/8"	95'	7'	89'					Pull temporary casing back 3'
1257						Sand 1/2"		1 bag		
1258	Carbon steel casing	9 5/8"	95'	9'	86'					Pull temporary casing back 2'

DAILY BOREHOLE/WELL COMPLETION LOG

Boring or Well Number UCD-2-02L
Location LEHR

Sheet 3 of 5
Project RT/CS

Logged by T. L. Wilkins
Reviewed by _____
Measuring Equipment _____
Date 10/29/95 Sign _____
Rev No. _____

Drilling Contractor Wake Dev. Corp.
Driller Jason Layton, Chuck Weber, Jan Fiedke
Rig/Equipment Spectra 16/Air Ruler

Time	Casing/Screen				Annular Fill				Over-lap	Comments
	Type	Diameter	Length	Depth	Type	Depth	Stickup	Quantity	Add-on	
129'	Carbon steel casing	9 5/8" OD	90'	4'	86'					Removed 5' of temporary casing, total = 90'
130'					Sand pack	81'				Tagged top of sand pack
1304'	Carbon steel casing	9 5/8"	90'	6'	84'					Pulled temporary casing back 2'
1306'					Sand pack	81'				Tagged top of sand pack
1315'										Predevelopment well using 2" dia ss man
1345'										Valve baller, bailed ~ 75 gal
1350'					Sand pack	82.5'				Tagged top of sand pack
1350-1359'										Gurge well to get sand pack to settle
1400'					Sand pack	84'				Tagged top of sand pack
1405'					Bailed baller Packed pellets 3/8" dia.			1/2 Bucket 25 lbs		Inlet water simultaneously
1407'	Carbon steel casing	9 5/8"	90'	7'	83'					Pulled temporary casing back to 1'
1414'					Bentonite sand pack in 400-45					Tagged top of bentonite pellet seal
1416'					Bentonite pellets			1 Bucket		
1418'	Carbon steel casing	9 5/8"	90'	9'	81'					Pulled temporary casing back 2'
1419'	Carbon steel casing	9 5/8"	85'	4'	81'					Removed 5' of temporary casing, total = 85'
1421'					Bentonite pellets					Tagged top of bentonite pellet seal
1422'					Bentonite pellets			1/4 Bucket		
1423'					Bentonite pellets					Tagged top of bentonite pellet seal
1425'	Carbon steel casing	9 5/8"	85'	9'	76'					Pulled temporary casing back 5'
1446'	Carbon steel casing	9 5/8"	80'	4'	76'					Removed 5' of temporary casing, total = 80'

DAI' BOREHOLE/WELL COMPLETION LOG

Boring or Well Number UCD 2-02/
Location LEHR

Sheet 4 of 5

Project RI/FS

Logged by T.L. Liikala Date 18 Sept 95
Print Sign
Reviewed by _____ Date _____
Print Sign
Measuring Equipment _____ Procedure _____ Rev No. _____

Drilling Contractor Water Dev. Corp.
Driller Jason Layton, Chuck Welton, Jan Fischer
Rig/Equipment Spindeler 16/ Air Rotary

Time	Casing/Screen					Annular Fill					Over-lap	Comments
	Type	Diameter	Length	Stickup	Depth	Type	Depth	Stickup	Quantity	Add-on		
1428	Carbon steel casing	9 5/8" OD	80'	7'	73'							Pulled temporary casing back 3'
1429						Bentonite Pellets	79'				0	Tagged top of bentonite pellet seal
1430-1455												Rig up to install Volclay GROUT Seal
1505	Carbon steel casing	9 5/8	80'	25'	55'							Pulled temporary casing back 18'
1507	Carbon steel casing	9 5/8	60'	5'	55'							Removed 20' of temporary casing, total = 60'
1510												Installed 70' of 1.5" tremie pipe
1512-						Pure Gold Grout			5 50 lb Bags			Mixed 5 50 lb bags w/ ~ 70-75 gal water
1519												per directions on product, 30% solids
												in horse trough, pumped downhole through
												tremie pipe (14.4 gal per 50 lb bag)
1519-1528												Remove tremie pipe
1529	Carbon steel casing	9 5/8	60'	25'	35'							Pulled temporary casing back 20'
1530	Carbon steel casing	9 5/8	40'	5'	35'							Removed 20' of temporary casing, total = 40'
1533	Carbon steel casing	9 5/8	40'	25'	15'							Pulled temporary casing back 20'
1535	Carbon steel casing	9 5/8	20'	5'	15'							Removed 20' of temporary casing, total = 20'
1544						Pure Gold Grout			6 50 lb Bags			Mixed 6 50 lb bags w/ ~ 85-90 gal water
												per product directions for 30% solids in
												horse trough, pump downhole through tremie
												pipe (14.4 gal per 50 lb bag)
1550	Carbon steel casing	9 5/8										Removed remaining 20' of temporary casing
1604						Pure Gold Grout	4'		6 50 lb Bags			Mixed 6 50 lb bags w/ ~ 85-90 gal water per
												product directions for 30% solids in horse
												trough, pump downhole through A-1800-004 (05/90)
												tremie (14.4 gal per 50 lb bag)

Sheet 5 of 5

Project RI / FS

Date 18 Sep 95

Sign

Date _____

Procedure

Rev No.

Drilling Contractor Water Des. Corp.

Driller Jason Layton Chuck Webber Jon Fischer

Rig/Equipment Speedstar 16/ Air Rotary

[illegible]

AS-BUILT DIAGRAM

Boring or Well Number UCD1-025

Sheet 1 of 1

Location Univ. of California-Davis

Project LEHR RI/FS

Logged by Terry Liikala (PNL)

Date Well Started 09-19-95

Reviewed by _____ Date _____

Date Well Completed 10-06-95

Well Construction Data			Geologic / Hydrologic Data		
Depth (ft)	Description	Construction Diagram	Depth in Feet	Sample Method	
				Lithologic Diagram	Lithologic Description
+4-76	Carbon Steel Casing, 9 5/8" OD - temporary		0		0 Original Ground Surface
0.1-2	Concrete w/8-in dia. well vault				NOTE: See well UCD2-027 As-Built Diagram for lithologic description.
2-4	PEL-PLUG Bentonite Pellets, 3/8"				
4-52	Pure Gold Grout				
1-60	4-in dia., 304, Sch 10 SS Casing				
			41.96' (10-12-95)		
52-56.9	Baroid Bentonite Pellets, 3/8"				
56.9-75	RMC Lonestar Sand, #1/20				
60-75	4-in dia., 10-slot SS Screen				

WELL COMPLETION SUMMARY

Page 1 of 1

Project RI/FS
 Location LEHR, Univ. of CA - Davis
 Drilling Co. Water Development Corp.
 Driller Jason Layton, Chuck Webber, Jon Fischer
 Other (companies) Harris Concrete
 Geologist(s) Terry Liikala (PNL)

Well No. UCD1-025 Temp. Well No. _____
 Coordinates _____
 Elevation: Casing _____ Survey Marker _____

DRILLING METHOD

Drilling Method(s) Air Rotary
 Drilling Fluid Air, Water
 Other _____

COMPLETION DATA

Drilled Depth 75'
 Completed Depth 75'
 Date Started 09-19-95
 Date Completed 10-06-95
 Static Water Level/Date 41.96' (a) / 10-12-95

OTHER (check if performed)

Well Abandonment _____ Manhole Cover _____
☒ Well Development _____ Pad w/Manhole Cover _____
☒ Aquifer Testing ☒ Protective Casing w/Pad _____
 Geophysical Log(s) _____ ☒ Locking Cap _____

SCREEN

Type	Outer Diameter	Length	Slot Size	Interval
304 Stainless Steel, flush threaded	4"	15'	10	60' - 75'

TEMPORARY CASING

Type	Nominal Diameter	Max. Outer Diameter	Interval
Carbon Steel (flush threaded)	8 5/8" ID	9 5/8"	+4' - 76'

PERMANENT CASING

Type	Nominal Diameter	Max. Outer Diameter	Interval
304 Stainless Steel, SCH 10, flush threaded	4"		1' - 60'

ANNULAR SEAL/FILL

Type	Interval	Quantity	Volume
RMC Lonestar Sand, #1/20	56.9' - 75'	9 100-lb bags	
Baroid Bentonite Pellets, 3/8"	52' - 56.9'	2 50-lb buckets	
Pure Gold Grout	4' - 52'		
PEL-PLUG Bentonite Pellets, 3/8", 30 min	2' - 4'		

PUMP

Type _____ Depth to Inlet _____ Date Set _____

ACCEPTANCE

Completed Well: Accept _____ Conditionally Accept _____
 Reject _____

COMMENTS

(a) Static water level measured from lip of well vault.

DAIL, BOREHOLE LOG

Boring or Well Number UCD 1-025

Depth 0 - 75' Sheet 1 0 1

Location LEHR

Project RT/FS

Logged by T.L. Liikala
Print

Date 19 Sep 95

Drilling Contractor Wah Dev. Corp.

Reviewed by _____ Print _____

Date _____

Driller Jason Layton, Chuck Webber, Jon Fischer

Lithologic Classification Scheme _____ Procedure _____ Rev No. _____

Rig/Method Speedstar 16/ Air Rotary

Measuring Equipment

[illegible]

W = wet M = moist D = dry

COMPLETION LOG

Boring or Well Number UCD 1 - 025Sheet 1 of 2Location LEHRProject RE/RSLogged by T.L. Liikala

Print

Sign

Date 19 Sep 95

Reviewed by

Print

Sign

Date

Measuring Equipment

Procedure

Rev No.

Drilling Contractor Water Dev. Corp.Driller Jason Layton, Chuck Webber, Jon FischerRig/Equipment Speedstar 16/Air Rata-6

Time	Casing/Screen					Annular Fill					Over-lap	Comments
	Type	Diameter	Length	Stickup	Depth	Type	Depth	Stickup	Quantity	Add-on		
1507	Carbon steel casing	9 5/8" OD	80'	4'	76'							
1512-1528	Stainless steel	4"	15'	screen	(10 slot) + bottom cap							Male threads down, flush threaded
		4"	1'	casing	w/centralizers							
		4"	20'	casing								
		4"	20'	casing								
		4"	10'	casing								
		4"	5'	casing								
		4"	3'	casing								
		4"	5'	casing								Total stainless steel casing = 79', temporary stickup = 3' 5"
1532						BMC core-sand #1/2			3 100 lb Bags			Inject water simultaneously
1536	Carbon steel casing	9 5/8"	80'	6'	74'							Pulled temporary casing back 2'
1537						Sand #1/2			1 bag			
1538	Carbon steel casing	9 5/8"	80'	7'	71'							Pulled temporary casing back 3'
1539	Carbon steel casing	9 5/8"	75'	4'	71'							Removed 5' of temporary casing, total = 75'
1542						Sand pack	68'				3'	Tagged top of sand pack
1543						Sand #1/2			2 bags			
1546	Carbon steel casing	9 5/8"	75'	9'	66'							Pulled temporary casing back 5'
1547	Carbon steel casing	9 5/8"	70'	4'	66'							Removed 5' of temporary casing, total = 70'
1550						Sand pack	61'				5'	Tagged top of sand pack
1552	Carbon steel casing	9 5/8"	70'	10'	60'							Pulled temporary casing back 6'

A-1800-004 (05/90)

IMPLETION LOG

Location LEH2

Project RI/FS

Logged by T.L. Little
 Reviewed by _____
 Measuring Equipment _____
 Date 1994
 Date _____
 Rev No. _____

Drilling Contractor Wark Dev. Corp.
 Driller Jason Layton, Chuck Webb, Jon Fiske
 Rig/Equipment Spudster 16/Air Rotary

Time	Casing/Screen				Annular Fill				Over-lap	Comments		
	Type	Diameter	Length	Stickup	Depth	Type	Depth	Stickup				
1554	Carbon steel casing	9 5/8" OD	65'	5'	60'					Removed 5' of temporary casing, hole = 65'	0	Tagged top of sand pack
1555						Sand pack	62'					
1557						Sand # 1/2			2 bags			
1603	Carbon steel casing	9 5/8	65'	10'	55'							Pulled temporary casing back 5'
1604	Carbon steel casing	9 5/8	60'	5'	55'							Removed 5' of temporary casing, hole = 60'
1606						Sand pack	58.5'				0	Tagged top of sand pack
1608						Sand # 1/2			1 1/2 bag			
1609						Sand pack	57.5'				0	Tagged top of sand pack
1610						Sand # 1/2			1 1/2 bag			
1611						Sand pack	57'				0	Tagged top of sand pack
1612-1635												Predevelopment well using 3" dia. ss ball valve
1636						Sand pack	56.9' TC	56.9' TC			0	Tagged top of sand pack
1637-1705												Shut down, clean up site

COMPLETION LOG

Location LEHRProject RI/ESLogged by T.L. Liikala Date 20 Sep 95
Print SignReviewed by _____ Date _____
Print Sign

Measuring Equipment _____ Procedure _____ Rev No. _____

Drilling Contractor Wake Dev. Corp.Driller Jason Layton, Chuck Webber, Jon FischerRig/Equipment Speedstar 16/Air Rotary

Time	Casing/Screen					Annular Fill					Over-lap	Comments
	Type	Diameter	Length	Stickup	Depth	Type	Depth	Stickup	Quantity	Add-on		
0700												Driller onsite
0700-0720												Tailgate safety mtg.
0735												Tagged top of sand pack
0740	Carbon steel casing	9 5/8" OD	60'	15'	45'	Sand pack	56.9'					Pulled temporary casing back 10'
0743	Carbon steel casing	9 5/8"	50'	5'	45'							Removed 10' of temporary casing, total = 50'
0746						Bentonite Pellets 3/8"			2 50 lb Buckets			
0748						Bent. Pellets	52'				0	Tagged top of bentonite pellet seal
0750	Carbon steel casing	9 5/8"	50'	15'	35'							Pulled temporary casing back 10'
0751	Carbon steel casing	9 5/8"	40'	5'	35'							Removed 10' of temporary casing, total = 40'
0755												Set tremie pipe, rig up to mix grout
0800						Pure Gold Grout			8 50 lb bags			Mixed 8 50 lb bags w/ ~ 115 gal water per product directions for 30% solids in bore
												tough, pump downhole through tremie
0818	Carbon steel casing	9 5/8"	40'	25'	15'							Pulled temporary casing back 20'
0819	Carbon steel casing	9 5/8"	20'	5'	15'							Removed 20' of temporary casing, total = 20'
0821	Carbon steel casing	9 5/8"										Removed remaining 20' of temporary casing
0825												Rig down
0843						Pure Gold Grout	4'		4 50 lb bags			Mixed 4 50 lb bags w/ ~ 53 gal water per product directions for 30% solids in bore
												tough, pump downhole through tremie
												(14.4 gal per 50 lb bag), topped off
												UCD2-026 (grout settled after previous pour)

A-1800-004 (05/90)

Project 121/ES

Logged by T. L. Liikala Print Sign Date 20 Sep 95

Reviewed by _____ Print _____ Sign Date _____

Measuring Equipment _____ Procedure _____ Rev No. _____

Drilling Contractor Water Dev. Corp.
Driller Jason Layton, Chuck Webber, Jon Fisher
Rig/Equipment Speedstar 16 / Air Rotary

[illegible]

AS-BUILT DIAGRAM

Boring or Well Number UCD2-035

Sheet 2 of 2

Location Univ. of California-Davis

Project LEHR RI/FS

Logged by Bill Schaal (IT)

Date Well Started 09-26-95

Reviewed by _____ Date _____

Date Well Completed 10-06-95

Drill Bit / Sample Method Used:

☐ Rotary

☒ Air Rotary

☐ Mud Rotary

☐ Air Percussion

☐ Back Hoe

☐ Auger

☒ Grab Sample

☒ Continuous Core Sampler

☐ Drive Sampler

☐ Hard Tool

☐ Split-Barrel

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WELL COMPLETION SUMMARY

Page 1 of 1

Project RI/FS
 Location LEHR, Univ. of CA - Davis
 Drilling Co. Water Development Corp.
 Driller Jason Layton, Chuck Webber, Jon Fischer
 Other (companies) Harris Concrete
 Geologist(s) Bill Schaal (IT)

Well No. UCD2-035 Temp. Well No. _____
 Coordinates _____
 Elevation: Casing _____ Survey Marker _____

DRILLING METHOD

Drilling Method(s) Air Rotary
 Drilling Fluid Air, Water
 Other _____

COMPLETION DATA

Drilled Depth 130'
 Completed Depth 122'
 Date Started 09-26-95
 Date Completed 10-06-95
 Static Water Level/Date 47.07' (a) / 10-18-95

OTHER (check if performed)

Well Abandonment _____ Manhole Cover _____
☒ Well Development _____ Pad w/Manhole Cover _____
☒ Aquifer Testing ☒ Protective Casing w/Pad _____
 Geophysical Log(s) _____ ☒ Locking Cap _____

SCREEN

Type	Outer Diameter	Length	Slot Size	Interval
304 Stainless Steel, flush threaded	4"	15'	20	107' - 122'

TEMPORARY CASING

Type	Nominal Diameter	Max. Outer Diameter	Interval
Carbon Steel (flush threaded)	8 5/8" ID	9 5/8"	+5' - 130'

PERMANENT CASING

Type	Nominal Diameter	Max. Outer Diameter	Interval
304 Stainless Steel, SCH 10, flush threaded	4"		1' - 107'

ANNULAR SEAL/FILL

Type	Interval	Quantity	Volume
PEL-PLUG Bentonite Pellets, 3/8", 30 min	122' - 130'	3 50-lb buckets	
RMC Lonestar Sand, #2/12	103' - 122'	10 100-lb bags	
PEL-PLUG Bentonite Pellets, 3/8", 30 min	98' - 103'	3 50-lb buckets	
Pure Gold Grout	4' - 98'		
PEL-PLUG Bentonite Pellets, 3/8", 30 min	2' - 4'		

PUMP

Type _____ Depth to Inlet _____ Date Set _____

ACCEPTANCE

Completed Well: Accept _____ Conditionally Accept _____
 Reject _____

COMMENTS

(a) Static water level measured from lip of well vault.

DAI BOREHOLE LOG

Boring or Well Number UCD-2-031

Depth

Sheet 18Location UC Preserve - Potomac Creek

Subject

Logged by Bill Schaal (IT)
Print

Sign

Date 9/26/95Reviewed by
Print

Sign

Date

Lithologic Classification Scheme ASTMProcedure Visual

Rev No.

Measuring Equipment

Drilling Contractor Water DevelopmentDriller Jason LaytonRig/Method air rotary casing hammerduring continuous core bit = auger
otherwise bit = air bit

DEPTH	SAMPLES		CONTAMINATION		MOISTURE	GRAPHIC LOG	LITHOLOGIC DESCRIPTION (PARTICLE SIZE DIST., SORTING, MINERALOGY, ROUNDNESS, COLOR, REACTION TO HCL, ETC.)	TIME	H ₂ O ADDED	DRILLING COMMENTS (DRILLING RATE, DOWN TIME, BLOW COUNTS, WATER LEVEL, DRILL FLUID, ETC.)	
	TYPE	NO.	INSTRUMENT	READING						CASING	
								7AM			arrive at facility.
								7:15			crew signs tailgate forms.
								7:30			Calibrate PID.
								9:00			Crew completes set-up at new hole
								9:15			Review H&S & other protocols - OK
								9:20			Dawn Mitchell authorizes site readiness
											Review sample collection protocols / Likal
								9:30			Establish that we are using 2 thw
								10:10			Geo & driller discuss sampling
								10:30			10:30 commence drilling
											1st couple of feet turned up concrete
											chips. Levy is constructed from fill.
											may not be able to core it.
								10:50			
								11:00			Examine core barrel
											Rig Refusal at 3 ft bgs.
											Can't core, must use air
											rotary casing hammer.

W = wet, M = moist, D = dry

A.73

DAILY BOREHOLE LOG

Boring or Well Number UCD - 2 - 35 Depth Sheet 2 of 2
 Location Project

Logged by SCHWARTZ (17) William Schaal Date 9/24/95
 Print Sign

Reviewed by Date
 Print Sign

Lithologic Classification Scheme Procedure Rev No.

Measuring Equipment

Drilling Contractor Water Development

Driller Jason Layton

Rig/Method air rotary casing hammer
(auger w/ core barrel to start casing)

DEPTH (ft)	SAMPLES		CONT. MEASUREMENT		MOISTURE	GRAPHIC LOG	LITHOLOGIC DESCRIPTION (PARTICLE SIZE DIST., SORTING, MINERALOGY, ROUNDNESS, COLOR, REACTION TO HCL, ETC.)	TIME	H ₂ O ADDED	DRILLING COMMENTS (DRILLING RATE, DOWN TIME, BLOW COUNTS, WATER LEVEL, DRILL FLUID, ETC.)	
	TYPE	NO.	INSTRUMENT	READING						CASING	
1-4						ml	silt (ml); brown, no plasticity, 70% silt, 15% vf sand, 10% gravel (subrounded 3 cm max), 5% organic material (grasses) dry. No dry strength. med to quick dilatancy.	10:30 am		10-	commence drilling 1st couple of feet turned up concrete chips OR gravel. Levy may be constructed of fill. May not be able to core this
							3 ft: med. coarse gravel or concrete debris	10:50		10-	examine core barrel
								11:00			Rig Refusal ~ 3' lgs. will use air rotary casing hammer
4-5			PIP	! ppm		gm	Silty gravel (gm), br gray, 15-20% gravel, subangular to subrounded, 2.5 cm max; SILT: br, dry, No dry strength, med quick dilatancy	11:50			
			PAN	23-30 ppm							
			GAN	0-1 ppm							
5-10						gc	clayey gravel (gc); dk. br, 70% gravel, 25% clay, 5% silt	11:55			Through 4-7' 3 blows drove casing 5', ∴ although clay - the formation is NOT competent
											through 8-17' formation firmed up 2 to 3 blows/ft
11-19						ch	clay, lite br, damp, 100% clay, med to hi plastic high dry strength	12:00			Have drilled through berm: cuttings are clay (1")

DAILY BOREHOLE LOG

Boring or Well Number UCD-2-1 Depth 35 Sheet 18
 Location _____ Project _____

Logged by S CHARR Date 9/26/85
 Print _____ Sign _____
 Reviewed by _____ Date _____
 Print _____ Sign _____
 Lithologic Classification Scheme _____ Procedure _____ Rev No. _____
 Measuring Equipment _____
 Drilling Contractor _____
 Driller _____
 Rig/Method _____

DEPTH	SAMPLES		CONTAMINATION		MOIS- TURE	GRAPHIC LOG	LITHOLOGIC DESCRIPTION (PARTICLE SIZE DIST., SORTING, MINERALOGY, ROUNDNESS, COLOR, REACTION TO HCL, ETC.)	TIME	H ₂ O ADDED	DRILLING COMMENTS (DRILLING RATE, DOWN TIME, BLOW COUNTS, WATER LEVEL, DRILL FLUID, ETC.)	
	TYPE	NO.	INSTRUMENT	READING						CASING	
											1200 well switch to contin. core.
											crew set core barrel on bot of hole & then breaks for lunch (12:25)
											lunch 1225 - 105
											1225 recommen. drilling
											19' Tagged
19-26 (20-25)			PID	2 ppm		ch	Flouy, dk br, damp, 100% clay, hi plastic, hi dry strength, slow dilatancy, Texture is. paleo sol. No HCL rxn, med-high dry strength	200pm		25	1st good core sample 100% recovery
			GAM	25-30cpm				130pm			
			PAN	0-5 cpm							
26-31 (28-30)			PID	1 ppm		ch	same as above w/ minor HCL rxn	215pm		30	100% recovery
			GAM	0-10							
			PAN	25-50							
31-36 (30-35)						ch	same as above (26-31)	230pm		35	Drilling is exceeding crew's ability to prepare core barrels 100% recovery

W = wet, M = moist, D = dry

DAILY BOREHOLE LOG

Boring or Well Number UCD - 2 - 35

Depth _____ Sheet 4 of 8

Location _____ Subject _____

Logged by Schaal (IT) William Schaal Date _____
 Print Sign

Reviewed by _____ Date _____
 Print Sign

Lithologic Classification Scheme _____ Procedure _____ Rev No. _____

Measuring Equipment _____

Drilling Contractor Water Development

Driller Tason Layton

Rig/Method air rotary casing hammer

DEPTH	SAMPLES		CONTAMINATION		MOISTURE	GRAPHIC LOG	LITHOLOGIC DESCRIPTION (PARTICLE SIZE DIST., SORTING, MINERALOGY, ROUNDNESS, COLOR, REACTION TO HCL, ETC.)	TIME	H ₂ O ADDED	DRILLING COMMENTS (DRILLING RATE, DOWN TIME, BLOW COUNTS, WATER LEVEL, DRILL FLUID, ETC.)	
	TYPE	NO.	INSTRUMENT	READING						CASING	
36-41 (35-40)			PID 0 ppm PAN 20-25 ppm GRM 0-5 ppm			ch	same as above + increased dry strength (high)	3:00		40	100% recovery
41-46 (40-45)						ch	increasing mottled color/texture. Appears to have increase in organic material. Brown w/ grey patches	3:15		45	100% recovery
46-51 (45-50)						ch	46-51: same as above + grey mottled areas contain micro stringers of caliche 51-52 - ch same as above 52-56	3:30		50	100% recovery
51-56 (50-55)						sp	poorly graded yellow-brown, 90%-95% v.f.s., 5-10% silt; grains are gtz. Moist in last 4 inches ? Some remnant caliche (gray patches w/ micro stringers) near contact at 52' logs	3:45		35	90% recovery
56-61 (55-60)						ch	56-58: same as above (SA) 58-59: clay, lite br w/ gray mottles, 80% clay, 15% v.f.s., 5% silt, caliche makes up 10% of clay, dry, med plastic	4:10		60	40% recovery

W - wet M -

D - dry

DAILY BOREHOLE LOG

Boring or Well Number

UCD-2-035

Depth

Sheet 6 of 8

Location

Project

Logged by SCHWAL

Print

Sign

Date

Drilling Contractor

Reviewed by

Print

Sign

Date

Driller

Lithologic Classification Scheme

Procedure

Rev No.

Rig/Method

Measuring Equipment

DEPTH	SAMPLES		CONTAMINATION		MOIS- TURE	GRAPHIC LOG	LITHOLOGIC DESCRIPTION (PARTICLE SIZE DIST., SORTING, MINERALOGY, ROUNDNESS, COLOR, REACTION TO HCL, ETC.)	TIME	H ₂ O ADDED	DRILLING COMMENTS (DRILLING RATE, DOWN TIME, BLOW COUNTS, WATER LEVEL, DRILL FLUID, ETC.)	
	TYPE	NO.	INSTRUMENT	READING						CASING	
						sp	from cuttings	930			continue to drill through flowing sands w/o casing or sampling. will take 2nd soil sample at 75-80 ft Repair to equipment 30 min Crew is in poly-tyvek Formation providing much H ₂ O
76						↓ gw	well graded gravel, predominantly gray w/ 20- 25% red brown, wet, loose, 10% sand, 90% gravel, subrounded to angular, 2.5cm max. sand is gtz, same as the sp above Gravel is Jasper, obsidian, ball gtz, siltstone	1000 1030			
100							increase in gravel sized .5 to 1cm up to 40-45%. Still have all sizes present	1050			
								1100			lunch
								1130			prepare to gather sample
160'							water grab sample #G(WGW) 0222 (Cox 104) 1 poly bott (1 liter) (Cr ⁶⁺ nitrate) 1 liter poly w/ nitric (Cr) 3 40 ml VOA bott (CLP VOA)	1140			collect grad H ₂ O from H ₂ SO ₄ -2

W = wet, M, 7ist, D = dry

DAIRY BOREHOLE LOG

Boring or Well Number

UCD-21 235

Depth

130'

Sheet

4 of 8

Location

Project

Logged by

W. Schaal
Print

William Schaal
Sign

Date 9/27/95

Drilling Contractor

Water Development

Reviewed by

Print

Sign

Date

Driller

Jason Layton

Lithologic Classification Scheme

ASTM

Procedure

Visual

Rev No.

Rig/Method

air rotary casing hammer

Measuring Equipment

DEPTH	SAMPLES		CONTAMINATION		MOISTURE	GRAPHIC LOG	LITHOLOGIC DESCRIPTION (PARTICLE SIZE DIST., SORTING, MINERALOGY, ROUNDNESS, COLOR, REACTION TO HCL, ETC.)	TIME	H ₂ O ADDED	DRILLING COMMENTS (DRILLING RATE, DOWN TIME, BLOW COUNTS, WATER LEVEL, DRILL FLUID, ETC.)	
	TYPE	NO.	INSTRUMENT	READING						CASING	
105'						gp	gw grades into gp poorly graded, predominantly dk gray, wet, loose 10% sand, 90% gravel. Gravel is subrounded to angular — may be misread could be angular due to cutting. Gravel is same minerals + rx above. Sand in gtz.	1150		*	0% recovery w/ split spoon samples. Although gravel is fines, can't core it.
105'-110'							'soil' sample # SSCLO09 (COC: 2044) 8 oz jar Cr, Cr ⁶⁺ , NO ₃ 8 oz jar tritium 4 oz jar CLP VOA	1200		*	Collect disturbed sample from cuttings
130'						ch	clay, lite br, dry, 100% clay, hi plastic, hi dry strength, slow dilatancy. Immature caliche & rhizoid castes	1220			Represents aquitard below +ISU-2. Will sample aquitard in case needed.
							soil sample # SSCLO10 (COC: 2045) 8 oz jar Cr, Cr ⁶⁺ , NO ₃ 8 oz jar tritium 4 oz jar CLP VOA	1250			1230 pull drive pipe then sample
							* HOLD FOR Liikala authorization				
							9/28/95 Liikala approves will notify lab to analyze sample SSCLO10. Regular turn.	1 pm			Dry brown smears trace that will need to be taken from the zone to fetch well materials

Boring or Well Number UCD-2-035 Depth _____ Sheet 8 of 8
Location _____ Project _____

Drilling Contractor Water Development

Driller Tagen Layton

Rig/Method air rotary casing hammer

[illegible]
$$D = d_{\text{rev}}$$

Completion Log

Boring Casing Well Number

U.C.D - 2 - W

Location

LEH

Sheet

1 of 7

Project

Logged by

Schael

Print

Date

9/27/95

Reviewed by

Print

Date

Measuring Equipment

tape

Procedure

Rev No.

Drilling Contractor

Water Development

Driller

T. J. L. L. L.

Rig/Equipment

air rotary casing hammer

Time	Casing/Screen				Annular Fill				Over-lap	Comments	
	Type	Diameter	Length	Stickup	Depth	Type	Stickup	Quantity			Add-on
2:20	carbon steel	9 5/8	13 5/8	5	130						tagged hole depth: 131'
2:25						band, full 8 1/8 full plug		3	50 lb buckets		packed
2:30											
2:35											
2:40			130	10	120						pull off 5' drill casing
2:42			125	10	115						Band is 3 ft too thick! Gravel collapsed into hole.
2:43											MUST REMOVED!
2:55			135	5	130						Rinse casing pump H ₂ O downhole, use 10' sand bucket to remove material.
3:15											material = formation stuff & bent.
3:25											No progress after approx 30 min. Abort procedure and set up to drill casing
3:40											clean
											casing drilled clean. 4 bags sand poured in hole to overcome floating formation pressure. Well set to 122'. Discovers begin w/ Schell about average gravelly. No H ₂ O-1 present. All H ₂ O is H ₂ O-2.
											Determine to screen when set 107-122 for lower portion of H ₂ O 2. A-1800-004 (05/90) Companion hole to screen upper H ₂ O-2.

A.81

COMPLETION LOG

Boring or well number 002-2-025Sheet 1 of 2

Location _____

Project _____

Logged by Schaal (IT) William Schaal Date 9/28/95
Print SignReviewed by _____ Date _____
Print SignMeasuring Equipment tape Procedure _____ Rev No. _____Drilling Contractor Water DevelopmentDriller Tyson LaytonRig/Equipment air casing rotary hammer

Time	Casing/Screen					Annular Fill					Over-lap	Comments
	Type	Diameter	Length	Stickup	Depth	Type	Depth	Stickup	Quantity	Add-on		
8/27/95	carbon steel	9 5/8"	130'	7'	123'	#2/12 sand	115'		4 100lb bags			poured in
	304 ss	4"	125'	3'	122'							15' slotted screen (.020); 107' blank
8/28/95												
0810	carbon steel	9 5/8"	130'	7'	123'	#2/12 sand	113'		2 100lb bags			33'
			124'	5'	119'							poured
0825			119'	5'	114'							pulled drill casing back & removed 5'
0832						#2/12 sand	113'		1 100lb bag			poured
0834							112'					tag and add sand
0839			114'	4'	110'							
0849						#2/12 sand	107'		1 100lb bag			poured
0851							107'					
												pull drill casing back & tag sand.
												pulled 10' casing in 2-3ft increments
												w/ tagging between each pull to assure
												sand remains at 107'
0855						#2/12 sand	105'		1 100lb bag			poured
0856			114'	5'	109'							pull drill casing
0858						#2/12 sand			1 100lb bag			poured
0900			114'	10'	104'							well tag after it settles (following casing pull)
0903												pull drill casing up
0906							103'					remove 5' drill casing
												tag sand = target depth

A-1800-004 (05/90)

Logged by Schaal (IT) Date 9/28/95
 Reviewed by William Schaal Sign _____ Date _____
 Measuring Equipment tape Procedure _____ Rev No. _____
 Drilling Contractor Water Development
 Driller Jason Layton
 Rig/Equipment pin casing setting hammer

Time	Casing/Screen				Annular Fill				Over-lap	Comments
	Type	Diameter	Length	Stickup	Depth	Type	Depth	Stickup	Quantity	Add-on
0907	carbon steel	9 5/8"	99'	5.5'	104.5'	'sand #2/2	103'			
0920										
0920										
0930							103'			
0935										
0945						Pel Plug cont 3/8"	90'		3 50 lb bushings	
0949			100'	5'	95'					
1005						Grout ↓	65'		5 bags	Streamed
1025							65 30		6 bags	
1105			25	5	20					
1110			15	5	10					
1115	carbon steel	9 5/8"	10	5	5					
1125			0	0	0					

All drive casing removed
 A-1800-004 (05/90)

COMPLETION LOG

 Boring or well number UCD-1-34 Sheet 5 of 5
 Location _____ Project _____

 Logged by Schwal (15) William Schaal Date 9/18/95
 Print Sign
 Reviewed by _____ Date _____
 Print Sign
 Measuring Equipment fiberglass tape Procedure _____ Rev No. _____

 Drilling Contractor water Development
 Driller Jason Layton
 Rig/Equipment air casing rotary hammer

Time	Casing/Screen					Annular Fill					Over-lap	Comments
	Type	Diameter	Length	Stickup	Depth	Type	Depth	Stickup	Quantity	Add-on		
1130	304 SS	4	125	3	123	grout	22		7 bags			MIXING MORE GROUT. T remied.
1140						↓	20		5 bags			remied
1145												Grout is displacing previously emplaced grout. Must wait for grout to harden before adding more
1210												lunch
1240												crew begins decom of rig, drill string, & support equip
4pm												48' w/ well that is nearly completed. (Needs grout top up)
9/29/95												
8:00 am												49'
8:30 am												6 buckets 40 gallons poured bent, chased w/ H ₂ O, into borehole to plug blow out in grout SOB "Daily Borehole Log" UCD-1-34

9/28/95, 430 pm

A-1800-004 (05/90)

AS-BUILT DIAGRAM

Boring or Well Number UCD1-034

Sheet 1 of 1

Location Univ. of California-Davis

Project LEHR RI/FS

Logged by Bill Schaal (IT)

Date Well Started 09-28-95

Reviewed by _____ Date _____

Date Well Completed 10-06-95

Well Construction Data

Geologic / Hydrologic Data

Drill Bit

Sample Method

Depth (ft)	Description	Construction Diagram	Depth in Feet	Lithologic Diagram	Depth (ft)	Lithologic Description
+5-80	Carbon Steel Casing, 9 5/8" OD - temporary		0		0	Original Ground Surface
0.75-2	Concrete w/8-in dia. well vault		5			NOTE: See well UCD2-035 As-Built Diagram for lithologic description.
2-4	PEL-PLUG Bentonite Pellets, 3/8"		10			
4-50	Pure Gold Grout		15			
1-61	4-in dia., 304, Sch 10 SS Casing		20			
			25			
			30			
			35			
			40			
			45			
			50			
50-57	PEL-PLUG Bentonite Pellets, 3/8"		55			
57-76	RMC Lonestar Sand, #1/20		60			
61-76	4-in dia., 10-slot SS Screen		65			
			70			
			75			
76-80	End Cap		80			
	Slough		85			
			90			

NOTES: 1) All casing is flush threaded.
2) Couplings are 304, Sch 40 Stainless Steel.
3) Depth of screen placement was determined by examination of lithologic logs.

Drill Bit / Sample Method Used:

☐ Rotary ☒ Air Rotary ☐ Mud Rotary ☐ Air Percussion ☐ Back Hoe ☐ Auger ☐ Drive Sampler ☐ Hard Tool ☐ Split-Barrel

WELL COMPLETION SUMMARY

Page 1 of 1

Project <u>RI/FS</u> Location <u>LEHR, Univ. of CA - Davis</u> Drilling Co. <u>Water Development Corp.</u> Driller <u>Jason Layton, Chuck Webber, Jon Fischer</u> Other (companies) <u>Harris Concrete</u> Geologist(s) <u>Bill Schaal (IT)</u>	Well No. <u>UCD1-034</u> Temp. Well No. _____ Coordinates _____ Elevation: Casing _____ Survey Marker _____ <div style="text-align: center; border-top: 1px solid black; border-bottom: 1px solid black; margin: 5px 0;">DRILLING METHOD</div> Drilling Method(s) <u>Air Rotary</u> Drilling Fluid <u>Air, Water</u> Other _____
--	--

<div style="text-align: center; border-top: 1px solid black; border-bottom: 1px solid black; margin: 5px 0;">COMPLETION DATA</div> Drilled Depth <u>80'</u> Completed Depth <u>76'</u> Date Started <u>09-28-95</u> Date Completed <u>10-06-95</u> Static Water Level/Date <u>46.59' (a) / 10-17-95</u>	<div style="text-align: center; border-top: 1px solid black; border-bottom: 1px solid black; margin: 5px 0;">OTHER (check if performed)</div> <table style="width: 100%;"> <tr> <td>☐ Well Abandonment</td> <td>☐ Manhole Cover</td> </tr> <tr> <td>☒ Well Development</td> <td>☐ Pad w/Manhole Cover</td> </tr> <tr> <td>☒ Aquifer Testing</td> <td>☒ Protective Casing w/Pad</td> </tr> <tr> <td>☐ Geophysical Log(s)</td> <td>☒ Locking Cap</td> </tr> </table>	☐ Well Abandonment	☐ Manhole Cover	☒ Well Development	☐ Pad w/Manhole Cover	☒ Aquifer Testing	☒ Protective Casing w/Pad	☐ Geophysical Log(s)	☒ Locking Cap
☐ Well Abandonment	☐ Manhole Cover								
☒ Well Development	☐ Pad w/Manhole Cover								
☒ Aquifer Testing	☒ Protective Casing w/Pad								
☐ Geophysical Log(s)	☒ Locking Cap								

SCREEN				
Type	Outer Diameter	Length	Slot Size	Interval
<u>304 Stainless Steel, flush threaded</u>	<u>4"</u>	<u>15'</u>	<u>10</u>	<u>61' - 76'</u>

TEMPORARY CASING			
Type	Nominal Diameter	Max. Outer Diameter	Interval
<u>Carbon Steel (flush threaded)</u>	<u>8 5/8" ID</u>	<u>9 5/8"</u>	<u>+5' - 80'</u>

PERMANENT CASING			
Type	Nominal Diameter	Max. Outer Diameter	Interval
<u>304 Stainless Steel, SCH 10, flush threaded</u>	<u>4"</u>		<u>1' - 61'</u>

ANNULAR SEAL/FILL				
Type	Interval	Quantity	Volume	
<u>RMC Lonestar Sand, #1/20</u>	<u>57' - 76'</u>	<u>14 100-lb bags</u>		
<u>PEL-PLUG Bentonite Pellets, 3/8", 30 min</u>	<u>50' - 57'</u>	<u>3 50-lb buckets</u>		
<u>Pure Gold Grout</u>	<u>4' - 50'</u>			
<u>PEL-PLUG Bentonite Pellets, 3/8", 30 min</u>	<u>2' - 4'</u>			

PUMP		
Type _____	Depth to Inlet _____	Date Set _____

ACCEPTANCE	
Completed Well: Accept _____	Conditionally Accept _____
Reject _____	

COMMENTS
(a) Static water level measured from lip of well vault.

DAILY BOREHOLE LOG

Boring or Well Number UCD-1-B34

Depth _____ Sheet 2 of 2

Location LEHR

Project _____

Logged by Schaal (U)
Print _____

Sign _____

Date 9/28/95

Reviewed by _____
Print _____

Sign _____

Date _____

Lithologic Classification Scheme _____

Procedure _____

Rev No. _____

Measuring Equipment _____

Drilling Contractor Water Development

Driller Jason Layton

Rig/Method air rotary casing hammer

DEPTH	SAMPLES		CONTAMINATION		MOISTURE	GRAPHIC LOG	LITHOLOGIC DESCRIPTION (PARTICLE SIZE DIST., SORTING, MINERALOGY, ROUNDNESS, COLOR, REACTION TO HCL, ETC.)	TIME	H ₂ O ⁺ ADDED	DRILLING COMMENTS (DRILLING RATE, DOWN TIME, BLOW COUNTS, WATER LEVEL, DRILL FLUID, ETC.)	
	TYPE	NO.	INSTRUMENT	READING						CASING	
											There is now concern over the integrity of well UCD-2-235. * must be especially vigilant during development
60						gc	same as above; decreased clay, increased gravel: 30% clay, 70% gravel	445			
70						gc	same as above; increased clay: 40% clay; 60% gravel	450			
80						ch	clay; lite br; dry; hi plastic, hi toughness hi dry strength, slow to some disintegration 90-95% clay; 5-10% gravel gravel: same same as 55'	500			tagged bottom: 76'
								505			crew begins to pull drill bit. D. Brown begins to collect samples
								600			depart from site
								9/29/95 8:45 am			47.5

9/28/95
8:45 am

9/29/95
8:45 am

COMPLETION LOG

Boring or Well Number UCD-1-3
Location LEHR

Project _____ Sheet _____ of _____

Logged by Schoal (IT) Print _____ Date 9/28/91
 Reviewed by _____ Sign _____
 Measuring Equipment _____ Procedure _____ Rev No. _____

Drilling Contractor Water Development
 Driller Taan Carlson
 Rig/Equipment air rotary casing hammer

Time	Casing/Screen				Annular Fill				Over-lap	Comments
	Type	Diameter	Length	Stickup	Depth	Type	Depth	Stickup	Quantity	Add-on
8:45	carbon steel	9 5/8"	85'	5'	80'					
8:55	304 SS screen (.010)	4"	16'	-60	60-76'					
8:57	304 SS blank	4"	20'	-40	40-60					
9:01			20'	-20	20-40					
9:03			25'	5	20-+5					
9:05	SS	4"	85'	5'	76'					
9:15	carbon steel	9 5/8"	85'	5'	80'					
9:16			80'	5'	75'					
9:29										
9:30			80	8	72					
9:32			80	10	70					
9:34			75	5	70					
9:40										
9:44										
9:45			75	7.5	67.5					
9:48			75	9	64					
9:52			70	4	64					
9:55			70	7	63					

pull casing back a full 100 ft - back on
 small (short) to mitigate hearing
 + keeping sand high in the drive casing
 pull casing back & then remove
 section; tag sand
 tag - sand
 inside drive casing 1 bag sand = 1 ft ht
 tag sand
 pull casing and add 1 bag sand
 tag sand
 pull drive casing & measure
 gentle bedding - predevelopment!
 combination of bedding and A-1800-004 (05/90)
 gentle swirling

COMPLETION LOG

Boring or Well Number UCLD - 1 - 34

Sheet / of

Location LEHR

Project _____

Logged by Schaal (IT) William Schaal Date 9/20/95
Print Sign

Reviewed by _____ Date _____

Print Sign

Measuring Equipment _____ Procedure _____ Rev No. _____

Drilling Contractor Water Develop.

Driller Jason Layton

Rig/Equipment air rotary casing hammer

Time	Casing/Screen					Annular Fill					Over-lap	Comments
	Type	Diameter	Length	Stickup	Depth	Type	Depth	Stickup	Quantity	Add-on		
10:15	carbon steel	9 5/8	70	7	63	#1/20 sand	55					tag sand
10:16			70	8	62							Add H ₂ O w/ hose, pull drill casing back. to help settle sand and add mass. (sand pack 76-5-57-75 ^{WCS} 76-5-57-75 yields 3ft sand above screen)
			65	3	62		54					
						#1/20 sand	55.5		2 bag 1100 lb			
			60	5	55	*1/20 sand	57		↓			
10:30						bent 3/8 per flang			3 buckets			logged between every and bucket (bentonite 50-57)
10:45						↓	50					pull casing from hole in preparation of grouting: Had field discussion w/ Schabla, ∴ missed observation of core work activities.
												bentonite had 45 min to set & swell prior to addition of grout. During the 45 min casing was pulled (30 min) and grout mixed (15 min). both Grout batch was split unevenly between the two holes
												70% to UCD 34; 30% to UCD 35
11:30						grout	220		8 bags			uneven split of this mix. 60% UCD 34 and 40% to UCD 35
												UCD 34 grout level 8+7 ft
												D. Brown taking tritium samples from P1 & 20' interval. Brekin

ing down.

A-1800-004 (05/90)

Appendix B

Sediment Physical Analyses from Well UCD2-026

PERCENT FINER

GRAIN SIZE - mm

Grain Size (mm)	Sieve Size	Percent Finer (%)
200	6 in.	100
100	3 in.	100
75	2 in.	100
60	1-1/2 in.	100
40	1 in.	100
30	3/4 in.	100
20	1/2 in.	100
15	3/8 in.	100
10	#4	100
4.75	#10	100
2.5	#20	100
1.18	#40	100
0.85	#60	100
0.425	#140	90
0.3	-	80
0.25	-	78
0.2	-	75
0.15	-	62
0.125	-	58
0.106	-	55
0.09	-	52
0.075	-	48
0.06	-	45
0.05	-	42

SIEVE Inches size	PERCENT FINER		
	●
GRAIN SIZE		
D ₆₀ D ₃₀ D ₁₀
COEFFICIENTS		
C _c C _u			

SIEVE number size	PERCENT FINER		
	●		
10	100.0		

Remarks:

Data Sheet No.

GRAIN SIZE DISTRIBUTION TEST DATA

Test No.: 9

Date: 10/20/95
Project No.:
Project: LEHR

Sample Data

Location of Sample:
Sample Description 1: SSVD0001-----#2
Sample Description 2: 18.5' to 19'
USCS Class: Liquid limit: Plasticity index:

Notes

Remarks:

Data Sheet No.:

Mechanical Analysis Data

Sieve	Size, mm	Percent finer
# 10	2.000	100.0

Hydrometer Analysis Data

Separation sieve is number 10
Percent -# 10 based on complete sample= 100.0
Weight of hydrometer sample: 20
Calculated biased weight= 20.00
Automatic temperature correction
Composite correction at 20 deg C =-4.6

Meniscus correction only= 0
Specific gravity of solids= 2.77
Specific gravity correction factor= 0.974
Hydrometer type: 152H Effective depth $L = 16.294964 - 0.164 \times R_m$

Elapsed time, min	Temp, deg C	Actual reading	Corrected reading	K	Rm	Eff. depth	Diameter mm	Percent finer
1.0	19.2	23.3	18.4	0.0133	23.3	12.5	0.0470	89.9
3.0	19.2	21.0	16.2	0.0133	21.0	12.9	0.0275	78.9
10.0	19.2	20.3	15.4	0.0133	20.3	13.0	0.0152	75.2
30.0	19.4	17.5	12.7	0.0133	17.5	13.4	0.0089	62.0
60.0	19.6	16.5	11.8	0.0132	16.5	13.6	0.0063	57.4
90.0	19.7	16.0	11.3	0.0132	16.0	13.7	0.0052	55.0
120.0	19.9	15.5	10.8	0.0132	15.5	13.8	0.0045	52.8
1440.0	20.5	13.2	8.7	0.0131	13.2	14.1	0.0013	42.2

Fractional Components

Gravel/Sand based on #10 sieve

Sand/Fines based on #270 sieve

% + 3 in. = 0.0 % GRAVEL = 0.0 % SAND = 9.2

% FILLT = 36.2 % CLAY = 54.6

D85= 0.04 D60= 0.008 D50= 0.004

6 in.
3 in.
2 in.
1-1/2 in.
1 in.
3/4 in.
1/2 in.
3/8 in.

SIEVE number size	PERCENT FINER		
10	100.0		

SSVD0001-----#3
19' to 19.5'

Data Sheet No. _____

GRAIN SIZE DISTRIBUTION TEST DATA

Test No.: 10

Date: 10/20/95

Project No.:

Project: LEHR

Sample Data

Location of Sample:

Sample Description 1: SSVD0001-----#3

Sample Description 2: 19' to 19.5'

USCS Class: Liquid limit: Plasticity index:

Notes

Remarks:

Data Sheet No.:

Mechanical Analysis Data

Sieve	Size, mm	Percent finer
# 10	2.000	100.0

Hydrometer Analysis Data

Separation sieve is number 10

Percent -# 10 based on complete sample= 100.0

Weight of hydrometer sample: 20

Calculated biased weight= 20.00

Automatic temperature correction

Composite correction at 20 deg C = -4.6

Meniscus correction only= 0

Specific gravity of solids= 2.8

Specific gravity correction factor= 0.969

Hydrometer type: 152H Effective depth $L = 16.294964 - 0.164 \times R_m$

Elapsed time, min	Temp, deg C	Actual reading	Corrected reading	K	Rm	Eff. depth	Diameter mm	Percent finer
1.0	15.7	20.0	14.4	0.0138	20.0	13.0	0.0498	69.9
3.0	15.7	17.0	11.4	0.0138	17.0	13.5	0.0293	55.4
10.0	15.7	15.5	9.9	0.0138	15.5	13.8	0.0162	48.1
30.0	15.8	13.5	8.0	0.0138	13.5	14.1	0.0094	38.5
60.0	16.2	12.5	7.1	0.0137	12.5	14.2	0.0067	34.1
90.0	16.8	11.5	6.2	0.0136	11.5	14.4	0.0054	30.0
120.0	17.8	11.0	5.9	0.0134	11.0	14.5	0.0047	28.6
1440.0	19.4	8.5	3.7	0.0132	8.5	14.9	0.0013	18.1

Fractional Components

Gravel/Sand based on #10 sieve
Sand/Fines based on #270 sieve
% + 3 in. = 0.0 % GRAVEL = 0.0 % SAND = 28.6
% SILT = 42.3 % CLAY = 29.1

D85= 0.11 D60= 0.036 D50= 0.019
D30= 0.0054

 
0.000000000000000000025	100
0.000000000000000000015	100
0.0000000000000000000075	100
0.00000000000000000000425	100
0.0000000000000000000025	100
0.0000000000000000000015	100
0.00000000000000000000075	100
0.000000000000000000000425	100
0.00000000000000000000025	100
0.00000000000000000000015	100
0.000000000000000000000075	100
0.0000000000000000000000425	100
0.000000000000000000000025	100
0.000000000000000000000015	100
0.0000000000000000000000075	100
0.00000000000000000000000425	100
0.0000000000000000000000025	100
0.0000000000000000000000015	100
0.00000000000000000000000075	

SIEVE Inches size	PERCENT FINER
GRAIN SIZE		
D ₆₀ D ₃₀ D ₁₀
COEFFICIENTS		
C _c C _u			

SIEVE number size	PERCENT FINER		
	●		
10	100.0		

SSVD 0002-----#4
39.5 to 40'

Remarks:

Data Sheet No. 3

GRAIN SIZE DISTRIBUTION TEST DATA

Test No.: 17

Date: 10/20/95
Project No.:
Project: LEHR

Sample Data

Location of Sample:
Sample Description 1: SSVD 0002-----#4
Sample Description 2: 39.5 to 40'
USCS Class: Liquid limit: Plasticity index:

Notes

Remarks:

Data Sheet No.: 3

Mechanical Analysis Data

Sieve	Size, mm	Percent finer
# 10	2.000	100.0

Hydrometer Analysis Data

Separation sieve is number 10
Percent -# 10 based on complete sample= 100.0
Weight of hydrometer sample: 20
Calculated biased weight= 20.00
Table of composite correction values:
Temp, deg C: 19.2 19.6 19.8 20.0 20.5
Comp. corr: - 5.0 - 4.8 - 4.7 - 4.6 - 4.3
Meniscus correction only= 0
Specific gravity of solids= 2.745
Specific gravity correction factor= 0.979
Hydrometer type: 152H Effective depth L= 16.294964 - 0.164 x Rm

Elapsed time, min	Temp, deg C	Actual reading	Corrected reading	K	Rm	Eff. depth	Diameter mm	Percent finer
1.0	19.2	22.0	17.0	0.0134	22.0	12.7	0.0477	83.3
3.0	19.3	20.0	15.1	0.0134	20.0	13.0	0.0279	73.7
10.0	19.3	19.8	14.8	0.0134	19.8	13.1	0.0153	72.5
30.0	19.4	19.0	14.1	0.0134	19.0	13.2	0.0089	69.1
60.0	19.6	18.0	13.2	0.0133	18.0	13.3	0.0063	64.6
90.0	19.8	17.0	12.3	0.0133	17.0	13.5	0.0052	60.2
120.0	20.0	16.5	11.9	0.0133	16.5	13.6	0.0045	58.3

Elapsed time, min	Temp, Actual deg C reading	Corrected reading	K	Rm	Eff. depth	Diameter mm	Percent finer	
1440.0	20.5	13.2	8.9	0.0132	13.2	14.1	0.0013	43.6

Fractional Components

Gravel/Sand based on #10 sieve

Sand/Fines based on #270 sieve

% + 3 in. = 0.0 % GRAVEL = 0.0 % SAND = 15.9

% SILT = 24.4 % CLAY = 59.7

D85= 0.06 D60= 0.005 D50= 0.002

PARTICLE SIZE DISTRIBUTION TEST REPORT

[illegible]

SIEVE Inches size	PERCENT FINER
	GRAIN SIZE		
D ₆₀ D ₃₀ D ₁₀
COEFFICIENTS		
C _c C _u			

SIEVE number size	PERCENT FINER		
	●		
10	100.0		

Sample information:

SSCL 1001-----#8
58.5 to 59'

Remarks:

**Pacific
Northwest
Laboratory**

Project No.:
Project: LEHR

Date: 10/20/95

Data Sheet No. 4

GRAIN SIZE DISTRIBUTION TEST DATA

Test No.: 14

Date: 10/20/95
Project No.:
Project: LEHR

Sample Data

Location of Sample:

Sample Description 1: SSCL 1001-----#8

Sample Description 2: 58.5 to 59'

USCS Class: Liquid limit: Plasticity index:

Notes

Remarks:

Data Sheet No.: 4

Mechanical Analysis Data

Sieve	Size, mm	Percent finer
# 10	2.000	100.0

Hydrometer Analysis Data

Separation sieve is number 10

Percent -# 10 based on complete sample= 100.0

Weight of hydrometer sample: 20

Calculated biased weight= 20.00

Table of composite correction values:

Temp, deg C: 19.3 19.9 20.1 20.5

Comp. corr: - 5.0 - 4.6 - 4.5 - 4.3

Meniscus correction only= 0

Specific gravity of solids= 2.729

Specific gravity correction factor= 0.983

Hydrometer type: 152H Effective depth L= 16.294964 - 0.164 x Rm

Elapsed time, min	Temp, deg C	Actual reading	Corrected reading	K	Rm	Eff. depth	Diameter mm	Percent finer
1.0	19.3	22.8	17.8	0.0134	22.8	12.6	0.0477	87.2
3.0	19.3	21.3	16.3	0.0134	21.3	12.8	0.0278	79.8
10.0	19.4	20.3	15.3	0.0134	20.3	13.0	0.0153	75.3
30.0	19.5	19.0	14.1	0.0134	19.0	13.2	0.0089	69.4
60.0	19.6	18.0	13.2	0.0134	18.0	13.3	0.0063	64.9
90.0	19.9	17.8	13.2	0.0133	17.8	13.4	0.0051	64.9
120.0	20.1	16.5	12.0	0.0133	16.5	13.6	0.0045	59.0

Elapsed time, min	Temp, deg C	Actual reading	Corrected reading	K	Rm	Eff. depth	Diameter mm	Percent finer
1440.0	20.5	14.0	9.7	0.0132	14.0	14.0	0.0013	47.7

Fractional Components

Gravel/Sand based on #10 sieve

Sand/Fines based on #270 sieve

% + 3 in. = 0.0 % GRAVEL = 0.0 % SAND = 11.6

% SILT = 24.7 % CLAY = 63.7

D85= 0.04 D60= 0.005 D50= 0.002

GRAIN SIZE DISTRIBUTION FOR TEST REPORT NO. 1

Grain Size (mm)	Percent Finer (%)
2.0 (#10)	98
0.85 (#20)	97
0.425 (#40)	94
0.25 (#60)	90
0.15 (#100)	82
0.075 (#200)	70
0.0425 (#40)	53
0.025 (#60)	45
0.015 (#100)	36
0.0075 (#200)	34
0.00425 (#40)	28
0.0025 (#60)	25
0.0015 (#100)	20
0.00075 (#200)	15

[illegible]

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		

SSCL 1001-----#9
59 to 59.5

Remarks:

**Pacific
Northwest
Laboratory**

Project:

Data Sheet No. 5

GRAIN SIZE DISTRIBUTION TEST DATA

Test No.: 15

Date: 10/20/95

Project No.:

Project:

Sample Data

Location of Sample:

Sample Description 1: SSCL 1001-----#9

Sample Description 2: 59 to 59.5

USCS Class: Liquid limit: Plasticity index:

Notes

Remarks:

Data Sheet No.: 5

Mechanical Analysis Data

Sieve	Size, mm	Percent finer
# 10	2.000	100.0

Hydrometer Analysis Data

Separation sieve is number 10

Percent -# 10 based on complete sample= 100.0

Weight of hydrometer sample: 20

Calculated biased weight= 20.00

Table of composite correction values:

Temp, deg C: 15.7 16.9 18.1 18.8 19.6

Comp. corr: - 6.5 - 6.2 - 5.8 - 5.5 - 5.3

Meniscus correction only= 0

Specific gravity of solids= 2.77

Specific gravity correction factor= 0.974

Hydrometer type: 152H Effective depth L= 16.294964 - 0.164 x Rm

Elapsed time, min	Temp, deg C	Actual reading	Corrected reading	K	Rm	Eff. depth	Diameter mm	Percent finer
1.0	15.7	20.0	13.5	0.0139	20.0	13.0	0.0502	65.8
3.0	15.7	17.5	11.0	0.0139	17.5	13.4	0.0294	53.6
10.0	15.8	16.0	9.5	0.0139	16.0	13.7	0.0163	46.4
30.0	16.1	14.0	7.6	0.0138	14.0	14.0	0.0095	37.0
60.0	16.4	13.5	7.2	0.0138	13.5	14.1	0.0067	35.0
90.0	17.2	12.0	5.9	0.0136	12.0	14.3	0.0054	28.7
120.0	18.1	11.2	5.4	0.0135	11.2	14.5	0.0047	26.3

Elapsed time, min	Temp, Actual deg C reading	Corrected reading	K	Rm	Eff. depth	Diameter mm	Percent finer
1440.0	19.5	8.7	3.4	0.0133	8.7	14.9	0.0013
							16.4

Fractional Components

Gravel/Sand based on #10 sieve

Sand/Fines based on #270 sieve

% + 3 in. = 0.0 % GRAVEL = 0.0 % SAND = 32.9

% SILT = 40.0 % CLAY = 27.1

D85= 0.14 D60= 0.040 D50= 0.022

D30= 0.0057

PARTICLE SIZE DISTRIBUTION TEST REPORT

[illegible]

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		

Sample information:

SSCL 1002-----#12
79 to 79.5'

Remarks:

**Pacific
Northwest
Laboratory**

Project No.:
Project: LEHR

Date: 10/20/95

Data Sheet No. 6

GRAIN SIZE DISTRIBUTION TEST DATA

Test No.: 16

Date: 10/20/95

Project No.:

Project: LEHR

Sample Data

Location of Sample:

Sample Description 1: SSCL 1002-----#12

Sample Description 2: 79 to 79.5'

USCS Class: Liquid limit: Plasticity index:

Notes

Remarks:

Data Sheet No.: 6

Mechanical Analysis Data

Sieve	Size, mm	Percent finer
# 10	2.000	100.0

Hydrometer Analysis Data

Separation sieve is number 10

Percent -# 10 based on complete sample= 100.0

Weight of hydrometer sample: 20

Calculated biased weight= 20.00

Table of composite correction values:

Temp, deg C: 15.7 16.9 18.1 18.8 19.6

Comp. corr: - 6.5 - 6.2 - 5.8 - 5.5 - 5.3

Meniscus correction only= 0

Specific gravity of solids= 2.705

Specific gravity correction factor= 0.988

Hydrometer type: 152H Effective depth $L = 16.294964 - 0.164 \times R_m$

Elapsed time, min	Temp, deg C	Actual reading	Corrected reading	K	Rm	Eff. depth	Diameter mm	Percent finer
1.0	15.9	18.0	11.6	0.0141	18.0	13.3	0.0517	57.0
3.0	15.9	15.0	8.6	0.0141	15.0	13.8	0.0304	42.2
10.0	16.0	13.5	7.1	0.0141	13.5	14.1	0.0168	34.9
30.0	16.3	12.0	5.7	0.0141	12.0	14.3	0.0097	27.9
60.0	16.9	11.0	4.8	0.0140	11.0	14.5	0.0069	23.7
90.0	17.8	10.0	4.1	0.0138	10.0	14.7	0.0056	20.3
120.0	18.6	9.5	3.9	0.0137	9.5	14.7	0.0048	19.3

Elapsed time, min	Temp, Actual deg C reading	Corrected reading	K	Rm	Eff. depth	Diameter mm	Percent finer
1440.0	19.6	8.0	2.7	0.0135	8.0	15.0	0.0014
							13.3

Fractional Components

Gravel/Sand based on #10 sieve

Sand/Fines based on #270 sieve

% + 3 in. = 0.0 % GRAVEL = 0.0 % SAND = 42.2

% SILT = 38.3 % CLAY = 19.5

D85= 0.19 D60= 0.057 D50= 0.041

D30= 0.0115 D15= 0.00186

PARTICLE SIZE DISTRIBUTION TEST REPORT

GRAIN SIZE DISTRIBUTION TEST DATA

Test No.: 7

Date: 10/20/95

Project No.:

Project: LEHR

Sample Data

Location of Sample:

Sample Description 1: SSCL2001-----#13

Sample Description 2: 88' to 88.5'

USCS Class: Liquid limit: Plasticity index:

Notes

Remarks:

Data Sheet No.:

Mechanical Analysis Data

Sieve	Weight retained	Sieve tare	Percent finer
# 5	468.30	460.14	98.3
# 10	487.08	474.28	95.7
# 18	322.90	315.60	94.2
# 35	450.76	420.09	87.8
# 60	640.19	377.26	33.5
# 120	375.76	242.95	6.1
# 230	397.23	372.33	0.9
# 325	393.97	391.50	0.4

Fractional Components

Gravel/Sand based on #10 sieve

Sand/Fines based on #270 sieve

% + 3 in. = 0.0 % GRAVEL = 4.3 % SAND = 95.1

% FINES = 0.6

D85= 0.48 D60= 0.366 D50= 0.323
D30= 0.2374 D15= 0.17599 D10= 0.14980
Cc = 1.0268 Cu = 2.4462

PARTICLE SIZE DISTRIBUTION TEST REPORT

	Test	% +3"	% GRAVEL	% SAND	% SILT	% CLAY	USCS	LL	PI
●	8	0.0	2.2	97.2	0.6				

SIEVE Inches size	PERCENT FINER		
	●		
X	GRAIN SIZE		
D ₆₀	0.38		
D ₃₀	0.28		
D ₁₀	0.20		
X	COEFFICIENTS		
C _c	1.02		
C _u	1.9		

SIEVE number size	PERCENT FINER		
	●		.
5	98.7		
10	97.8		
18	95.2		
35	81.9		
60	21.3		
120	2.9		
230	0.8		
325	0.4		

Sample information:

SSCL2001-----#14
88.5' to 89'

Remarks:

**Pacific
Northwest
Laboratory**

Project No.:
Project: LEHR

Date: 10/20/95

Data Sheet No. _____

GRAIN SIZE DISTRIBUTION TEST DATA

Test No.: 8

Date: 10/20/95

Project No.:

Project: LEHR

Sample Data

Location of Sample:

Sample Description 1: SSCL2001----#14

Sample Description 2: 88.5' to 89'

USCS Class: Liquid limit: Plasticity index:

Notes

Remarks:

Data Sheet No.:

Mechanical Analysis Data

Initial

Dry sample and tare= 479.70

Tare = 96.93

Dry sample weight = 382.77

Sieve tare method

Sieve	Weight retained	Sieve tare	Percent finer
# 5	465.10	460.12	98.7
# 10	477.82	474.30	97.8
# 18	325.37	315.47	95.2
# 35	470.89	419.85	81.9
# 60	609.13	377.24	21.3
# 120	313.06	242.90	2.9
# 230	380.59	372.28	0.8
# 325	392.76	391.45	0.4

Fractional Components

Gravel/Sand based on #10 sieve

Sand/Fines based on #270 sieve

% + 3 in. = 0.0 % GRAVEL = 2.2 % SAND = 97.2

% FINES = 0.6

D85= 0.53 D60= 0.383 D50= 0.346

D30= 0.2796 D15= 0.22465 D10= 0.19999

Cc = 1.0198 Cu = 1.9165

Grain size distribution curve showing Percent Finer versus Grain Size (mm). The curve indicates a sharp drop in percent finer between 0.425 mm and 0.075 mm, suggesting a well-graded material with a narrow range of particle sizes.

Grain Size (mm)	Percent Finer (%)
6 in.	100
3 in.	100
2 in.	100
1-1/2 in.	100
1 in.	100
3/4 in.	100
1/2 in.	100
3/8 in.	100
#4	95
#10	93
#20	88
#40	78
#60	26
#140	7
#200	2

SIEVE Inches size	PERCENT FINER		
	●		
X	GRAIN SIZE		
D ₆₀	0.38		
D ₃₀	0.26		
D ₁₀	0.14		
X	COEFFICIENTS		
C _c	1.23		
C _u	2.6		

SIEVE number size	PERCENT FINER		
	●		
5	96.4		
10	93.6		
18	89.7		
35	78.2		
60	27.3		
120	8.4		
230	3.2		
325	1.8		

Remarks:

Data Sheet No.

GRAIN SIZE DISTRIBUTION TEST DATA

Test No.: 5

Date: 10/21/95
Project No.:
Project:

Sample Data

Location of Sample:
Sample Description 1: SSCL2001-----#15
Sample Description 2: 89' to 89.5'
USCS Class: t Liquid limit: Plasticity index:

Notes

Remarks:

Data Sheet No.:

Mechanical Analysis Data

Initial
Dry sample and tare= 586.16
Tare = 103.20
Dry sample weight = 482.96
Sieve tare method

Sieve	Weight retained	Sieve tare	Percent finer
# 5	477.73	460.14	96.4
# 10	487.42	474.26	93.6
# 18	334.65	315.46	89.7
# 35	475.16	419.94	78.2
# 60	623.35	377.22	27.3
# 120	334.19	242.92	8.4
# 230	397.03	372.28	3.2
# 325	398.21	391.44	1.8

Fractional Components

Gravel/Sand based on #10 sieve
Sand/Fines based on #270 sieve
% + 3 in. = 0.0 % GRAVEL = 6.4 % SAND = 91.2
% FINES = 2.4

D85= 0.59 D60= 0.383 D50= 0.339
D30= 0.2609 D15= 0.18685 D10= 0.14504
Cc = 1.2260 Cu = 2.6394

Appendix C

Geophysical Logging Systems and Calibration for Well UCD2-027

Appendix C

Geophysical Logging Systems and Calibration for Well UCD2-027

This appendix provides information on the relevant history, calibration methods used, and the resulting precision and accuracy measured for each of the geophysical logging systems employed in well UCD2-027 at the Laboratory for Energy-Related Health Research (LEHR) site. These include the spectral gamma ray logging system, neutron-neutron logging systems, and the gamma-gamma density logging system.

C.1 Spectral Gamma Ray Logging System

Some radioactive elements within the formation, both naturally occurring (e.g., potassium-40, uranium-238 series, thorium-232 series) and created (e.g., cesium-137, cobalt-60), spontaneously emit gamma rays as they decay. The number and energies of the emitted gamma rays are distinctive for each element. A spectral gamma logging system passively measures the energy and intensity of incident gamma rays and computes the activity of the gamma-emitting radionuclides within the formation. The naturally occurring radionuclides reside primarily in clay minerals, micas, and potassium feldspar.

The spectral gamma logging service employed in well UCD2-027 was the Hostile Natural Gamma Spectroscopy (HNGS) system. The HNGS system was designed to identify and quantify naturally occurring radionuclides within oil wells and has been optimized to provide maximum sensitivity, so that typical oil field logging speeds can be used while retaining effective counting statistics. To this end, the system uses two scintillators composed of bismuth germanate (BGO) (Figure C.1). BGO has a high specific gravity of approximately 7 g/cm^3 , a characteristic that increases efficiency by promoting the capture of more (compared to most commonly employed scintillators) gamma rays that enter the detector. Two detectors are employed to increase the sensitivity without degrading the system's vertical resolution. Further technical information is provided in Flanagan et al. (1991).

C.1.1 Calibration

Schlumberger Wells Services adapted the HNGS service for environmental boreholes at arid U.S. Department of Energy (DOE) sites. A set of data quality objectives (DQOs), primarily for accuracy and precision, were developed for scintillation spectral systems. Additional DQOs addressed which created radionuclides the system should identify and the dynamic range for cesium-137 measurements. This system was tested for precision and accuracy in an existing set of calibration models (Steele and George 1986) built by the DOE-Grand Junction Project Office (DOE-GJPO) and

SG95110016.3

Figure C.1. Schematic of Hostile Natural Gamma Spectroscopy Sonde

now located at the Hanford Site in eastern Washington. The four models contain known potassium-40, uranium-235 (radium-226), and thorium-232 concentrations. Radium-226 is a surrogate of uranium because most gamma rays in the uranium decay chain are emitted by the bismuth daughter, bismuth-214, which is produced after radium-226 decays.

Table C.1 presents the results of the DQO tests for precision and accuracy of the naturally occurring radionuclides. These DQOs were met.

Table C.1. DQOs and Results for the Scintillation Spectral Gamma Logging System

System Check	DQOs	HNGS
Tool O.D. (in.)		3.75
Logging Speed	5 ft/min	
Precision and Accuracy Tolerances	One standard deviation	
Depth Precision	± 3 in. at a depth of 250 ft	
Distance Between Recordings		Continuous (6 in.)
Recording Times (sec)		6
Potassium Precision (pCi/g)	± 3	± 0.27
Potassium Accuracy (pCi/g)	48.5 - 60.5	50.5
Uranium Precision (pCi/g)	± 0.7	± 0.52
Thorium Precision (pCi/g)	± 0.2	± 0.13
Thorium Accuracy (pCi/g)	51.2 - 66.0	51.6

There are no calibration models for created radionuclides (e.g., cesium-137, cobalt-60). Schlumberger Well Services modeled system response using small laboratory sources and gamma-ray transport computer codes (Ellis et al. 1995).

C.2 Neutron-Neutron Logging Systems

Neutron-neutron logging systems were used to measure the volume of moisture within the formation surrounding well UCD2-027. Note that the formation is saturated below the water table; thus, this system provides a measure of porosity in this interval. These logging systems actually measure the presence of the hydrogen atom. High-energy neutrons are emitted from a source in the downhole sonde, and they collide with nuclei of the formation elastically. With each collision, the neutron loses some of its energy. The relative loss of energy is a function of the mass of the nuclei; the greatest loss occurs when a neutron strikes a nuclei of equal mass, a hydrogen atom. Collisions with heavy nuclei do not slow the neutron very much. Thus, the slowing of neutrons depends largely on the amount of hydrogen in the formation (Schlumberger 1989a).

Where the hydrogen concentration of the formation is large, most of the neutrons are slowed and captured within a short distance of the source. On the other hand, if the hydrogen content is low, more of the neutrons will travel farther before they are captured. Neutron detector(s) are spaced at least 20 cm from the source (Hearst and Carlson 1994), and their count rate decreases as the hydrogen content increases.

The nuclei of some elements are efficient in absorbing neutrons at thermal energies below 0.1 eV. Examples of particularly efficient thermal absorbers include boron and cadmium. If sufficient quantities of thermal absorbers are present in the formation, then a neutron-neutron system that measures thermal neutrons will be affected. For a set moisture content, the system will have fewer counts than anticipated

and the moisture will be overestimated. Epithermal neutrons with energies from 0.1 to 1 keV are not nearly as affected by absorption. Thus, the neutron-neutron logging systems employed at the LEHR site used epithermal neutron detectors to remove this source of error. The population of epithermal neutrons, however, is typically much smaller than the population of thermal neutrons, so a large neutron source is used to ensure acceptable counting statistics.

Most neutron-neutron logging systems use at least two detectors, a close-spaced and a far-spaced detector (Figure C.2). The close-spaced detector is used to compensate for borehole effects on the far-spaced detector by a simple division of counting rates (Ellis 1987).

A neutron-neutron logging system cannot differentiate between hydrogen in water molecules and in other minerals (e.g., hydrous minerals). The sediments beneath the LEHR site have significant clay content, so the neutron-neutron logging systems will respond, in part, to bound water in clays. Above the water table, these systems display moisture in units of volume fraction water (VFW), the volume of formation occupied by moisture; below the water table, these systems display moisture in units of porosity (pu), the volume of pore space occupied by water. Two different neutron-neutron systems were used in well UCD2-027.

Figure C.2. Conventional Neutron-Neutron Logging System

C.2.1 Compensated Neutron Log

The compensated neutron log (CNT-G) is a conventional neutron-neutron logging system. It uses a chemical source (16 Ci AmBe) that continuously emits approximately 4-MeV neutrons at a flux rate of around 4×10^7 neutrons per second (Tittman 1987). The system employs two thermal and two epithermal detectors. Because of the low moisture content within the unsaturated zone, only the epithermal count ratios were reported. The CNT-G has a vertical resolution of 6 in., an average depth of investigation of 10 in., and a diameter of 3.6 in. (Schlumberger 1989b). The tool begins measuring 3.8 ft above bottom.

C.2.2 Accelerator Porosity Sonde

The accelerator porosity sonde (APS), like the CNT-G, is also used to measure the presence of the hydrogen atom. However, the APS design is fundamentally different from that of the CNT-G. It uses an electronic neutron source that generates 14-MeV neutrons in a pulsed mode at a flux rate of approximately 3×10^8 neutrons per second (Scott et al. 1994).

This system employs one thermal and four epithermal neutron detectors (Figure C.3). The detector configuration permits the calculation of a ratio of moisture/porosity similar to the CNT-G, here referred to as the "near-far" porosity or moisture content. In addition, a medium-spaced, two epithermal detector array is used to measure moisture/porosity through slowing down time, where the array measures the decay of epithermal neutrons that occurs subsequent to a neutron pulse. The decay rate is a function of the hydrogen concentration (i.e., the more hydrogen, the faster the decay) (Mills et al. 1988). This "slowing-down" moisture/porosity measurement provides a better vertical resolution, approximately 3 in. (Ellis et al. 1995), at the expense of a poorer depth of investigation. The resulting moisture/porosity measurement is independent of lithology (i.e., concentration of thermal neutron absorbers).

The thermal neutron detector is used to calculate the decay rate of thermal neutrons subsequent to the neutron pulse. The decay is a function of the formation sigma (Σ), the macroscopic thermal neutron absorption cross section. Sigma is a function of the types and quantities of thermal neutron absorbers present within the formation. The larger Σ is, the faster the decay of the thermal neutron population. Sigma is typically measured in "capture units" (cu), a unit related to the mass-normalized thermal neutron cross section. Quartz has a Σ of about 4 cu, fresh water has one of 22 cu. A comparison of Σ and epithermal neutron porosity can differentiate zones within the formation that contain higher concentrations of thermal neutron absorbers, independent of moisture/porosity. The APS system begins measuring around 13 ft above bottom.

C.2.3 Calibration

Schlumberger Well Services calibrated both the CNT-G and APS services in moisture tanks built by Schlumberger (Ellis et al. 1995). They were subsequently tested in seven moisture tanks built by Pacific Northwest National Laboratory (PNNL) as part of a Cooperative Research and Development

Figure C.3. Schematic of Accelerator Porosity Sonde

Agreement (CRADA) (Engelman et al. 1995b) to ensure that the resulting measurements met DQOs for precision and accuracy. Three of the tanks had 6-in. and 8-in. steel casings. The results for the 6-in. casings are listed in Table C.2.

The Σ measurement has not been calibrated for environmental boreholes. Measurements from the calibration models were higher than values calculated based on the model composition. The discrepancy is probably due to the enhanced diffusion of the neutron cloud in the low density of the calibration models. Additional calibration is planned, but the data can still be used for relative measurements in the interim.

C.3 Gamma-Gamma Density Logging System

Formation bulk density is typically measured with a gamma-gamma logging system. These logging systems irradiate the formation with medium-energy gamma rays that collide with electrons in the formation. At each collision a gamma ray loses some, but not all, of its energy to electrons, and continues

Table C.2. DQOs and Results for the Neutron-Neutron Moisture/Porosity Logging Systems

System Check	DQOs	APS	CNT-G
(Near-Far)			
Tool O.D. (in.)		3.625	3.375
Logging Speed	5 ft/min		
Precision and Accuracy Tolerances	One standard deviation		
Depth Precision	± 3 in. at a depth of 250 ft		
Distance Between Recordings		Continuous (2 in.)	Continuous (2 in.)
Recording Times (sec)		3	2
5% VFW 6-in. Casing			
Precision (% VFW)	±1.0	±0.02	±0.03
Accuracy (% VFW)	3.0 - 7.0	5.62	5.17
12% VFW 6-in. Casing			
Precision (% VFW)	±1.2	±0.06	±0.07
Accuracy (% VFW)	9.5 - 14.3	11.45	12.2
20% VFW 6-in. Casing			
Precision (% VFW)	±2.0	±0.15	±0.30
Accuracy (% VFW)	15.8 - 23.8	18.55	19.72

with diminished energy. The scattered gamma rays reaching the detector on the sonde, at a fixed distance from the source, are counted as an indication of formation density (Schlumberger 1989a). The fewer the counts, the greater the electron density.

Gamma-gamma logging systems have a shallow depth of investigation, and their response is affected by borehole condition. Most gamma-gamma logging systems use dual detectors that allow the tool to correct for borehole effects (Figure C.4). A correction, based on the relationship between counting rates for each detector, is applied to the processed log. The amount of correction is plotted on the log for quality control.

The conversion of bulk density (ρ_b) to porosity (ϕ) is performed with a simple transform that requires an estimate of the grain density (ρ_{ma}) and fluid density (ρ_f) in the pore space:

$$\phi = \frac{\rho_{ma} - \rho_b}{\rho_{ma} - \rho_f} \quad (C.1)$$

The grain density was assumed to be 2.65 g/cm³ for the sediments surrounding well UCD2-027, and this assumption has led to an error in the displayed density porosity. The magnitude of the error is discussed in Section 2.2.2.2 of the main text.

Figure C.4. Gamma-Gamma Density Tool

The litho-density sonde (LDS) was used to measure formation bulk density. It uses dual detectors that provide some spectral information. The LDS has a vertical resolution of 4 in. and a depth of investigation of 4 to 6 in. The tool is sensitive to changes in bulk density of 0.01 g/cm^3 (Flanagan et al. 1991).

C.3.1 Calibration

Unlike the neutron tools discussed above, this tool has not yet been calibrated for environmental boreholes. The primary adaptation concern is the presence of steel casing (i.e., this tool is usually run in uncased holes) and the effect of any gaps between the casing and surrounding formation. Calibration models have been constructed (Engelman et al. 1995a) and measurements are complete. Once adaptation of the LDS service is complete, the log can be recomputed.

C.4 References

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Appendix D

Slug Test Result Discussion and Analysis Plots

Appendix D

Slug Test Result Discussion and Analysis Plots

This appendix presents results of individual well site slug test analyses, including test discussion and supporting analysis plots. The analyses are presented in the following order.

UCD2-007	UCD1-024
UCD1-010	UCD1-025
UCD1-011	UCD2-026
UCD1-012	UCD2-027
UCD1-013	Zone 1
UCD2-015	Zone 2
UCD2-016	Zone 3
UCD2-017	Zone 4
UCD1-018	Zone 5
UCD1-019	Zone 6
UCD1-020	Zone 7
UCD1-021	UCD1-034
UCD1-022	UCD2-035
UCD1-023	

Well Number: UCD2-007	Test Date: November 6, 1995									
Hydrogeologic Unit: HSU-2	Test Interval Depth: 80 to 90 ft									
<p>Test Description: Two slug withdrawal tests were conducted. The slugging rod used had a calculated displacement volume of 0.047 ft³, which theoretically imparts a maximum stress level, H₀, of 2.14 ft for the tests. Because of the small well casing radius and the fact that the slugging rod could not be removed "instantaneously" from the water column, the theoretical maximum stress level was not observed during the initial phases of the slug test. A maximum observed stress level of 1.45 ft was recorded immediately following slugging rod removal. A comparison of responses for Tests 1 and 2 indicate very similar oscillatory underdamped slug test behavior; Test 2, however, exhibited more instrument noise during the course of the test. For this reason, Test 1 was used as the focus of the test analysis.</p>										
<p>Test Site/Formation Conditions: The static water level prior to Test 1 was 40.98 ft below the top of the 2-in. PVC well casing. No water-level trend was exhibited within the test interval during testing. The test responses were monitored with a pressure transducer within the well casing above the well screen interval. The well screen/test interval penetrates 26% of the saturated aquifer thickness, b, and is located in the upper portion of HSU-2. The aquifer top is 78 ft below land surface and represents the contact between HSU-1 and HSU-2. The aquifer bottom is estimated to occur at a depth of 116 ft below land surface. The test interval completion consists of a 2-inch I.D. PVC screen (80 - 90 ft bgs) within an 8-inch I.D. borehole. The test interval is completed with a 4-inch thick sandpack between the well screen/borehole annulus, which extends 5 ft above the well screen interval. No adjacent observation wells were available within the radius of investigation of the tests.</p>										
<p>Analysis: Slug Test 1 oscillatory response was analyzed using the analytical methods for non-frictional (Van der Kamp 1976, 1984) and frictional underdamped test response (Van der Kamp 1984). Examination of head loss conditions during the test response indicates that laminar flow conditions were established approximately 7 sec after test initiation. For this reason, oscillatory slug test data ≥ 7 sec were the focus of the test analysis. Analysis results for Test 1 indicate transmissivity values ranging between 1190 ft²/d and 1340 ft²/d for the non-frictional analytical methods presented in Van der Kamp (1984) and (1976), respectively. A transmissivity value of 1220 ft²/d was obtained using the frictional analysis method presented in Van der Kamp (1984). These analysis results assume a storativity value of 0.0001. To examine the sensitivity of the frictional analysis method, transmissivity values were also calculated for storativities equal to 0.0005 and 0.00005. Transmissivity values of 880 ft²/d and 1370 ft²/d were calculated, respectively.</p>										
<p>Comments: The frictional underdamped slug test analyses described above provide an estimate range for effective hydraulic conductivity ranging between 88 ft/d and 137 ft/d. No previously reported hydraulic property values are available for this well for comparison purposes. Because the tests exhibit responses that are quickly damped, with a calculated, relatively high, damping constant, d, value of 0.36, the indicated analysis properties should be considered to be qualitative estimates. The frictional analysis results are considered to provide the best estimate values for hydraulic property determination. The best estimate value for transmissivity and equivalent hydraulic conductivity (based on an assumed value of storativity of 0.0001) are 1220 ft²/d and 122 ft/d, respectively.</p>										
<p>Test Result Summary:</p>										
	<table><tr><th></th><th><u>Frictional Analysis Results</u></th><th><u>Previous Test Results</u></th></tr><tr><td>Transmissivity</td><td>Range: 880 to 1370 ft²/d Best Estimate: 1220 ft²/d</td><td>None</td></tr><tr><td>Equivalent Hydraulic Conductivity</td><td>Range: 88 to 137 ft/d Best Estimate: 122 ft/d</td><td>None</td></tr></table>		<u>Frictional Analysis Results</u>	<u>Previous Test Results</u>	Transmissivity	Range: 880 to 1370 ft ² /d Best Estimate: 1220 ft ² /d	None	Equivalent Hydraulic Conductivity	Range: 88 to 137 ft/d Best Estimate: 122 ft/d	None
	<u>Frictional Analysis Results</u>	<u>Previous Test Results</u>								
Transmissivity	Range: 880 to 1370 ft ² /d Best Estimate: 1220 ft ² /d	None								
Equivalent Hydraulic Conductivity	Range: 88 to 137 ft/d Best Estimate: 122 ft/d	None

Well Number: UCD1-010	Test Date: November 1, 1995	
Hydrogeologic Unit: HSU-1	Test Interval Depth: 52 to 70 ft	
Test Description: Two slug withdrawal tests were conducted. Slugging rods used had displacement volumes of 0.124 ft ³ and 0.323 ft ³ , which imparted maximum observed stress levels, H ₀ , of 1.355 ft and 3.430 ft for Tests 1 and 2, respectively. For comparison purposes, the theoretical values for H ₀ representing instantaneous responses are 1.424 ft and 3.703 ft, respectively. Normalized responses for each of the different stress level tests compared favorably, yielding similar overdamped test response patterns (i.e., exponential decay curves) for elapsed test times, t > 10 sec. The test responses exhibited transient type behavior due to slugging rod removal for early test times less than 10 sec. Laminar flow conditions were established after 7 sec for Test 1 and 12 sec for Test 2.		
Test Site/Formation Conditions: The static water level prior to testing was 38.66 ft bgs and changed negligibly over the duration of testing. The test responses occurred within the well casing above the well screen interval. The test interval penetrates 56% of the saturated aquifer thickness, b, and is located in the lower two-thirds portion of HSU-1. The aquifer bottom is 71 ft below land surface and represents the contact between HSU-1 and HSU-2. The test interval completion consists of a 4-inch I.D. PVC screen (54 - 69 ft bgs) within a 12-inch I.D. borehole. A 4-inch thick sandpack (52 - 70 ft bgs) extends above and below the well screen interval within the annulus. No adjacent observation wells were available within the radius of investigation of the test responses.		
Analysis: Composite type-curve and derivative analyses were employed for each slug test using analytical methods presented in Spane and Wurstner (1993) and Spane (1996). Overdamped test response data exhibiting laminar flow conditions (i.e., >7 sec for Test 1 and >12 sec for Test 2) were analyzed. The sandpack interval (rather than the well screen interval) was used to represent the test interval for the analyses because it is considered to be more representative in conveying formational test responses. This is due to the assumed higher transmissive properties of the sandpack in comparison to the surrounding test formation. The maximum observed H ₀ stress levels were used for the test analyses. The observed H ₀ values (which are lower than the theoretical values) are considered to be more representative of actual test conditions because withdrawal of the slugging rods were not purely instantaneous (i.e., the duration of complete withdrawal of the submerged slugging rod required 1 to 2 sec for each test). The value for the anisotropy ratio (K _D) was assumed to be 0.1 (Note: slug test responses are not very sensitive to K _D values). A storativity value of 0.001 gave slightly better type-curve matches than 0.0001 for the analyses of both tests. Composite type-curve and derivative analysis for both tests provided a range of 62 to 70 ft ² /d for transmissivity (T) and 1.9 to 2.2 ft/d for equivalent horizontal hydraulic conductivity (K _e).		
Comments: The overdamped response data for Tests 1 and 2 compared favorably with each other. Because of the close test correspondence, an average of the test analysis results was used for calculating the best estimate values. The best estimate values for transmissivity and equivalent hydraulic conductivity are 66 ft ² /d and 2.1 ft/d, respectively. The slug test analyses described above provide a value of equivalent hydraulic conductivity that is ~30% higher than that reported in DOE (1993) for previously conducted tests. However, these previous estimates were derived using the Bouwer and Rice (1976) method, which has been shown by Hyder and Butler (1995) and Brown et al. (1995) to commonly underestimate hydraulic property values.		
Test Result Summary:		
Transmissivity	<u>Analysis</u> Range: 62 to 70 ft ² /d Best Estimate: 66 ft ² /d	<u>Previous Test Results</u> Not Reported
Equivalent Hydraulic Conductivity	Range: 1.9 to 2.2 ft/d Best Estimate: 2.1 ft/d	1.6 ft/d (DOE 1993)

Well Number: UCD1-011	Test Date: November 2, 1995									
Hydrogeologic Unit: HSU-1	Test Interval Depth: 47.0 to 66.5 ft									
Test Description: Two slug withdrawal tests were conducted. Slugging rods used had displacement volumes of 0.124 ft ³ and 0.323 ft ³ , which imparted maximum observed stress levels, H _o , of 1.309 ft and 3.275 ft for Tests 1 and 2, respectively. For comparison purposes, the theoretical values for H _o representing instantaneous responses are 1.424 ft and 3.703 ft, respectively. Normalized responses for each of the different stress level tests compared favorably, yielding similar overdamped test response patterns (i.e., exponential decay curves) for elapsed test times, t > 3 sec. The test responses exhibited transient type behavior due to slugging rod removal for early test times less than 3 sec. Laminar flow conditions were established after 7 sec for Test 1 and 12 sec for Test 2.										
Test Site/Formation Conditions: The static water level prior to testing was 38.26 ft bgs and changed negligibly over the duration of the test. The test responses occurred within the well casing above the well screen interval. The test interval penetrates 49% of the saturated aquifer thickness, b, and is located in the middle portion of HSU-1. The aquifer bottom is 78 ft below land surface and represents the contact between HSU-1 and HSU-2. The test interval completion consists of a 4-inch I.D. PVC screen (50 - 65 ft bgs) within a 12-inch I.D. borehole. A 4-inch thick sandpack (47.0 - 66.5 ft bgs) extends above and below the well screen interval within the annulus. No adjacent observation wells were available within the radius of investigation of the test responses.										
Analysis: Composite type-curve and derivative analyses were employed for each slug test using analytical methods presented in Spane and Wurstner (1993) and Spane (1996). Overdamped test response data exhibiting laminar flow conditions (i.e., >7 sec for Test 1 and >12 sec for Test 2) were analyzed. The sandpack interval (rather than the well screen interval) was used to represent the test interval for the analyses because it is considered to be more representative in conveying formational test responses. This is due to the assumed higher transmissive properties of the sandpack in comparison to the surrounding test formation. The maximum observed H _o stress levels were used for the test analyses. The observed H _o values (which are lower than the theoretical values) are considered to be more representative of actual test conditions because withdrawal of the slugging rods were not purely instantaneous (i.e., the duration of complete withdrawal of the submerged slugging rod required 1 to 2 sec for each test). The value for the anisotropy ratio (K _D) was assumed to be 0.1 (Note: slug test responses are not sensitive to K _D values). A storativity value of 0.0001 gave the best type-curve matches for the analyses of both tests. Composite type-curve and derivative analysis for both tests provided a range of 250 to 270 ft ² /d for transmissivity (T) and 6.3 to 6.8 ft/d for equivalent horizontal hydraulic conductivity (K _e).										
Comments: The overdamped response data for Tests 1 and 2 compared favorably with each other. Because of the close test correspondence, an average of the test analysis results was used for calculating the best estimate values. The best estimate values for transmissivity and equivalent hydraulic conductivity are 260 ft ² /d and 6.6 ft/d, respectively. The slug test analyses described above provide a value of equivalent hydraulic conductivity that is ~80% higher than that reported in DOE (1993) for previously conducted tests. However, these previous estimates were derived using the Bouwer and Rice (1976) method, which has been shown by Hyder and Butler (1995) and Brown et al. (1995) to commonly underestimate hydraulic property values.										
Test Result Summary:										
	<table><tr><td></td><td><u>Analysis</u></td><td><u>Previous Test Results</u></td></tr><tr><td>Transmissivity</td><td>Range: 250 to 270 ft²/d Best Estimate: 260 ft²/d</td><td>Not Reported</td></tr><tr><td>Equivalent Hydraulic Conductivity</td><td>Range: 6.3 to 6.8 ft/d Best Estimate: 6.6 ft/d</td><td>3.7 ft/d (DOE 1993)</td></tr></table>		<u>Analysis</u>	<u>Previous Test Results</u>	Transmissivity	Range: 250 to 270 ft ² /d Best Estimate: 260 ft ² /d	Not Reported	Equivalent Hydraulic Conductivity	Range: 6.3 to 6.8 ft/d Best Estimate: 6.6 ft/d	3.7 ft/d (DOE 1993)
	<u>Analysis</u>	<u>Previous Test Results</u>								
Transmissivity	Range: 250 to 270 ft ² /d Best Estimate: 260 ft ² /d	Not Reported								
Equivalent Hydraulic Conductivity	Range: 6.3 to 6.8 ft/d Best Estimate: 6.6 ft/d	3.7 ft/d (DOE 1993)

Well Number: UCD1-012		Test Date: November 1, 1995	
Hydrogeologic Unit: HSU-1		Test Interval Depth: 47.0 to 66.5 ft	
Test Description: Two slug withdrawal tests were conducted. Slugging rods used had displacement volumes of 0.124 ft ³ and 0.323 ft ³ , which imparted maximum observed stress levels, H ₀ , of 1.257 ft and 3.128 ft for Tests 1 and 2, respectively. For comparison purposes, the theoretical values for H ₀ representing instantaneous responses are 1.424 ft and 3.703 ft, respectively. Normalized responses for each of the different stress level tests compared favorably, yielding similar overdamped test response patterns (i.e., exponential decay curves) for elapsed test times, t > 13 sec. The test responses exhibited transient type behavior due to slugging rod removal for early test times less than 13 sec. Laminar flow conditions were established after 11 sec for Test 1 and 13 sec for Test 2.			
Test Site/Formation Conditions: The static water level prior to testing was 39.40 ft bgs and changed negligibly over the duration of the test. The test responses occurred within the well casing above the well screen interval. The test interval penetrates 47% of the saturated aquifer thickness, b, and is located in the middle portion of HSU-1. The aquifer bottom is 81 ft below land surface and represents the contact between HSU-1 and HSU-2. The test interval completion consists of a 4-inch I.D. PVC screen (49.5 - 64.5 ft bgs) within a 12-inch I.D. borehole. A 4-inch thick sandpack (47.0 - 66.5 ft bgs) extends above and below the well screen interval within the annulus. No adjacent observation wells were available within the radius of investigation of the test responses.			
Analysis: Composite type-curve and derivative analyses were employed for each slug test using analytical methods presented in Spane and Wurstner (1993) and Spane (1996). Overdamped test response data exhibiting laminar flow conditions (i.e., >11 sec for Test 1 and >13 sec for Test 2) were analyzed. The sandpack interval (rather than the well screen interval) was used to represent the test interval for the analyses because it is considered to be more representative in conveying formational test responses. This is due to the assumed higher transmissive properties of the sandpack in comparison to the surrounding test formation. The maximum observed H ₀ stress levels were used for the test analyses. The observed H ₀ values (which are lower than the theoretical values) are considered to be more representative of actual test conditions because withdrawal of the slugging rods were not purely instantaneous (i.e., the duration of complete withdrawal of the submerged slugging rod required 1 to 2 sec for each test). The value for the anisotropy ratio (K _D) was assumed to be 0.1 (Note: slug test responses are not very sensitive to K _D values). A storativity value of 0.001 gave slightly better type-curve matches than 0.0001 for the analyses of both tests. Composite type-curve and derivative analysis for both tests provided values of 90 ft ² /d for transmissivity (T) and 2.2 ft/d for equivalent horizontal hydraulic conductivity (K _e).			
Comments: The overdamped response data for Tests 1 and 2 compared favorably with each other. Because of the identical test analysis results, the best estimate values for transmissivity and equivalent hydraulic conductivity are 90 ft ² /d and 2.2 ft/d, respectively. The slug test analyses described above provide a value of equivalent hydraulic conductivity that is ~3.6 times higher than that reported in DOE (1993) for previously conducted tests. However, these previous estimates were derived using the Bouwer and Rice (1976) method, which has been shown by Hyder and Butler (1995) and Brown et al. (1995) to commonly underestimate hydraulic property values.			
Test Result Summary:			
		<u>Analysis</u>	<u>Previous Test Results</u>
Transmissivity	Best Estimate:	90 ft ² /d	Not Reported
Equivalent Hydraulic Conductivity			
	Best Estimate:	2.2 ft/d	0.6 ft/d (DOE 1993)

Well Number: UCD1-013	Test Date: November 3, 1995	
Hydrogeologic Unit: HSU-1	Test Interval Depth: 47.0 to 66.5 ft	
Test Description: Two slug withdrawal tests were conducted. Slugging rods used had displacement volumes of 0.124 ft ³ and 0.323 ft ³ , which imparted maximum observed stress levels, H ₀ , of 1.292 ft and 3.236 ft for Tests 1 and 2, respectively. For comparison purposes, the theoretical values for H ₀ representing instantaneous responses are 1.424 ft and 3.703 ft, respectively. Normalized responses for each of the different stress level tests compared favorably, yielding similar overdamped test response patterns (i.e., exponential decay curves) for elapsed test times, t > 10 sec. The test responses exhibited transient type behavior due to slugging rod removal for early test times less than 10 sec. Laminar flow conditions were established after 9 sec for Test 1 and 12 sec for Test 2.		
Test Site/Formation Conditions: The static water level prior to testing was 39.38 ft bgs and changed negligibly over the duration of the test. The test responses occurred within the well casing above the well screen interval. The test interval penetrates 48% of the saturated aquifer thickness, b, and is located in the middle portion of HSU-1. The aquifer bottom is 80 ft below land surface and represents the contact between HSU-1 and HSU-2. The test interval completion consists of a 4-inch I.D. PVC screen (50 - 65 ft bgs) within a 12-inch I.D. borehole. A 4-inch thick sandpack (47.0 - 66.5 ft bgs) extends above and below the well screen interval within the annulus. No adjacent observation wells were available within the radius of investigation of the test responses.		
Analysis: Composite type-curve and derivative analyses were employed for each slug test using analytical methods presented in Spane and Wurstner (1993) and Spane (1996). Overdamped test response data exhibiting laminar flow conditions (i.e., >9 sec for Test 1 and >12 sec for Test 2) were analyzed. The sandpack interval (rather than the well screen interval) was used to represent the test interval for the analyses because it is considered to be more representative in conveying formational test responses. This is due to the assumed higher transmissive properties of the sandpack in comparison to the surrounding test formation. The maximum observed H ₀ stress levels were used for the test analyses. The observed H ₀ values (which are lower than the theoretical values) are considered to be more representative of actual test conditions because withdrawal of the slugging rods were not purely instantaneous (i.e., the duration of complete withdrawal of the submerged slugging rod required 1 sec for each test). The value for the anisotropy ratio (K _D) was assumed to be 0.1 (Note: slug test responses are not very sensitive to K _D values). A storativity value of 0.0003 gave the best type-curve matches for the analyses of both tests. Composite type-curve and derivative analysis for both tests provided a range of 105 to 115 ft ² /d for transmissivity (T) and 2.6 to 2.8 ft/d for equivalent horizontal hydraulic conductivity (K _e).		
Comments: The overdamped response data for Tests 1 and 2 compared favorably with each other. Because of the close test correspondence, an average of the test analysis results was used for calculating the best estimate values. The best estimate values for transmissivity and equivalent hydraulic conductivity are 110 ft ² /d and 2.7 ft/d, respectively. The slug test analyses described above provide a value of equivalent hydraulic conductivity that is ~2.5 times higher than that reported in DOE (1993) for previously conducted tests. However, these previous estimates were derived using the Bouwer and Rice (1976) method, which has been shown by Hyder and Butler (1995) and Brown et al. (1995) to commonly underestimate hydraulic property values.		
Test Result Summary:		
	<u>Analysis</u>	<u>Previous Test Results</u>
Transmissivity	Range: 105 to 115 ft ² /d Best Estimate: 110 ft ² /d	Not Reported
Equivalent Hydraulic Conductivity	Range: 2.6 to 2.8 ft/d Best Estimate: 2.7 ft/d	1.1 ft/d (DOE 1993)

Well Number: UCD2-015	Test Date: October 31, 1995									
Hydrogeologic Unit: HSU-2	Test Interval Depth: 91 to 116 ft									
Test Description: Five slug withdrawal tests were conducted. Tests 1 and 2 were performed using a slugging rod with a displacement volume of 0.124 ft ³ . Tests 3, 4 and 5 were conducted using a slugging rod with a displacement volume of 0.323 ft ³ . The displacement volumes for the slugging rods used for the tests, theoretically cause a maximum stress level, H ₀ , of 1.424 ft for Tests 1 and 2, and 3.703 ft for Tests 3, 4 and 5.										
Test Site/Formation Conditions: The static water level prior to the tests was 40.66 ft bgs. No significant water-level change was exhibited within the test interval during testing. The test responses were monitored with a pressure transducer within the well casing above the well screen interval. The well screen/test interval penetrates 75% of the saturated HSU-2 aquifer thickness at this site. The aquifer top is 85 ft below land surface and represents the contact between HSU-1 and HSU-2. The aquifer bottom occurs at a depth of 118 ft below land surface. The test interval completion consists of a 4-inch I.D. PVC screen (91 - 116 ft bgs) within an 12-inch I.D. borehole. The test interval is completed with a 4-inch thick sandpack between the well screen/borehole annulus, which extends over the depth interval 86 - 120.5 ft. No adjacent observation wells were available within the radius of investigation of the tests.										
Analysis: The oscillatory slug test responses for Test 2 and 3 were quantitatively analyzed using the analytical methods for non-frictional (Van der Kamp 1976, 1984) and frictional underdamped test response (Van der Kamp 1984). Note: Test 1 exhibited a significant trend during the test; Test 4 did not fully remove the slugging rod from the water column; and, Test 5 provided identical oscillatory response as Test 3 after the initial 2 sec of the test. These three tests, therefore, were not analyzed. Examination of flow velocity conditions during the tests indicates that laminar flow conditions were established approximately 10 sec and 14 sec after initiation of Test 2 and Test 3, respectively. Laminar flow, oscillatory slug test data were the focus of the test analysis. Analysis results for Test 2 indicate transmissivity values ranging between 6,180 ft ² /d and 6,580 ft ² /d for the non-frictional analytical methods presented in Van der Kamp (1984) and (1976), respectively. A transmissivity value of 6,250 ft ² /d was obtained using the frictional analysis method presented in Van der Kamp (1984). These analysis results assume a storativity value of 0.0001. To examine the sensitivity of the frictional analysis method, transmissivity values were also calculated for storativities equal to 0.0005 and 0.00005. Transmissivity values of 4,830 ft ² /d and 6,850 ft ² /d were calculated, respectively. Identical analysis results were indicated for the analysis of Test 3. This is because the same oscillatory period (10.4 sec) and damping constant (0.155 sec ⁻¹) were obtained from the analysis.										
Comments: Because identical results were obtained, the frictional analysis results derived from either Test 2 and 3 are considered to provide the best estimate values for hydraulic property determination. It should be noted that the relatively high value for analysis parameter d (0.249), suggests that the oscillatory analysis may be highly qualitative. The frictional underdamped slug test analysis described above provides a best estimate value for transmissivity and equivalent hydraulic conductivity (based on an assumed value of storativity of 0.0001) of 6,250 ft ² /d and 250 ft/d, respectively. Previous estimates for hydraulic conductivity obtained from earlier slug tests at this well site are reported in DOE (1993) to range between 27 ft/d and 30 ft/d. These previous estimates, however, were derived using inappropriate analytical methods (e.g., Bouwer and Rice, 1976) for oscillatory slug test responses.										
Test Result Summary:										
	<table><tr><th></th><th><u>Frictional Analysis Results</u></th><th><u>Previous Test Results</u></th></tr><tr><td>Transmissivity</td><td>Range: 4,830 to 6,850 ft²/d Best Estimate: 6,250 ft²/d</td><td>Not Reported</td></tr><tr><td>Equivalent Hydraulic Conductivity</td><td>Range: 193 to 274 ft/d Best Estimate: 250 ft/d</td><td>27 to 30 ft/d (DOE 1993)</td></tr></table>		<u>Frictional Analysis Results</u>	<u>Previous Test Results</u>	Transmissivity	Range: 4,830 to 6,850 ft ² /d Best Estimate: 6,250 ft ² /d	Not Reported	Equivalent Hydraulic Conductivity	Range: 193 to 274 ft/d Best Estimate: 250 ft/d	27 to 30 ft/d (DOE 1993)
	<u>Frictional Analysis Results</u>	<u>Previous Test Results</u>								
Transmissivity	Range: 4,830 to 6,850 ft ² /d Best Estimate: 6,250 ft ² /d	Not Reported								
Equivalent Hydraulic Conductivity	Range: 193 to 274 ft/d Best Estimate: 250 ft/d	27 to 30 ft/d (DOE 1993)								

Well UCD2-015: Slug Test 2 Analysis

Well UCD2-015: Slug Test 3 Analysis

Well Number: UCD2-016	Test Date: November 3, 1995	
Hydrogeologic Unit: HSU-2	Test Interval Depth: 92 to 117 ft	
Test Description: Three slug withdrawal tests were conducted. Test 1 was performed using a slugging rod with a displacement volume of 0.124 ft ³ . Tests 2 and 3 were conducted using a slugging rod with a displacement volume of 0.323 ft ³ . The displacement volumes for the slugging rods used during the tests, theoretically cause a maximum stress level, H _o , of 1.424 ft for Test 1 and 3.703 ft for Test 2 and 3.		
Test Site/Formation Conditions: The static water level prior to the tests was 38.69 ft bgs. No water-level trend was exhibited within the test interval during testing. The test responses were monitored with a pressure transducer within the well casing above the well screen interval. The well screen/test interval penetrates 80% of the saturated HSU-2 aquifer thickness at this site. The aquifer top is 88 ft below land surface and represents the contact between HSU-1 and HSU-2. The aquifer bottom occurs at a depth of 119 ft below land surface. The test interval completion consists of a 4-inch I.D. PVC screen (92 - 117 ft bgs) within an 12-inch I.D. borehole. The test interval is completed with a 4-inch thick sandpack between the well screen/borehole annulus, which extends over the depth interval 89 - 122 ft. No adjacent observation wells were available within the radius of investigation of the tests.		
Analysis: The oscillatory slug test responses for Test 1 and 3 were quantitatively analyzed using the analytical methods for non-frictional (Van der Kamp 1976, 1984) and frictional underdamped test response (Van der Kamp 1984). Note: A comparison of responses for Tests 2 and 3 indicate identical oscillatory underdamped slug test behavior after the initial 2 sec of the test. Examination of flow velocity conditions during the tests indicates that laminar flow conditions were established approximately 20 sec and 25 sec after initiation of Test 1 and Test 3, respectively. Oscillatory slug test data indicative of laminar flow conditions were the focus of the test analysis. Analysis results for Test 1 indicate transmissivity values ranging between 12,100 ft ² /d and 12,500 ft ² /d for the non-frictional analytical methods presented in Van der Kamp (1984) and (1976), respectively. A transmissivity value of 12,300 ft ² /d was obtained using the frictional analysis method presented in Van der Kamp (1984). These analysis results assume a storativity value of 0.0001. To examine the sensitivity of the frictional analysis method, transmissivity values were also calculated for storativities equal to 0.0005 and 0.00005. Transmissivity values of 9,760 ft ² /d and 13,400 ft ² /d were calculated, respectively. Very similar results were indicated for the analysis of Test 3. Calculated transmissivity values ranged between 11,800 ft ² /d and 12,200 ft ² /d for the various analytical methods (assuming S = 0.0001).		
Comments: Because of the dependence of the analysis methods on low stress levels, results for Test 1 are considered to provide the best results for hydraulic property estimation. The frictional analysis results are also considered to provide the best estimate values for hydraulic property determination. The frictional underdamped slug test analysis described above provides a best estimate value for transmissivity and equivalent hydraulic conductivity (based on an assumed value of storativity of 0.0001) of 12300 ft ² /d and 492 ft/d, respectively. Previous estimates for hydraulic conductivity obtained from earlier slug tests at this well site are reported in DOE (1993) to range between 23 ft/d and 46 ft/d. These previous estimates, however, were derived using inappropriate analytical methods (e.g., Bouwer and Rice, 1976, Cooper et al. 1967) for oscillatory slug test responses.		
Test Result Summary:		
	<u>Frictional Analysis Results</u>	<u>Previous Test Results</u>
Transmissivity	Range: 9760 to 13400 ft ² /d Best Estimate: 12300 ft ² /d	Not Reported
Equivalent Hydraulic Conductivity	Range: 390 to 536 ft/d Best Estimate: 492 ft/d	23 to 46 ft/d (DOE 1993)

Well UCD2-016: Slug Test 1 Analysis

Well UCD2-016: Slug Test 3 Analysis

Well Number: UCD2-017	Test Date: October 31, 1995									
Hydrogeologic Unit: HSU-2	Test Interval Depth: 88 to 113 ft									
Test Description: Four slug withdrawal tests were conducted. Tests 1 and 2 were performed using a slugging rod with a displacement volume of 0.124 ft ³ . Tests 3 and 4 were conducted using a slugging rod with a displacement volume of 0.323 ft ³ . The displacement volumes for the slugging rods used during the tests, theoretically cause a maximum stress level, H ₀ , of 1.424 ft for Tests 1 and 2, and 3.703 ft for Tests 3 and 4.										
Test Site/Formation Conditions: The static water level prior to the tests was 40.71 ft bgs. No significant water-level change was exhibited within the test interval during testing. The test responses were monitored with a pressure transducer within the well casing above the well screen interval. The well screen/test interval penetrates 47% of the saturated HSU-2 aquifer thickness at this site. The aquifer top is 85 ft below land surface and represents the contact between HSU-1 and HSU-2. The aquifer bottom occurs at a depth of 138 ft below land surface. The test interval completion consists of a 4-inch I.D. PVC screen (88 - 113 ft bgs) within an 12-inch I.D. borehole. The test interval is completed with a 4-inch thick sandpack between the well screen/borehole annulus, which extends over the depth interval 81 - 118 ft. No adjacent observation wells were available within the radius of investigation of the tests.										
Analysis: The oscillatory slug test responses for Test 2 and 4 were quantitatively analyzed using the analytical methods for non-frictional (Van der Kamp 1976, 1984) and frictional underdamped test response (Van der Kamp 1984). Note: Test 1 exhibited a significant trend during the test and, therefore, was not analyzed. Test 3 indicate identical oscillatory underdamped slug test behavior as Test 4. Examination of flow velocity conditions during the tests indicates that laminar flow conditions were established approximately 24 sec and 34 sec after initiation of Test 2 and Test 4 respectively. Oscillatory slug test data indicative of laminar flow conditions were the focus of the test analysis. Analysis results for Test 2 indicate transmissivity values ranging between 15,200 ft ² /d and 15,600 ft ² /d for the non-frictional analytical methods presented in Van der Kamp (1984) and (1976), respectively. A transmissivity value of 15,500 ft ² /d was obtained using the frictional analysis method presented in Van der Kamp (1984). These analysis results assume a storativity value of 0.0001. To examine the sensitivity of the frictional analysis method, transmissivity values were also calculated for storativities equal to 0.0005 and 0.00005. Transmissivity values of 12,400 ft ² /d and 16,800 ft ² /d were calculated, respectively. Very similar results were indicated for the analysis of Test 4. Calculated transmissivity values ranged between 15,000 ft ² /d and 15,400 ft ² /d for the various analytical methods (assuming S = 0.0001).										
Comments: Because of the dependence of the analysis methods on low stress levels, results for Test 2 are considered to provide the best results for hydraulic property estimation. The frictional analysis results are also considered to provide the best estimate values for hydraulic property determination. The frictional underdamped slug test analysis described above provides a best estimate value for transmissivity and equivalent hydraulic conductivity (based on an assumed value of storativity of 0.0001) of 15,500 ft ² /d and 620 ft/d, respectively. Previous estimates for hydraulic conductivity obtained from earlier slug tests at this well site are reported in DOE (1993) to range between 39 ft/d and 54 ft/d. These previous estimates, however, were derived using inappropriate analytical methods (e.g., Bouwer and Rice, 1976) for oscillatory slug test responses.										
Test Result Summary:										
	<table><tr><th></th><th><u>Frictional Analysis Results</u></th><th><u>Previous Test Results</u></th></tr><tr><td>Transmissivity</td><td>Range: 12,400 to 16,800 ft²/d Best Estimate: 15,500 ft²/d</td><td>Not Reported</td></tr><tr><td>Equivalent Hydraulic Conductivity</td><td>Range: 496 to 672 ft/d Best Estimate: 620 ft/d</td><td>39 to 54 ft/d (DOE 1993)</td></tr></table>		<u>Frictional Analysis Results</u>	<u>Previous Test Results</u>	Transmissivity	Range: 12,400 to 16,800 ft ² /d Best Estimate: 15,500 ft ² /d	Not Reported	Equivalent Hydraulic Conductivity	Range: 496 to 672 ft/d Best Estimate: 620 ft/d	39 to 54 ft/d (DOE 1993)
	<u>Frictional Analysis Results</u>	<u>Previous Test Results</u>								
Transmissivity	Range: 12,400 to 16,800 ft ² /d Best Estimate: 15,500 ft ² /d	Not Reported								
Equivalent Hydraulic Conductivity	Range: 496 to 672 ft/d Best Estimate: 620 ft/d	39 to 54 ft/d (DOE 1993)								

Well UCD2-017: Slug Test 2 Analysis

Well UCD2-017: Slug Test 4 Analysis

Well Number: UCD1-018		Test Date: October 31, 1995									
Hydrogeologic Unit: HSU-1		Test Interval Depth: 51 to 70 ft									
<p>Test Description: Two slug withdrawal tests were conducted. Slugging rods used had displacement volumes of 0.124 ft³ and 0.323 ft³, which imparted maximum observed stress levels, H_o, of 1.378 ft and 3.367 ft for Tests 1 and 2, respectively. For comparison purposes, the theoretical values for H_o representing instantaneous responses are 1.424 ft and 3.703 ft, respectively. Normalized responses for each of the different stress level tests compared favorably, yielding similar overdamped test response patterns (i.e., exponential decay curves) for elapsed test times, $t > 5$ sec. The test responses exhibited transient type behavior due to slugging rod removal for early test times less than 5 sec. Laminar flow conditions were established after 5 sec for Test 1 and 16 sec for Test 2.</p>											
<p>Test Site/Formation Conditions: The static water level prior to testing was 35.75 ft bgs and changed negligibly over the duration of testing. The test responses occurred within the well casing above the well screen interval. The test interval penetrates 42% of the saturated aquifer thickness, b, and is located in the middle portion of HSU-1. The aquifer bottom is 81 ft below land surface and represents the contact between HSU-1 and HSU-2. The test interval completion consists of a 4-inch I.D. PVC screen (54 - 69 ft bgs) within a 12-inch I.D. borehole. A 4-inch thick sandpack (51 - 70 ft bgs) extends above and below the well screen interval within the annulus. No adjacent observation wells were available within the radius of investigation of the test responses.</p>											
<p>Analysis: Composite type-curve and derivative analyses were employed for each slug test using analytical methods presented in Spane and Wurstner (1993) and Spane (1996). Overdamped test response data exhibiting laminar flow conditions (i.e., >5 sec for Test 1 and >16 sec for Test 2) were analyzed. The sandpack interval (rather than the well screen interval) was used to represent the test interval for the analyses because it is considered to be more representative in conveying formational test responses. This is due to the assumed higher transmissive properties of the sandpack in comparison to the surrounding test formation. The maximum observed H_o stress levels were used for the analyses. The observed values for H_o (which are lower than the theoretical values) are considered to be more representative of actual test conditions because withdrawal of the slugging rods were not purely instantaneous (i.e., the duration of complete withdrawal of the submerged slugging rod required 1 to 2 sec for each test). The value for the anisotropy ratio (K_D) was assumed to be 0.1 (Note: slug test responses are not very sensitive to K_D values). A storativity value of 0.001 for Test 1 and 0.0004 for Test 2 gave slightly better type-curve matches for the analyses. Composite type-curve and derivative analysis for both tests provided a range of 490 to 540 ft²/d for transmissivity (T) and 11 to 12 ft/d for equivalent horizontal hydraulic conductivity (K_e).</p>											
<p>Comments: The overdamped response data for Tests 1 and 2 exhibit slightly different responses. The differences are attributed to higher head loss due to turbulence associated with the higher stress test (i.e., Test 2). Therefore, the test analysis results for the lower stress test (i.e., Test 1) were used for calculating the best estimate values. The best estimate values for transmissivity and equivalent hydraulic conductivity are 540 ft²/d and 12 ft/d, respectively. The slug test analyses described above provide a value of equivalent hydraulic conductivity that is ~70% higher than that reported in DOE (1993) for previously conducted tests. However, these previous estimates were derived using the Bouwer and Rice (1976) method, which has been shown by Hyder and Butler (1995) and Brown et al. (1995) to commonly underestimate hydraulic property values.</p>											
Test Result Summary:											
<table> <tr> <th></th><th><u>Analysis</u></th><th><u>Previous Test Results</u></th></tr> <tr> <td>Transmissivity</td><td>Range: 490 to 540 ft²/d Best Estimate: 540 ft²/d</td><td>Not Reported</td></tr> <tr> <td>Equivalent Hydraulic Conductivity</td><td>Range: 11 to 12 ft/d Best Estimate: 12 ft/d</td><td>7.2 ft/d (DOE 1993)</td></tr> </table>				<u>Analysis</u>	<u>Previous Test Results</u>	Transmissivity	Range: 490 to 540 ft ² /d Best Estimate: 540 ft ² /d	Not Reported	Equivalent Hydraulic Conductivity	Range: 11 to 12 ft/d Best Estimate: 12 ft/d	7.2 ft/d (DOE 1993)
	<u>Analysis</u>	<u>Previous Test Results</u>									
Transmissivity	Range: 490 to 540 ft ² /d Best Estimate: 540 ft ² /d	Not Reported									
Equivalent Hydraulic Conductivity	Range: 11 to 12 ft/d Best Estimate: 12 ft/d	7.2 ft/d (DOE 1993)									

Baseline Response: Well UCD1-018

Well UCD1-018: Slug Test 1 Analysis

Well Number: UCD1-019		Test Date: November 6, 1995
Hydrogeologic Unit: HSU-1		Test Interval Depth: 53.5 to 72.5 ft
<p>Test Description: Two slug withdrawal tests were conducted. Slugging rods used had displacement volumes of 0.124 ft³ and 0.323 ft³, which imparted maximum observed stress levels, H_0, of 1.261 ft and 3.172 ft for Tests 1 and 2, respectively. For comparison purposes, the theoretical values for H_0 representing instantaneous responses are 1.424 ft and 3.703 ft, respectively. Normalized responses for each of the different stress level tests compared favorably, yielding similar overdamped test response patterns (i.e., exponential decay curves) for elapsed test times, $t > 11$ sec. The test responses exhibited transient type behavior due to slugging rod removal for early test times less than 11 sec. Laminar flow conditions were established after 9 sec for Test 1 and 11 sec for Test 2.</p> <p>Test Site/Formation Conditions: The static water level prior to testing was 39.37 ft bgs and changed negligibly over the duration of the test. The test responses occurred within the well casing above the well screen interval. The test interval penetrates 49% of the saturated aquifer thickness, b, and is located in the lower two-thirds portion of HSU-1. The aquifer bottom is 78 ft below land surface and represents the contact between HSU-1 and HSU-2. The test interval completion consists of a 4-inch I.D. PVC screen (56.5 - 71.5 ft bgs) within a 12-inch I.D. borehole. A 4-inch thick sandpack (53.5 - 72.5 ft bgs) extends above and below the well screen interval within the annulus. No adjacent observation wells were available within the radius of investigation of the test responses.</p> <p>Analysis: Composite type-curve and derivative analyses were employed for each slug test using analytical methods presented in Spane and Wurstner (1993) and Spane (1996). Overdamped test response data exhibiting laminar flow conditions (i.e., >9 sec for Test 1 and >11 sec for Test 2) were analyzed. The sandpack interval (rather than the well screen interval) was used to represent the test interval for the analyses because it is considered to be more representative in conveying formational test responses. This is due to the higher transmissive properties of the sandpack in comparison to the surrounding test formation. The maximum observed H_0 stress levels were used for the analyses. The observed H_0 values (which are lower than the theoretical values) are considered to be more representative of actual test conditions because withdrawal of the slugging rods were not purely instantaneous (i.e., the duration of complete withdrawal of the submerged slugging rod required 1 to 2 sec for each test). The value for the anisotropy ratio (K_D) was assumed to be 0.1 (Note: slug test responses are not very sensitive to K_D values). A storativity value of 0.00001 gave slightly better type-curve matches for the analyses of both tests. Composite type-curve and derivative analysis provided a range of 75 to 105 ft²/d for transmissivity (T) and 1.9 to 2.7 ft/d for equivalent horizontal hydraulic conductivity (K_e).</p> <p>Comments: The overdamped response data for Tests 1 and 2 exhibit slightly different responses. The differences are attributed to higher head loss due to turbulence associated with the higher stress test (i.e., Test 2). Therefore, the test analysis results for the lower stress test (i.e., Test 1) were used for calculating the best estimate values. The best estimate values for transmissivity and equivalent hydraulic conductivity are 105 ft²/d and 2.7 ft/d, respectively. The low value of storativity suggests the presence of well skin effects. The slug test analyses described above provide a value of equivalent hydraulic conductivity that is ~35% higher than that reported in DOE (1993) for previously conducted tests. However, these previous estimates were derived using the Bouwer and Rice (1976) method, which has been shown by Hyder and Butler (1995) and Brown et al. (1995) to commonly underestimate hydraulic property values.</p>		
Test Result Summary:		
Transmissivity	<u>Analysis</u>	<u>Previous Test Results</u>
	Range: 75 to 105 ft ² /d Best Estimate: 105 ft ² /d	Not Reported
Equivalent Hydraulic Conductivity	Range: 1.9 to 2.7 ft/d	
	Best Estimate: 2.7 ft/d	2.0 ft/d (DOE 1993)

Well Number: UCD1-020	Test Date: November 2, 1995						
Hydrogeologic Unit: HSU-1	Test Interval Depth: 54.0 to 73.5 ft						
Test Description: Two slug withdrawal tests were conducted. Slugging rods used had displacement volumes of 0.124 ft ³ and 0.323 ft ³ , which imparted maximum observed stress levels, H _o , of 1.300 ft and 3.258 ft for Tests 1 and 2, respectively. For comparison purposes, the theoretical values for H _o representing instantaneous responses are 1.424 ft and 3.703 ft, respectively. Normalized responses for each of the different stress level tests compared favorably, yielding similar overdamped test response patterns (i.e., exponential decay curves) for elapsed test times, t > 4 sec. The test responses exhibited transient type behavior due to slugging rod removal for early test times less than 4 sec. Laminar flow conditions were established after 4 sec for Test 1 and 11 sec for Test 2.							
Test Site/Formation Conditions: The static water level prior to testing was 37.86 ft bgs and changed negligibly over the duration of testing. The test responses occurred within the well casing above the well screen interval. The test interval penetrates 50% of the saturated aquifer thickness, b, and is located in the lower two-thirds portion of HSU-1. The aquifer bottom is 77 ft below land surface and represents the contact between HSU-1 and HSU-2. The test interval completion consists of a 4-inch I.D. PVC screen (57 - 72 ft bgs) within a 12-inch I.D. borehole. A 4-inch thick sandpack (54.0 - 73.5 ft bgs) extends above and below the well screen interval within the annulus. No adjacent observation wells were available within the radius of investigation of the test responses.							
Analysis: Composite type-curve and derivative analyses were employed for each slug test using analytical methods presented in Spane and Wurster (1993) and Spane (1996). Overdamped test response data exhibiting laminar flow conditions (i.e., >4 sec for Test 1 and >11 sec for Test 2) were analyzed. The sandpack interval (rather than the well screen interval) was used to represent the test interval for the analyses because it is considered to be more representative in conveying formational test responses. This is due to the assumed higher transmissive properties of the sandpack in comparison to the surrounding test formation. The maximum observed H _o stress levels were used for the analyses. The observed values for H _o (which are lower than the theoretical values) are considered to be more representative of actual test conditions because withdrawal of the slugging rods were not purely instantaneous (i.e., the duration of complete withdrawal of the submerged slugging rod required 1 to 2 sec for each test). The value for the anisotropy ratio (K _D) was assumed to be 0.1 (Note: slug test responses are not very sensitive to K _D values). Storativity (S) values of 0.002 for Test 1 and 0.0003 for Test 2 gave slightly better type-curve matches for the analyses. Composite type-curve and derivative analysis for both tests provided a range of 98 to 110 ft ² /d for transmissivity (T) and 2.5 to 2.8 ft/d for equivalent horizontal hydraulic conductivity (K _e).							
Comments: The overdamped response data for Tests 1 and 2 exhibit slightly different test responses. The differences are attributed to higher head loss due to turbulence associated with the higher stress test (i.e., Test 2). Therefore, the test analysis results for the lower stress test (i.e., Test 1) were used for calculating the best estimate values. The best estimate values for transmissivity and equivalent hydraulic conductivity are 98 ft ² /d and 2.5 ft/d, respectively. The slug test analyses described above provide a value of equivalent hydraulic conductivity that is ~60% higher than that reported in DOE (1993) for previously conducted tests. However, these previous estimates were derived using the Bouwer and Rice (1976) method, which has been shown by Hyder and Butler (1995) and Brown et al. (1995) to commonly underestimate hydraulic property values.							
Test Result Summary:							
Transmissivity	<table><tr><td><u>Analysis</u></td><td><u>Previous Test Results</u></td></tr><tr><td>Range: 98 to 110 ft²/d</td><td></td></tr><tr><td>Best Estimate: 98 ft²/d</td><td>Not Reported</td></tr></table>	<u>Analysis</u>	<u>Previous Test Results</u>	Range: 98 to 110 ft ² /d		Best Estimate: 98 ft ² /d	Not Reported
<u>Analysis</u>	<u>Previous Test Results</u>						
Range: 98 to 110 ft ² /d							
Best Estimate: 98 ft ² /d	Not Reported						
Equivalent Hydraulic Conductivity	<table><tr><td>Range: 2.5 to 2.8 ft/d</td><td></td></tr><tr><td>Best Estimate: 2.5 ft/d</td><td>1.6 ft/d (DOE 1993)</td></tr></table>	Range: 2.5 to 2.8 ft/d		Best Estimate: 2.5 ft/d	1.6 ft/d (DOE 1993)		
Range: 2.5 to 2.8 ft/d							
Best Estimate: 2.5 ft/d	1.6 ft/d (DOE 1993)

Well Number: UCD1-021		Test Date: November 6, 1995	
Hydrogeologic Unit: HSU-1		Test Interval Depth: 54.0 to 73.5 ft	
Test Description: Two slug withdrawal tests were conducted. Slugging rods used had displacement volumes of 0.124 ft ³ and 0.323 ft ³ , which imparted maximum observed stress levels, H ₀ , of 1.321 ft and 3.322 ft for Tests 1 and 2, respectively. For comparison purposes, the theoretical values for H ₀ representing instantaneous responses are 1.424 ft and 3.703 ft, respectively. Normalized responses for each of the different stress level tests compared favorably, yielding similar overdamped test response patterns (i.e., exponential decay curves) for elapsed test times, t > 7 sec. The test responses exhibited transient type behavior due to slugging rod removal for early test times less than 7 sec. Laminar flow conditions were established after 6 sec for Test 1 and 13 sec for Test 2.			
Test Site/Formation Conditions: The static water level prior to testing was 38.41 ft bgs and changed negligibly over the duration of the test. The test responses occurred within the well casing above the well screen interval. The test interval penetrates 47% of the saturated aquifer thickness, b, and is located in the lower two-thirds portion of HSU-1. The aquifer bottom is 80 ft below land surface and represents the contact between HSU-1 and HSU-2. The test interval completion consists of a 4-inch I.D. PVC screen (57 - 72 ft bgs) within a 12-inch I.D. borehole. A 4-inch thick sandpack (54.0 - 73.5 ft bgs) extends above and below the well screen interval within the annulus. No adjacent observation wells were available within the radius of investigation of the test responses.			
Analysis: Composite type-curve and derivative analyses were employed for each slug test using analytical methods presented in Spane and Wurstner (1993) and Spane (1996). Overdamped test response data exhibiting laminar flow conditions (i.e., >6 sec for Test 1 and >13 sec for Test 2) were analyzed. The sandpack interval (rather than the well screen interval) was used to represent the test interval for the analyses because it is considered more representative in conveying formational test responses. This is due to its assumed higher transmissive properties of the sandpack in comparison to the surrounding test formation. The maximum observed H ₀ stress levels were used for the test analyses. The observed H ₀ values (which are lower than the theoretical values) are considered to be more representative of actual test conditions because withdrawal of the slugging rods were not purely instantaneous (i.e., the duration of complete withdrawal of the submerged slugging rod required 1 to 2 sec for each test). The value for the anisotropy ratio (K _D) was assumed to be 0.1 (Note: slug test responses are not very sensitive to K _D values). A storativity value of 0.0005 for Test 1 and 0.0006 for Test 2 gave slightly better type-curve matches for the analyses. Composite type-curve and derivative analysis for both tests provided a range of 190 to 215 ft ² /d for transmissivity (T) and 4.6 to 5.2 ft/d for equivalent horizontal hydraulic conductivity (K _e).			
Comments: The overdamped response data for Tests 1 and 2 compared favorably with each other. Because of the close correspondence, an average of the test analysis results was used for calculating the best estimate values. The best estimate values for transmissivity and equivalent hydraulic conductivity are 200 ft ² /d and 4.9 ft/d, respectively. The slug test analyses described above provide a value of equivalent hydraulic conductivity that is ~50% higher than that reported in DOE (1993) for previously conducted tests. However, these previous estimates were derived using the Bouwer and Rice (1976) method, which has been shown by Hyder and Butler (1995) and Brown et al. (1995) to commonly underestimate hydraulic property values.			
Test Result Summary:			
	<u>Analysis</u>	<u>Previous Test Results</u>	
Transmissivity	Range: 190 to 215 ft ² /d Best Estimate: 200 ft ² /d	Not Reported	
Equivalent Hydraulic Conductivity	Range: 4.6 to 5.2 ft/d Best Estimate: 4.9 ft/d	3.3 ft/d (DOE 1993)

Well Number: UCD1-022		Test Date: November 6, 1995	
Hydrogeologic Unit: HSU-1		Test Interval Depth: 54 to 73 ft	
Test Description: Two slug withdrawal tests were conducted. Slugging rods used had displacement volumes of 0.124 ft ³ and 0.323 ft ³ , which imparted maximum observed stress levels, H ₀ , of 1.365 ft and 3.387 ft for Tests 1 and 2, respectively. For comparison purposes, the theoretical values for H ₀ representing instantaneous responses are 1.424 ft and 3.703 ft, respectively. Normalized responses for each of the different stress level tests compared favorably, yielding similar overdamped test response patterns (i.e., exponential decay curves) for elapsed test times, t > 5 sec. The test responses exhibited transient type behavior due to slugging rod removal for early test times less than 5 sec. Laminar flow conditions were established after 8 sec for Test 1 and 10 sec for Test 2.			
Test Site/Formation Conditions: The static water level prior to testing was 38.41 ft bgs and changed negligibly over the duration of the test. The test responses occurred within the well casing above the well screen interval. The test interval penetrates 44% of the saturated aquifer thickness, b, and is located in the lower two-thirds portion of HSU-1. The aquifer bottom is 82 ft below land surface and represents the contact between HSU-1 and HSU-2. The test interval completion consists of a 4-inch I.D. PVC screen (57 - 72 ft bgs) within a 12-inch I.D. borehole. A 4-inch thick sandpack (54 - 73 ft bgs) extends above and below the well screen interval within the annulus. No adjacent observation wells were available within the radius of investigation of the test responses.			
Analysis: Composite type-curve and derivative analyses were employed for each slug test using analytical methods presented in Spane and Wurstner (1993) and Spane (1996). Overdamped test response data exhibiting laminar flow conditions (i.e., >8 sec for Test 1 and >10 sec for Test 2) were analyzed. The sandpack interval (rather than the well screen interval) was used to represent the test interval for the analyses because it is considered to be more representative in conveying formational test responses. This is due to the assumed higher transmissive properties of the sandpack in comparison to the surrounding test formation. The maximum observed H ₀ stress levels were used for the analyses. The observed H ₀ values (which are lower than the theoretical values) are considered to be more representative of actual test conditions because withdrawal of the slugging rods were not purely instantaneous (i.e., the duration of complete withdrawal of the submerged slugging rod required 1 to 2 sec for each test). The value for the anisotropy ratio (K _D) was assumed to be 0.1 (Note: slug test responses are not very sensitive to K _D values). Storativity (S) values of 0.0001 for Test 1 and 0.00005 for Test 2 were used to provide an acceptable match between data and type curve derivatives. Composite type-curve and derivative analysis for both tests provided a range of 125 to 155 ft ² /d for transmissivity (T) and 2.9 to 3.6 ft/d for equivalent horizontal hydraulic conductivity (K _e).			
Comments: The overdamped response data for Tests 1 and 2 exhibit slightly different responses. The differences are attributed to higher head loss due to turbulence associated with the higher stress test (i.e., Test 2). Therefore, the test analysis results for the lower stress test (i.e., Test 1) were used for calculating the best estimate values. The best estimate values for transmissivity and equivalent hydraulic conductivity are 155 ft ² /d and 3.6 ft/d, respectively. The low value for storativity for Test 2 suggests the presence of well skin effects. Slug test analyses described above provide a value of equivalent hydraulic conductivity that is ~30% higher than that reported in DOE (1993) for previously conducted tests. However, these previous estimates were derived using the Bouwer and Rice (1976) method, which has been shown by Hyder and Butler (1995) and Brown et al. (1995) to commonly underestimate hydraulic property values.			
Test Result Summary:			
		<u>Analysis</u>	<u>Previous Test Results</u>
Transmissivity	Range: 125 to 155 ft ² /d		Not Reported
	Best Estimate: 155 ft ² /d		
Equivalent Hydraulic Conductivity	Range: 2.9 to 3.6 ft/d		2.8 ft/d (DOE 1993)
	Best Estimate: 3.6 ft/d

Well Number: UCD1-023	Test Date: November 6, 1995	
Hydrogeologic Unit: HSU-1	Test Interval Depth: 53.5 to 73.0 ft	
Test Description: Two slug withdrawal tests were conducted. Slugging rods used had displacement volumes of 0.124 ft ³ and 0.323 ft ³ , which imparted maximum observed stress levels, H _o , of 1.316 ft and 3.270 ft for Tests 1 and 2, respectively. For comparison purposes, the theoretical values for H _o representing instantaneous responses are 1.424 ft and 3.703 ft, respectively. Normalized responses for each of the different stress level tests compared favorably, yielding similar overdamped test response patterns (i.e., exponential decay curves) for elapsed test times, t > 4 sec. The test responses exhibited transient type behavior due to slugging rod removal for early test times less than 4 sec. Laminar flow conditions were established after 5 sec for Test 1 and 18 sec for Test 2.		
Test Site/Formation Conditions: The static water level prior to testing was 38.43 ft bgs and changed negligibly over the duration of testing. The test responses occurred within the well casing above the well screen interval. The test interval penetrates 44% of the saturated aquifer thickness, b, and is located in the lower two-thirds portion of HSU-1. The aquifer bottom is 83 ft below land surface and represents the contact between HSU-1 and HSU-2. The test interval completion consists of a 4-inch I.D. PVC screen (56.5 - 72.0 ft bgs) within a 12-inch I.D. borehole. A 4-inch thick sandpack (53.5 - 73.0 ft bgs) extends above and below the well screen interval within the annulus. No adjacent observation wells were available within the radius of investigation of the test responses.		
Analysis: Composite type-curve and derivative analyses were employed for each slug test using analytical methods presented in Spane and Wurstner (1993) and Spane (1996). Overdamped test response data exhibiting laminar flow conditions (i.e., >5 sec for Test 1 and >18 sec for Test 2) were analyzed. The sandpack interval (rather than the well screen interval) was used to represent the test interval for the analyses because it is considered to be more representative in conveying formational test responses. This is due to the assumed higher transmissive properties of the sandpack in comparison to the surrounding test formation. The maximum observed H _o stress levels were used for the analyses. The observed values for H _o (which are lower than the theoretical values) are considered to be more representative of actual test conditions because withdrawal of the slugging rods were not purely instantaneous (i.e., the duration of complete withdrawal of the submerged slugging rod required 1 to 2 sec for each test). The value for the anisotropy ratio (K _D) was assumed to be 0.1 (Note: slug test responses are not very sensitive to K _D values). Storativity (S) values of 0.0015 for Test 1 and 0.0006 for Test 2 gave slightly better type-curve matches for the analyses. Composite type-curve and derivative analysis for both tests provided a range of 280 to 290 ft ² /d for transmissivity (T) and 6.3 to 6.5 ft/d for equivalent horizontal hydraulic conductivity (K _e).		
Comments: The overdamped response data for Tests 1 and 2 compared favorably with each other. Because of the close test correspondence, an average of the test analysis results was used for calculating the best estimate values. The best estimate values for transmissivity and equivalent hydraulic conductivity are 285 ft ² /d and 6.4 ft/d, respectively. The slug test analyses described above provide a value of equivalent hydraulic conductivity that is ~80% higher than that reported in DOE (1993) for previously conducted tests. However, these previous estimates were derived using the Bouwer and Rice (1976) method, which has been shown by Hyder and Butler (1995) and Brown et al. (1995) to commonly underestimate hydraulic property values.		
Test Result Summary:		
	<u>Analysis</u>	<u>Previous Test Results</u>
Transmissivity	Range: 280 to 290 ft ² /d	
	Best Estimate: 285 ft ² /d	Not Reported
Equivalent Hydraulic Conductivity	Range: 6.3 to 6.5 ft/d	
	Best Estimate: 6.4 ft/d	3.5 ft/d (DOE 1993)

Well Number: UCD1-024	Test Date: November 2, 1995				
Hydrogeologic Unit: HSU-1	Test Interval Depth: 54 to 73 ft				
Test Description: Two slug withdrawal tests were conducted. Slugging rods used had displacement volumes of 0.124 ft ³ and 0.323 ft ³ , which imparted maximum observed stress levels, H _o , of 1.367 ft and 3.407 ft for Tests 1 and 2, respectively. For comparison purposes, the theoretical values for H _o representing instantaneous responses are 1.424 ft and 3.703 ft, respectively. Normalized responses for each of the different stress level tests compared favorably, yielding similar overdamped test response patterns (i.e., exponential decay curves) for elapsed test times, t > 5 sec. The test responses exhibited transient type behavior due to slugging rod removal for early test times less than 5 sec. Laminar flow conditions were established after 9 sec for Test 1 and 20 sec for Test 2.					
Test Site/Formation Conditions: The static water level prior to testing was 38.86 ft bgs and changed negligibly over the duration of the test. The test responses occurred within the well casing above the well screen interval. The test interval penetrates 45% of the saturated aquifer thickness, b, and is located in the lower two-thirds portion of HSU-1. The aquifer bottom is 81 ft below land surface and represents the contact between HSU-1 and HSU-2. The test interval completion consists of a 4-inch I.D. PVC screen (57 - 72 ft bgs) within a 12-inch I.D. borehole. A 4-inch thick sandpack (54 - 73 ft bgs) extends above and below the well screen interval within the annulus. No adjacent observation wells were available within the radius of investigation of the test responses.					
Analysis: Composite type-curve and derivative analyses were employed for each slug test using analytical methods presented in Spane and Wurstner (1993) and Spane (1996). Overdamped test response data exhibiting laminar flow conditions (i.e., >9 sec for Test 1 and >20 sec for Test 2) were analyzed. The sandpack interval (rather than the well screen interval) was used to represent the test interval for the analyses because it is considered to be more representative in conveying formational test responses. This is due to the assumed higher transmissive properties of the sandpack in comparison to the surrounding test formation. The maximum observed H _o stress levels were used for the test analyses. The observed H _o values (which are lower than the theoretical values) are considered to be more representative of actual test conditions because withdrawal of the slugging rods were not purely instantaneous (i.e., the duration of complete withdrawal of the submerged slugging rod required 1 to 2 sec for each test). The value for the anisotropy ratio (K _D) was assumed to be 0.1 (Note: slug test responses are not very sensitive to K _D values). Storativity (S) values of 0.0003 for Test 1 and 0.0002 for Test 2 gave slightly better type-curve matches for the analyses. Composite type-curve and derivative analysis for both tests provided a range of 290 to 310 ft ² /d for transmissivity (T) and 6.9 to 7.4 ft/d for equivalent horizontal hydraulic conductivity (K _e).					
Comments: The overdamped response data for Tests 1 and 2 compared favorably with each other. Because of the close correspondence, an average of the test analysis results was used for calculating the best estimate values. The best estimate values for transmissivity and equivalent hydraulic conductivity are 300 ft ² /d and 7.2 ft/d, respectively. Slug test analyses described above provide a value of equivalent hydraulic conductivity that is about 2.3 times higher than that reported in DOE (1993) for previously conducted tests. However, these previous estimates were derived using the Bouwer and Rice (1976) method, which has been shown by Hyder and Butler (1995) and Brown et al. (1995) to commonly underestimate hydraulic property values.					
Test Result Summary:					
Transmissivity	<table><tr><td><u>Analysis</u></td><td><u>Previous Test Results</u></td></tr><tr><td>Range: 290 to 310 ft²/d Best Estimate: 300 ft²/d</td><td>Not Reported</td></tr></table>	<u>Analysis</u>	<u>Previous Test Results</u>	Range: 290 to 310 ft ² /d Best Estimate: 300 ft ² /d	Not Reported
<u>Analysis</u>	<u>Previous Test Results</u>				
Range: 290 to 310 ft ² /d Best Estimate: 300 ft ² /d	Not Reported				
Equivalent Hydraulic Conductivity	<table><tr><td>Range: 6.9 to 7.4 ft/d Best Estimate: 7.2 ft/d</td><td>3.1 ft/d (DOE 1993)</td></tr></table>	Range: 6.9 to 7.4 ft/d Best Estimate: 7.2 ft/d	3.1 ft/d (DOE 1993)		
Range: 6.9 to 7.4 ft/d Best Estimate: 7.2 ft/d	3.1 ft/d (DOE 1993)

Well Number: UCD1-025	Test Date: November 2, 1995
Hydrogeologic Unit: HSU-1	Test Interval Depth: 56.9 to 75 ft
<p>Test Description: Two pneumatic slug withdrawal tests were conducted. Test 1 was performed by depressing the well fluid column approximately 4.8 ft using compressed air. Test 2 was conducted at a significantly higher stress rate for test design purposes for planned slug interference testing at the test site. For Test 2, the well fluid column was depressed approximately 17.5 ft. Laminar flow conditions were established within 8 sec of test initiation for Test 1, and after approximately 60 sec after the start of Test 2. Comparison of normalized responses for each of the tests indicated a slower decay response for Test 2, which is attributed to the effects of prolonged turbulent flow conditions that occurred during the first minute of the test. Because of the significant effects of turbulence in Test 2, only Test 1 is considered to provide representative information concerning formation properties immediately surrounding well UCD1-025.</p>	
<p>Test Site/Formation Conditions: The static water level prior to the tests was 39.78 ft bgs. No significant water-level trend was exhibited within the test interval during testing. The test responses were monitored with a pressure transducer within the well casing above the well screen interval. The well screen/test interval penetrates 43% of the aquifer and is located in the lower two-thirds of HSU-1 at this site. The aquifer bottom occurs at a depth of 82 ft below land surface and represents the contact between HSU-1 and HSU-2. The test interval completion consists of a 4-inch I.D. PVC screen within a 9.63-inch I.D. borehole. A 2.8-inch thick sandpack extends between the well screen/borehole annulus, which extends over the depth interval 56.9 - 75 ft. Three HSU-1 monitor zones in well UCD2-027, were available for observing possible test responses.</p>	
<p>Analysis: Composite type-curve and derivative analysis was employed for each slug test using analytical methods presented in Spane and Wurstner (1993) and Spane (1996). Test data indicative of laminar flow conditions (i.e., for test times greater than about 8 sec) were analyzed. The sandpack interval (rather than the well screen interval) was used to represent the test interval for the analyses. This is because the assumed higher transmissive properties of the sandpack (in comparison to the test formation) is considered to be more representative in conveying test responses to the surrounding formation. The projected maximum observed H_0 stress level was used for the analysis. The projected observed value for H_0 (which is slightly lower than the applied air pressure used to depress the water column) is considered to be more representative of actual test conditions. This is because evacuation of the compressed air used to depress the water column in the well, could not be accomplished "instantaneously". For analysis purposes, a value of 0.1 was assumed for the anisotropy ratio, K_D (Note: slug test responses are not very sensitive to K_D values). A storativity (S) value of 0.0001 was used for the analysis of both tests. Composite type-curve and derivative analysis for Test 1 provided a value of 110 ft²/d for transmissivity (T) and 2.6 ft/d for equivalent horizontal hydraulic conductivity (K_e).</p>	
<p>Comments: As noted previously, results from Test 2 were not used for hydraulic property determination, because of the adverse effects of extended turbulence in the test. Results from Test 1, therefore, were only utilized in calculating the best estimate values. The best estimate values for transmissivity and equivalent hydraulic conductivity are 110 ft²/d and 2.6 ft/d. Since UCD1-025 is a new well test site, no previous test analysis results are available. A comparison with other new HSU-1 slug test analysis results, however, indicates that the hydraulic property estimates are within the upper range of reported values.</p>	
Test Result Summary:	Analysis Results
Transmissivity	Best Estimate: 110 ft ² /d
Equivalent Hydraulic Conductivity	Best Estimate: 2.6 ft/d

Baseline Response: Well UCD1-025

Well UCD1-025: Slug Test 1 Analysis

Well Number: UCD2-026	Test Date: November 1, 1995
Hydrogeologic Unit: HSU-2	Test Interval Depth: 87 to 102 ft
<p>Test Description: Three pneumatic slug withdrawal tests were conducted. Test 1 was performed by depressing the well fluid column approximately 2.9 ft using compressed air. Tests 2 and 3 were conducted at a significantly higher stress rate to support the design of planned slug interference tests at the site. For these high stress tests, the well fluid column was depressed approximately 15.3 ft and 40.1 ft for Test 2 and 3, respectively. Because of the higher stress levels involved for Tests 2 and 3, turbulent flow conditions were exhibited for extended periods of time; thereby, eliminating the possibility of analysis of the observed test responses (note: > 95% recovery occurred during the turbulent flow period for Tests 2 and 3). For Test 1, laminar flow conditions were established within 14 sec of test initiation, after 80% of the test recovery had already occurred.</p>	
<p>Test Site/Formation Conditions: The static water level prior to the tests was 39.42 ft bgs. No significant water-level trend was exhibited within the test interval during testing. The test responses were monitored with a pressure transducer within the well casing above the well screen interval. The well screen interval penetrates approximately 34% of the aquifer and is located in the upper two-thirds of HSU-2 at this site. The aquifer top occurs at a depth of 82 ft below land surface and represents the contact between HSU-1 and HSU-2. The aquifer bottom occurs at a depth of 126 ft. The test interval completion consists of a 4-inch I.D. PVC screen within a 9.63-inch I.D. borehole. A 2.8-inch thick sandpack extends between the well screen/borehole annulus, which extends over the depth interval 84 - 102 ft.</p>	
<p>Analysis: Quantitative analysis of the overdamped slug test responses that occurred at Well UCD2-026 is not possible due to the rapid recovery and extended occurrence of turbulent flow conditions during the tests. Qualitative analysis, however, was attempted for Test 1 (which exhibited the greatest degree of laminar flow conditions for the three tests performed). The qualitative analysis employed the same composite type-curve and derivative analysis procedure used for quantitative analysis of HSU-1 overdamped slug test responses (Spane and Wurstner, 1993 and Spane 1996). The well screen interval (rather than the sand pack interval) was used to represent the test interval for the analyses. This is because the formation is assumed to have a high permeability than the sand pack; and, therefore, test response transmission is expected to propagate faster laterally from the well screen to the surrounding test formation, rather than vertically within the sand pack zone. The projected maximum observed H_0 stress level (2.932 ft) was used for the analysis and is only slightly lower than the applied air pressure used to depress the water column (i.e., 2.94 ft). For analysis purposes, a value of 0.1 was assumed for the anisotropy ratio, K_D (Note: slug test responses are not very sensitive to K_D values). A storativity (S) value of 0.0001 was used for the test analysis. Composite type-curve and derivative analysis for Test 1 provided a value of >1200 ft²/d for transmissivity (T) and >27 ft/d for equivalent horizontal hydraulic conductivity (K_e).</p>	
<p>Comments: Analysis methods used for Test 1 do not account for the effects of turbulence or inertia which occurred during the testing of well UCD2-026. The analysis results, therefore, are considered to be highly qualitative and should not be used for quantitative characterization of HSU-2 hydraulic properties. The qualitative analysis results are indicative of minimum hydraulic property values. This is in part attributed to the effects of turbulence and inertia, which tend to delay dissipation of test responses to the surrounding formation at the stress well location. It is assumed that the actual hydraulic property values are greater than these indicated minimum values. Since UCD2-026 is a new well test site, no previous test analysis results are available.</p>	
Test Result Summary:	
	<u>Analysis Results</u>
Transmissivity	Best Estimate: >1200 ft ² /d
Equivalent Hydraulic Conductivity	Best Estimate: >27 ft/d

Well Number: UCD2-027 (Zone 1)	Test Date: October 17, 1995
Hydrogeologic Unit: HSU-1	Test Interval Depth: 51.5 to 57.5 ft
<p>Test Description: Two pneumatic slug withdrawal tests were conducted. The tests were conducted by depressing the well fluid column approximately 6 to 7 ft using compressed air. Laminar flow conditions were maintained during the entire duration of each test. Comparison of normalized responses for each of the tests indicated identical responses for Test 1 and Test 2.</p> <p>Test Site/Formation Conditions: Slug testing was performed using an inflatable straddle packer (with a tubing string radius = 2-inch I.D.) to isolate the Zone 1 well screen from the underlying monitoring zones within well UCD2-027. The tests were conducted prior to installation of the Westbay MOSDAX monitoring system. The test responses were monitored with a pressure transducer mounted on the top of the straddle packer assembly, connected with a pressure access tube through the top packer. The Zone 1 well screen (53 to 55 ft bgs) is located in the upper half of HSU-1. The stratigraphic contact between HSU-1 and HSU-2 occurs at a depth of 82 ft below land surface. The static water level prior to the tests was 41.15 ft bgs and represents the top of HSU-1. A water-level trend ($+ 1.754 \times 10^{-4}$ ft/min) was observed during testing; however, the trend had no influence on subsequent slug test analyses. The test interval completion consists of a 5-inch I.D. stainless steel screen, which is within a 9.63-inch I.D. borehole. A 2.38-inch thick sandpack extends between the well screen/borehole annulus, which extends over the depth interval 51.5 - 57.5 ft. Bentonite seals are present in the annular zone above and below the sand pack to ensure monitor zone isolation.</p> <p>Analysis: Composite type-curve and derivative analysis was employed for each slug test using analytical methods presented in Spane and Wurstner (1993) and Spane (1996). All test data exhibit laminar flow conditions and were analyzed. The sandpack interval (rather than the well screen interval) was used to represent the test interval for the analyses. This is because the assumed higher transmissive properties of the sandpack (in comparison to the test formation) is considered to be more representative in conveying test responses to the surrounding formation. Projected maximum observed H_0 stress levels were used for the analyses. The projected observed values for H_0 (which are lower than the applied air pressure used to depress the water column) are considered to be more representative of actual test conditions. This is because evacuation of the compressed air used to depress the water column in the well, could not be accomplished "instantaneously". For analysis purposes, a value of 0.1 was assumed for the anisotropy ratio, K_D (Note: slug test responses are not very sensitive to K_D values). A storativity (S) value of 0.0001 was used for the analysis of both tests. Composite type-curve and derivative analysis for both tests provided the same estimates for transmissivity (14 ft²/d) and equivalent hydraulic conductivity (0.34 ft/d).</p> <p>Comments: Identical test responses and hydraulic property estimates were obtained from Test 1 and 2. The best estimate values for transmissivity and equivalent hydraulic conductivity are 14 ft²/d and 0.34 ft/d, respectively. Since UCD2-027 is a new well test site, no previous test analysis results are available. A comparison with other new HSU-1 slug test analysis results, however, indicates that the hydraulic property estimates are within the lower range of reported values.</p>	
Test Result Summary:	Analysis Results
Transmissivity	Best Estimate: 14 ft ² /d
Equivalent Hydraulic Conductivity	Best Estimate: 0.34 ft/d

Baseline Response: Zone 1 - Test 1

Zone 1 Slug Test 1 Analysis

Well Number: UCD2-027 (Zone 2)	Test Date: October 17, 1995
Hydrogeologic Unit: HSU-1	Test Interval Depth: 61.5 to 66.5 ft
<p>Test Description: Two pneumatic slug withdrawal tests were conducted. The tests were conducted by depressing the well fluid column approximately 5 ft (Test 1) and 8 ft (Test 2) using compressed air. Laminar flow conditions were established after approximately 6 sec after initiation of each test. Comparison of normalized responses for each of the tests indicated a slower decay response for Test 2, which was conducted at a higher stress level. The cause for the slower decay response for Test 2 is unknown, but may be attributed to increased head loss conditions associated with the higher applied stress. Because of the possible nonformational effects associated with Test 2, Test 1 is considered to provide more representative information concerning formation properties immediately surrounding well UCD2-027 for this depth interval within HSU-1.</p>	
<p>Test Site/Formation Conditions: Slug testing was performed using an inflatable straddle packer (with a tubing string radius = 2-inch I.D.) to isolate the Zone 2 well screen from the over- and underlying monitoring zones within well UCD2-027. The tests were conducted prior to installation of the Westbay MOSDAX monitoring system. The test responses were monitored with a pressure transducer mounted on the top of the straddle packer assembly, connected with a pressure access tube through the top packer. The Zone 2 well screen (63 to 65 ft bgs) is located approximately in the middle section of HSU-1. The stratigraphic contact between HSU-1 and HSU-2 occurs at a depth of 82 ft below land surface. The static water level prior to the tests was 41.15 ft bgs and represents the top of HSU-1. A water-level trend (-2.86×10^{-4} ft/min) was observed during testing; however, the trend had no influence on subsequent slug test analyses. The test interval completion consists of a 5-inch I.D. stainless steel screen, which is within a 9.63-inch I.D. borehole. A 2.38-inch thick sandpack extends between the well screen/borehole annulus, which extends over the depth interval 61.5 - 66.5 ft. Bentonite seals are present in the annular zone above and below the sand pack to ensure monitor zone isolation.</p>	
<p>Analysis: Composite type-curve and derivative analysis was employed for each slug test using analytical methods presented in Spane and Wurstner (1993) and Spane (1996). Test data exhibiting laminar flow conditions (i.e., > 6 sec after test initiation) were analyzed. The sandpack interval (rather than the well screen interval) was used to represent the test interval for the analyses. This is because the assumed higher transmissive properties of the sandpack (in comparison to the test formation) is considered to be more representative in conveying test responses to the surrounding formation. Projected maximum observed H_0 stress levels were used for the analyses. The projected observed values for H_0 (which are lower than the applied air pressure used to depress the water column) are considered to be more representative of actual test conditions. This is because evacuation of the compressed air used to depress the water column in the well, could not be accomplished "instantaneously". For analysis purposes, a value of 0.1 was assumed for the anisotropy ratio, K_D (Note: slug test responses are not very sensitive to K_D values). A storativity (S) value of 0.0001 was used for the analysis of both tests. Composite type-curve and derivative analysis provided estimates for transmissivity of 38 ft²/d and 30 ft²/d, and for equivalent hydraulic conductivity of 0.93 ft/d and 0.73 ft/d for Test 1 and Test 2, respectively.</p>	
<p>Comments: Slightly higher hydraulic property estimates and overall better composite type-curve and derivative matches were obtained from analysis of Test 1. Because of the lower applied stress and better test response match, Test 1 was utilized for calculating the best estimate values. The best estimate values for transmissivity and equivalent hydraulic conductivity are 38 ft²/d and 0.93 ft/d, respectively. Since UCD2-027 is a new well test site, no previous test analysis results are available. A comparison with other new HSU-1 slug test analysis results, however, indicates that the hydraulic property estimates are within the lower range of reported values.</p>	
Test Result Summary:	Analysis Results
Transmissivity	Best Estimate: 38 ft ² /d
Equivalent Hydraulic Conductivity	Best Estimate: 0.93 ft/d

Baseline Response: Zone 2 - Test 1

Zone 2 Slug Test 1 Analysis

Well Number: UCD2-027 (Zone 3)	Test Date: October 18, 1995
Hydrogeologic Unit: HSU-1	Test Interval Depth: 71.5 to 76.5 ft
<p>Test Description: Two pneumatic slug withdrawal tests were conducted. The tests were conducted by depressing the well fluid column approximately 8 ft (Test 1) and 4 ft (Test 2) using compressed air. Laminar flow conditions were established after approximately 12 sec after initiation of Test 1 and 4 sec after the start of Test 2. Comparison of normalized responses for each of the tests indicated identical response behavior after about 6 sec for both tests; therefore, identical hydraulic property estimates were obtained for both test analyses. Examination of the test responses indicates a composite or heterogeneous formation response, with an initially rapid dissipation of the slug stress followed by a transitional, slower decay response behavior. The cause of this response pattern is not completely understood; however, this type of response behavior is consistent with a conceptual model where higher permeability formation materials immediately surround the well/test interval, which with distance from the well grades into lower permeability materials. This composite type of response behavior was not exhibited at other tested HSU-1 well/test sites.</p> <p>Test Site/Formation Conditions: Slug testing was performed using an inflatable straddle packer (with a tubing string radius = 2-inch I.D.) to isolate the Zone 3 well screen from the over- and underlying monitoring zones within well UCD2-027. The tests were conducted prior to installation of the Westbay MOSDAX monitoring system. The test responses were monitored with a pressure transducer mounted on the top of the straddle packer assembly, connected with a pressure access tube through the top packer. The Zone 3 well screen (73 to 75 ft bgs) is located approximately in the lower section of HSU-1. The stratigraphic contact between HSU-1 and HSU-2 occurs at a depth of 82 ft below land surface. The static water level prior to the tests was 41.12 ft bgs and represents the top of HSU-1. No significant water-level trend was observed during testing. The test interval completion consists of a 5-inch I.D. stainless steel screen, which is within a 9.63-inch I.D. borehole. A 2.38-inch thick sandpack extends between the well screen/borehole annulus, which extends over the depth interval 71.5 - 76.5 ft. Bentonite seals are present in the annular zone above and below the sand pack to ensure monitor zone isolation.</p> <p>Analysis: Combined type-curve and derivative analysis was employed for each slug test using analytical methods presented in Spane and Wurstner (1993). Because the test response exhibited a composite formation response, the type-curve generating program discussed in Hyder and Butler (1995) was utilized. Note: the type-curve generating procedure presented in Spane (1996) was not used due to the lack of available composite formation response pumping test type curves. Test data exhibiting laminar flow conditions (i.e., > 12 sec for Test 1; > 4 sec for Test 2) were analyzed. The sandpack interval (rather than the well screen interval) was used to represent the test interval for the analyses. This is because the assumed higher transmissive properties of the sandpack (in comparison to the test formation) is considered to be more representative in conveying test responses to the surrounding formation. Projected maximum observed H_o stress levels were used for the analyses. The projected observed values for H_o (which are lower than the applied air pressure used to depress the water column) are considered to be more representative of actual test conditions. This is because evacuation of the compressed air used to depress the water column in the well, could not be accomplished "instantaneously". For analysis purposes, a value of 0.1 was assumed for the anisotropy ratio, K_D (Note: slug test responses are not very sensitive to K_D values). A storativity (S) value of 0.001 gave slightly better type-curve matches than 0.0001 for the analysis of both tests. The combined type-curve and derivative analysis using composite formation type curves provided estimates for transmissivity ranging from 160 ft²/d (near the well) to 75 ft²/d (for more distant formation materials), and for equivalent hydraulic conductivity ranging from 3.9 ft/d to 1.8 ft/d. The calculated radial distance from the well to the contact between the higher and lower transmissivity formation materials surrounding the well/test interval was 4.4 ft.</p> <p>Comments: The analysis results of the composite formation response exhibited during the tests are not unique; and, therefore, slightly different combinations of transmissivity, storativity, and transmissivity zone radial distances will provide similar type-curve matching results. The final analysis results reported, represent the best type-curve match of many analytical parameter combinations examined. The reported best estimate range for transmissivity (160 ft²/d to 75 ft²/d) and equivalent hydraulic conductivity (3.9 ft/d to 1.8 ft/d) are within the middle range of reported values for HSU-1.</p>	
Test Result Summary:	Analysis Results
Transmissivity	Best Estimate: 160 to 75 ft ² /d
Equivalent Hydraulic Conductivity	Best Estimate: 3.9 to 1.8 ft/d

Well Number: UCD2-027 (Zone 4)	Test Date: October 18, 1995
Hydrogeologic Unit: HSU-2	Test Interval Depth: 86 to 88 ft
<p>Test Description: Two pneumatic slug withdrawal tests were conducted. The tests were conducted by depressing the well fluid column approximately 2 ft (Test 1) and 5 ft (Test 2) using compressed air. Laminar flow conditions were established after approximately 6 sec (Test 1) and 14 sec (Test 2) after test initiation. Comparison of normalized responses for each of the tests indicated a slightly slower decay response for Test 2, which was conducted at a higher stress level. The cause for the slower decay response for Test 2 is unknown, but may be attributed to increased head loss conditions associated with the higher applied stress. Because of the possible nonformational effects associated with Test 2, Test 1 is considered to provide more representative information concerning formation properties immediately surrounding well UCD2-027 for this depth interval within HSU-2.</p>	
<p>Test Site/Formation Conditions: Slug testing was performed using an inflatable straddle packer (with a tubing string radius = 2-inch I.D.) to isolate the Zone 4 well screen from the over- and underlying monitoring zones within well UCD2-027. The tests were conducted prior to installation of the Westbay MOSDAX monitoring system. The test responses were monitored with a pressure transducer mounted on the top of the straddle packer assembly, connected with a pressure access tube through the top packer. The Zone 4 well screen (86 to 88 ft bgs) is located in the upper section of HSU-2. The stratigraphic contact between HSU-1 and HSU-2 occurs at a depth of 82 ft below land surface. The static water level prior to the tests was 40.93 ft bgs. No significant water-level trend was observed during testing. The test interval completion consists of a 5-inch I.D. stainless steel screen, which is within a 9.63-inch I.D. borehole. A 2.38-inch thick sandpack extends between the well screen/borehole annulus, which extends over the depth interval 84.9 - 90.0 ft. Bentonite seals are present in the annular zone above and below the sand pack to ensure monitor zone isolation.</p>	
<p>Analysis: Composite type-curve and derivative analysis was employed for each slug test using analytical methods presented in Spane and Wurstner (1993) and Spane (1996). Test data exhibiting laminar flow conditions (i.e., > 6 sec after Test 1 initiation) were analyzed. The well screen interval (rather than the well sand pack interval) was used to represent the test interval for the analyses. This is because the formation is assumed to have a higher permeability than the sandpack; and, therefore, test response transmission is expected to propagate faster laterally from the well screen to the surrounding test formation, rather than vertically within the sand pack zone. Projected maximum observed H_0 stress levels were used for the analyses. The projected observed values for H_0 (which are lower than the applied air pressure used to depress the water column) are considered to be more representative of actual test conditions. This is because evacuation of the compressed air used to depress the water column in the well, could not be accomplished "instantaneously". For analysis purposes, a value of 0.1 was assumed for the anisotropy ratio, K_D (Note: slug test responses are not very sensitive to K_D values). A storativity (S) value of 0.0005 gave slightly better type-curve matches than 0.0001 for the analysis of both tests. Composite type-curve and derivative analysis provided estimates for transmissivity of 1100 ft²/d and 1000 ft²/d, and for equivalent hydraulic conductivity of 25.0 ft/d and 22.7 ft/d for Test 1 and Test 2, respectively.</p>	
<p>Comments: Slightly higher hydraulic property estimates and overall better composite type-curve and derivative matches were obtained from analysis of Test 1. Because of the lower applied stress and better test response match, Test 1 was utilized for calculating the best estimate values. The best estimate values for transmissivity and equivalent hydraulic conductivity are 1100 ft²/d and 25.0 ft/d, respectively. Since UCD2-027 is a new well test site, no previous test analysis results are available. A comparison with other new HSU-2 slug test analysis results, however, indicates that the hydraulic property estimates are within the lower range of reported values. It should be noted that the 2-ft well screen penetrates only a small portion of the entire aquifer thickness; the test results, therefore, should only be considered to be qualitative indications of hydraulic property conditions of formation materials in proximity of the well screen depth interval.</p>	
Test Result Summary:	
<p>Transmissivity Equivalent Hydraulic Conductivity</p>	
Analysis Results	
<p>Best Estimate: 1100 ft²/d Best Estimate: 25.0 ft/d</p>	

Baseline Response: Zone 4 - Test 1

Zone 4 Slug Test 1 Analysis

Well Number: UCD2-027 (Zone 5)	Test Date: October 18-19, 1995
Hydrogeologic Unit: HSU-2	Test Interval Depth: 96 to 98 ft
<p>Test Description: Three pneumatic slug withdrawal tests were conducted. The tests were performed by depressing the well fluid column using compressed air (Test 1 $\approx$ 3 ft; Test 2 $\approx$ 6 ft; Test 3 $\approx$ 11 ft). Turbulent flow conditions were exhibited for extended periods of time for all slug tests performed; thereby, eliminating the possibility of quantitative analysis of the observed test responses (note: > 95% recovery occurred during the turbulent flow period for all tests. Laminar flow conditions were established after 7 sec, 10 sec, and 13 sec for Tests 1, 2, and 3, respectively).</p> <p>Test Site/Formation Conditions: The static water level prior to the tests was 40.89 ft bgs. No significant water-level trend was exhibited within the test interval during testing. The test responses were monitored with a pressure transducer within the well casing above the well screen interval. The well screen interval is situated in the upper third of HSU-2 at this site. The aquifer top occurs at a depth of 82 ft below land surface and represents the contact between HSU-1 and HSU-2. The aquifer bottom occurs at a depth of 126 ft. The test interval completion consists of a 5-inch I.D. stainless steel screen, which is within a 9.63-inch I.D. borehole. A 2.38-inch thick sandpack extends between the well screen/borehole annulus, which extends over the depth interval 94.5 - 100.0 ft. Bentonite seals are present in the annular zone above and below the sand pack to ensure monitor zone isolation.</p> <p>Analysis: Quantitative analysis of the overdamped slug test responses that occurred at Well UCD2-027 is not possible due to the rapid recovery and extended occurrence of turbulent flow conditions during the tests. Qualitative analysis, however, was attempted for Test 1. The qualitative analysis employed the same composite type-curve and derivative analysis procedure used for quantitative analysis of overdamped slug test responses (Spane and Wurstner, 1993 and Spane 1996). The well screen interval (rather than the sand pack interval) was used to represent the test interval for the analyses. This is because the formation is assumed to have a higher permeability than the sand pack; and, therefore, test response transmission is expected to propagate faster laterally from the well screen to the surrounding test formation, rather than vertically within the sand pack zone. The projected maximum observed H_0 stress level (2.345 ft) was used for the analysis and is considered to be more representative of actual test conditions. This is because evacuation of the compressed air used to depress the water column in the well, could not be accomplished "instantaneously". (Note that the projected maximum stress is only slightly lower than the applied air pressure used to depress the water column, i.e., 3.02 ft). For analysis purposes, a value of 0.1 was assumed for the anisotropy ratio, K_D (Note: slug test responses are not very sensitive to K_D values). A storativity (S) value of 0.0001 was used for the analysis of both tests. Composite type-curve and derivative analysis for Test 1 provided a value of >3000 ft²/d for transmissivity (T) and >68 ft/d for equivalent horizontal hydraulic conductivity (K_e).</p> <p>Comments: Analysis methods used for Test 1 do not account for the effects of turbulent head loss, which occurred during the testing of Zone 5. The analysis results, therefore, are considered to be highly qualitative and should not be used for quantitative characterization of HSU-2 hydraulic properties. The qualitative analysis results are indicative of minimum hydraulic property values. This is in part attributed to the effects of turbulence, which tend to delay dissipation of test responses to the surrounding formation at the stress well location. It is assumed that the actual hydraulic property values are greater than these indicated minimum values. Since UCD2-027 is a new well test site, no previous test analysis results are available.</p>	
Test Result Summary:	Analysis Results
Transmissivity	Best Estimate: >3000 ft ² /d
Equivalent Hydraulic Conductivity	Best Estimate: >68 ft/d

Well Number: UCD2-027 (Zone 6)	Test Date: October 18-19, 1995
Hydrogeologic Unit: HSU-2	Test Interval Depth: 106 to 108 ft
<p>Test Description: Two pneumatic slug withdrawal tests were conducted. The tests were performed by depressing the well fluid column using compressed air (Test 1 $\approx$ 5.5 ft; Test 2 $\approx$ 11 ft). Turbulent flow conditions were exhibited for extended periods of time for all slug tests performed; thereby, eliminating the possibility of quantitative analysis of the observed test responses (note: > 95% recovery occurred during the turbulent flow period for all tests. Laminar flow conditions were established after 8.5 sec and 13 sec for Tests 1 and 2, respectively).</p> <p>Test Site/Formation Conditions: The static water level prior to the tests was 40.88 ft bgs. No significant water-level trend was exhibited within the test interval during testing. The test responses were monitored with a pressure transducer within the well casing above the well screen interval. The well screen interval is situated near the middle of HSU-2 at this site. The aquifer top occurs at a depth of 82 ft below land surface and represents the contact between HSU-1 and HSU-2. The aquifer bottom occurs at a depth of 126 ft. The test interval completion consists of a 5-inch I.D. stainless steel screen, which is within a 9.63-inch I.D. borehole. A 2.38-inch thick sandpack extends between the well screen/borehole annulus, which extends over the depth interval 104.5 - 109.5 ft. Bentonite seals are present in the annular zone above and below the sand pack to ensure monitor zone isolation.</p> <p>Analysis: Quantitative analysis of the overdamped slug test responses that occurred at Well UCD2-027 is not possible due to the rapid recovery and extended occurrence of turbulent flow conditions during the tests. Qualitative analysis, however, was attempted for Test 1. The qualitative analysis employed the same composite type-curve and derivative analysis procedure used for quantitative analysis of overdamped slug test responses (Spane and Wurster, 1993 and Spane 1996). The well screen interval (rather than the sand pack interval) was used to represent the test interval for the analyses. This is because the formation is assumed to have a higher permeability than the sand pack; and, therefore, test response transmission is expected to propagate faster laterally from the well screen to the surrounding test formation, rather than vertically within the sand pack zone. The projected maximum observed H_0 stress level (4.005 ft) was used for the analysis and is considered to be more representative of actual test conditions. This is because evacuation of the compressed air used to depress the water column in the well, could not be accomplished "instantaneously". (Note: the applied air pressure used to depress the water column was 5.68 ft). For analysis purposes, a value of 0.1 was assumed for the anisotropy ratio, K_D (Note: slug test responses are not very sensitive to K_D values). A storativity (S) value of 0.0001 was used for the analysis of both tests. Composite type-curve and derivative analysis for Test 1 provided a value of >3000 ft²/d for transmissivity (T) and >68.2 ft/d for equivalent horizontal hydraulic conductivity (K_e).</p> <p>Comments: Analysis methods used for Test 1 do not account for the effects of turbulent head loss, which occurred during the testing of Zone 6. The analysis results, therefore, are considered to be highly qualitative and should not be used for quantitative characterization of HSU-2 hydraulic properties. The qualitative analysis results are indicative of minimum hydraulic property values. This is in part attributed to the effects of turbulence, which tend to delay dissipation of test responses to the surrounding formation at the stress well location. It is assumed that the actual hydraulic property values are greater than these indicated minimum values. Since UCD2-027 is a new well test site, no previous test analysis results are available.</p>	
Test Result Summary:	Analysis Results
Transmissivity	Best Estimate: >3000 ft ² /d
Equivalent Hydraulic Conductivity	Best Estimate: >68.2 ft/d

Baseline Response: Zone 6 - Test 1

Zone 6 Slug Test Turbulence Assessment

Well Number: UCD2-027 (Zone 7)	Test Date: October 19, 1995
Hydrogeologic Unit: HSU-2	Test Interval Depth: 116 to 118 ft
<p>Test Description: Two pneumatic slug withdrawal tests were conducted. Both tests were conducted by depressing the well fluid column using compressed air (Test 1 $\approx$ 10 ft; Test 2 $\approx$ 5 ft). Turbulent flow conditions were exhibited for extended periods of time for both slug tests conducted; thereby, eliminating the possibility of quantitative analysis of the observed test response (Note: $> 85\%$ recovery occurred during the turbulent flow period for both tests). Comparison of normalized responses for each of the tests indicated a slightly slower decay response for Test 1, which was conducted at a higher stress level. The cause for the slower decay response for Test 1 is unknown, but may be attributed to increased head loss conditions associated with the higher applied stress.</p> <p>Test Site/Formation Conditions: Slug testing was performed using an inflatable straddle packer (with a tubing string radius = 2-inch I.D.) to isolate the Zone 7 well screen from the overlying monitoring zones within well UCD2-027. The tests were conducted prior to installation of the Westbay MOSDAX monitoring system. The test responses were monitored with a pressure transducer mounted on the top of the straddle packer assembly, connected with a pressure access tube through the top packer. The Zone 7 well screen (116 to 118 ft bgs) is located in the lower section of HSU-2. The stratigraphic contact between HSU-2 and the underlying aquitard occurs at a depth of 126 ft below land surface. The static water level prior to the tests was 40.93 ft bgs. No significant water-level trend was observed during testing. The test interval completion consists of a 5-inch I.D. stainless steel screen, which is within a 9.63-inch I.D. borehole. A 2.38-inch thick sandpack extends between the well screen/borehole annulus, which extends over the depth interval 114.5 - 119.0 ft. Bentonite seals are present in the annular zone above and below the sand pack to ensure monitor zone isolation.</p> <p>Analysis: Quantitative analysis of the overdamped slug test responses that occurred for the Zone 7 test interval is not possible due to the rapid recovery and extended occurrence of turbulent flow conditions during the tests. Qualitative analysis, however, was attempted for Test 2. The qualitative analysis employed the same composite type-curve and derivative analysis procedure used for quantitative analysis of overdamped slug test responses (Spane and Wurstner, 1993 and Spane 1996). The well screen interval (rather than the sand pack interval) was used to represent the test interval for the analyses. This is because the formation is assumed to have a higher permeability than the sand pack; and, therefore, test response transmission is expected to propagate faster laterally from the well screen to the surrounding test formation, rather than vertically within the sand pack zone. The projected maximum observed H_0 stress level (5.168 ft) was used for the analysis. The projected observed value for H_0, which is lower than the applied air pressure (5.53 ft) used to depress the water column, is considered to be more representative of actual test conditions. This is because evacuation of the compressed air used to depress the water column in the well, could not be accomplished "instantaneously". For analysis purposes, a value of 0.1 was assumed for the anisotropy ratio, K_D (Note: slug test responses are not very sensitive to K_D values). A storativity (S) value of 0.0001 was also used for the test analysis. Composite type-curve and derivative analysis for Test 2 provided a value of >2400 ft²/d for transmissivity (T) and >54.5 ft/d for equivalent horizontal hydraulic conductivity (K_e).</p> <p>Comments: Analysis methods used for Test 2 do not account for the effects of turbulent head loss, which occurred during the testing of Zone 7. The analysis results, therefore, are considered to be highly qualitative and should not be used for quantitative characterization of HSU-2 hydraulic properties. The qualitative analysis results are indicative of minimum hydraulic property values. This is in part attributed to the effects of turbulence, which tend to delay dissipation of test responses to the surrounding formation at the stress well location. It is assumed that the actual hydraulic property values are greater than these indicated minimum values. Since UCD2-027 is a new well test site, no previous test analysis results are available.</p>	
Test Result Summary:	Analysis Results
Transmissivity	Best Estimate: >2400 ft ² /d
Equivalent Hydraulic Conductivity	Best Estimate: >54.5 ft/d

Baseline Response: Zone 7 - Test 2

Zone 7 Slug Test 2 Analysis

Well Number: UCD1-034	Test Date: October 31, 1995
Hydrogeologic Unit: HSU-1	Test Interval Depth: 57 to 76 ft
<p>Test Description: Two pneumatic slug withdrawal tests were conducted. Test 1 was performed by depressing the well fluid column approximately 4.90 ft using compressed air. Test 2 was conducted in similar fashion as Test 1, with the well fluid column depressed approximately 12.95 ft. Laminar flow conditions were established within 4 sec of test initiation for each of the tests. Comparison of normalized responses for each of the tests indicated a slightly lower decay response for Test 2, which was conducted at a higher stress rate. The cause for this difference in test response is unknown, but may be attributed to increased head loss conditions associated with higher applied stress (Test 2), lateral variations in hydraulic properties within the respective areas of investigation of each test, etc.</p>	
<p>Test Site/Formation Conditions: The static water level prior to the tests was 45.11 ft bgs. No significant water-level trend was exhibited within the test interval during testing. The test responses were monitored with a pressure transducer within the well casing above the well screen interval. The well screen/test interval penetrates 62% of the aquifer and is located in the lower portion of HSU-1 at this site. The aquifer bottom occurs at a depth of 76 ft below land surface and represents the contact between HSU-1 and HSU-2. The test interval completion consists of a 4-inch I.D. PVC screen within a 9.63-inch I.D. borehole. A 2.8-inch thick sandpack extends between the well screen/borehole annulus, which extends over the depth interval 57 - 76 ft. No adjacent HSU-1 observation wells were available within the radius of investigation of the tests.</p>	
<p>Analysis: Composite type-curve and derivative analysis was employed for each slug test using analytical methods presented in Spane and Wurstner (1993) and Spane (1996). Test data indicative of laminar flow conditions (i.e., for test times greater than about 4 sec) were analyzed for each test. The sandpack interval (rather than the well screen interval) was used to represent the test interval for the analyses. This is because the assumed higher transmissive properties of the sandpack (in comparison to the test formation) is considered to be more representative in conveying test responses to the surrounding formation. Projected maximum observed H_0 stress levels were used for the analyses. The projected observed values for H_0 (which are slightly lower than the applied air pressure used to depress the water column) are considered to be more representative of actual test conditions. This is because evacuation of the compressed air used to depress the water column in the well, could not be accomplished "instantaneously". For analysis purposes, a value of 0.1 was assumed for the anisotropy ratio, K_D (Note: slug test responses are not very sensitive to K_D values). A storativity (S) value of 0.0001 was used for the analysis of both tests. Composite type-curve and derivative analysis for both tests provided a range of 23 to 35 ft²/d for transmissivity (T) and 0.74 and 1.1 ft/d for equivalent horizontal hydraulic conductivity (K_e).</p>	
<p>Comments: Slightly higher hydraulic property estimates and overall better composite type-curve and derivative matches were obtained from the analysis of Test 1. Both tests exhibited oversteepened type curve responses over the dimensionless head range of 0.0 to 0.6, which may be attributed to lateral variations within HSU-1 or possible vertical leakage effects from the underlying HSU-2. Because of the lower applied stress and better test response match, Test 1 was utilized for calculating the best estimate values. The best estimate values for transmissivity and equivalent hydraulic conductivity at 35 ft²/d and 1.1 ft/d. Since UCD1-034 is a new well test site, no previous test analysis results are available. A comparison with other new HSU-1 slug test analysis results, however, indicates that the hydraulic property estimates are within the lower range of reported values.</p>	
<p>Test Result Summary:</p>	
<p>Analysis Results</p>	
Transmissivity	Range: 23 to 35 ft ² /d Best Estimate: 35 ft ² /d
Equivalent Hydraulic Conductivity	Range: 0.74 to 1.1 ft/d Best Estimate: 1.1 ft/d

Well Number: UCD2-035	Test Date: October 30, 1995
Hydrogeologic Unit: HSU-2	Test Interval Depth: 107 to 122 ft
<p>Test Description: Three pneumatic slug withdrawal tests were conducted. The tests were performed by depressing the well fluid column using compressed air (Test 1 $\approx$ 4 ft; Test 2 $\approx$ 15 ft; Test 3 $\approx$ 39 ft). Tests 2 and 3 were conducted at a significantly higher stress rate to examine possible hydrologic response within an adjacent well UCD1-034, which monitors HSU-1. No associated response within well UCD1-034 was observed during these tests. Turbulent flow conditions were exhibited for extended periods of time for all slug tests performed; thereby, eliminating the possibility of quantitative analysis of the observed test responses (note: > 95% recovery occurred during the turbulent flow period for all tests. Laminar flow conditions were established after 12 sec, 29 sec, and 60 sec for Tests 1, 2, and 3, respectively).</p>	
<p>Test Site/Formation Conditions: The static water level prior to the tests was 45.87 ft bgs. No significant water-level trend was exhibited within the test interval during testing. The test responses were monitored with a pressure transducer within the well casing above the well screen interval. The well screen interval penetrates approximately 28% of the aquifer and is situated in the lower half of HSU-2 at this site. The aquifer top occurs at a depth of 76 ft below land surface and represents the contact between HSU-1 and HSU-2. The aquifer bottom occurs at a depth of 130 ft. The test interval completion consists of a 4-inch I.D. PVC screen within a 9.63-inch I.D. borehole. A 2.8-inch thick sandpack extends between the well screen/borehole annulus, over the depth interval 103 - 122 ft.</p>	
<p>Analysis: Quantitative analysis of the overdamped slug test responses that occurred at Well UCD2-035 is not possible due to the rapid recovery and extended occurrence of turbulent flow conditions during the tests. In addition, Test 1 exhibited transient response characteristics immediately after test initiation, which suggest a temporary flow restriction during the first seconds of the test, which would obviate the possibility of test analysis. Qualitative analysis, however, was attempted for Test 2. The qualitative analysis employed the same composite type-curve and derivative analysis procedure used for quantitative analysis of HSU-1 overdamped slug test responses (Spane and Wurster, 1993 and Spane 1996). The well screen interval (rather than the sand pack interval) was used to represent the test interval for the analyses. This is because the formation is assumed to have a higher permeability than the sand pack; and, therefore, test response transmission is expected to propagate faster laterally from the well screen to the surrounding test formation, rather than vertically within the sand pack zone. The projected maximum observed H_0 stress level (14.49 ft) was used for the analysis and is only slightly lower than the applied air pressure used to depress the water column (i.e., 15.05 ft). For analysis purposes, a value of 0.1 was assumed for the anisotropy ratio, K_D (Note: slug test responses are not very sensitive to K_D values). A storativity (S) value of 0.0001 was used for the analysis of both tests. Composite type-curve and derivative analysis for Test 2 provided a value of >2000 ft²/d for transmissivity (T) and >37.0 ft/d for equivalent horizontal hydraulic conductivity (K_e).</p>	
<p>Comments: Analysis methods used for Test 2 do not account for the effects of turbulence or inertia which occurred during the testing of well UCD2-035. The analysis results, therefore, are considered to be highly qualitative and should not be used for quantitative characterization of HSU-2 hydraulic properties. The qualitative analysis results are indicative of minimum hydraulic property values. This is in part attributed to the effects of turbulence and inertia, which tend to delay dissipation of test responses to the surrounding formation at the stress well location. It is assumed that the actual hydraulic property values are greater than these indicated minimum values. Since UCD2-035 is a new well test site, no previous test analysis results are available.</p>	
Test Result Summary:	Analysis Results
Transmissivity	Best Estimate: >2000 ft ² /d
Equivalent Hydraulic Conductivity	Best Estimate: >37.0 ft/d

Appendix E

Components and Tools in the Westbay MP55 Multi-Level Ground-Water Monitoring System

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Components and Tools in the Westbay MP55 Multi-Level Ground-Water Monitoring System

This appendix gives additional details about the components and tools in the Westbay MP55 Multi-Level Ground-Water Monitoring System. Information is provided on the casing and packers, couplings, MOSDAX sampler probe and hand-held controller, pumping port open/close tool, and MOSDAX pressure probes and datalogger.

E.1 Components and Tools in the Westbay Ground-Water Monitoring System

The Westbay ground-water monitoring system is a modular, multi-level ground-water sampling and pressure monitoring system with a single, hydraulically sealed access casing and various valved and unvalved couplings. It allows access to multiple monitoring zones in a single borehole. The system consists of permanently installed casing components, portable sampling and monitoring probes, and specialized tools. Casing components include 2.25-in.-ID casing sections and inflatable packers linked by regular couplings, measurement port (i.e., sampling port) couplings, or pumping port couplings. The packers isolate the annulus of the stainless steel casing between each monitoring zone.

E.1.1 Casing and Packers

The Westbay ground-water monitoring system casing sections (Figure E.1) used in well UCD2-027 are of standard 1-m, 1.5-m, and 3-m lengths, and include a coupling. Section lengths were measured from the end of the coupling to the end of the casing piece.

The inflatable packers (see Figure E.1) consist of a casing section having an inflation valve, surrounded by a flexible bladder. The packer length includes the coupling; the total nominal length is 1.5 m.

E.1.2 Couplings

All Westbay ground-water monitoring system couplings are fitted with O-rings for a water-tight hydraulic seal. Once the coupling and casing are fitted together, a flexible shear wire is pushed through the channel made by mating a square-shouldered groove on the outside of the casing with one on the inside of the coupling. This shear wire provides the tensile strength to hold the components together.

(After Westbay Instruments, Inc. 1992)

Figure E.1. Permanent Components of the Westbay Ground-Water Monitoring System

Regular couplings are used to connect casing sections together where no valved couplings are required. A regular coupling end cap is put on the bottom of the casing string to create an annulus that is hydraulically sealed from the material outside the casing.

Measurement port couplings (see Figure E.1) have a helical shoulder on the inside of the coupling to guide the sampling or pressure probe to the small valve in the wall of the coupling. A leaf spring holds the valve closed when not in use, and a cover plate or screen holds the spring in place. Ground water flows into the coupling opposite the valve and travels through a channel in the wall of the coupling to the valve.

Pumping port couplings (see Figure E.1) allow the withdrawal of much larger volumes of ground water than would be feasible through the much smaller measurement port valve. Pumping ports have an O-ring-sealed sliding sleeve valve that can be opened to allow ground water to flow through the large slots in the wall of the coupling. A screen is secured to the coupling around the slots.

E.1.3 MOSDAX Sampler Probe and Hand-Held Controller

The MOSDAX sampler probe (Figure E.2) is used to monitor formation pressure and to collect ground-water samples. The probe uses a retractable location arm to locate the probe intake valve at the measurement port valve in the measurement port coupling of the Westbay ground-water monitoring system. A backing shoe extends to lock the probe in place. At the start of a sampling run, the probe is located in a vacuum coupling and a vacuum check of the seals and valves is completed. The probe's sampling valve is then opened and a stainless steel sampling container is evacuated using a hand-operated vacuum pump. When the vacuum reaches 24 psi, the sampling valve is closed and the backing shoe and location arms are retracted. The probe is lowered to a point just below the measurement port and the location arm is released. As the probe is raised above the port and then lowered, the location arm contacts the helical shoulder of the coupling and the probe's weight causes it to rotate along the helical shoulder into position to operate the intake valve. Once the probe is located correctly, the backing shoe is activated on the opposite side of the probe from the probe intake valve. When fully extended, the backing shoe presses the probe intake against the measurement port valve, sealing the valve with an O-ring seal, and opening the valve to the screened interval. The probe's pressure transducer then monitors the formation pressure. When the probe's sampling valve is opened, ground water flows from inside the screened interval to the pre-evacuated stainless steel sampling container attached to the lower end of the probe. The probe is lowered and raised using a tripod-mounted cable reel. Probe depth is monitored with a cable counter.

The movement of the location arm and backing shoe, as well as the opening and closing of the sampling valve, is controlled by a hand-held controller, operated at the surface by trained sampling personnel. Temperatures and pressures monitored by the sampler probe's pressure transducer are displayed on the controller's digital display.

E.1.4 Pumping Port Open/Close Tool

An open/close tool (Figure E.3) is used to operate the pumping port in the Westbay ground-water monitoring system. The open/close tool has mechanically activated, spring-loaded arms used to open or close the port's sliding valve.

(After Westbay Instruments, Inc. 1992)

Figure E.2. MOSDAX Sampler Probe

(After Westbay Instruments, Inc. 1992)

Figure E.3. Pumping Port Open/Close Tool for the Westbay Ground-Water Monitoring System

To open the valve, the tool is lowered just past the pumping port through the system casing with the arms out and pointing upward. The tool is then raised by pulling on the cable at the surface. When the tool is raised, the arms catch on the lower shoulder of the valve, pulling the valve up and exposing the screened intake slots. The tool is then lowered slightly and "snapped" to bring the arms inside the tool body. The tool is then raised out of the casing.

To close the valve, the tool is reversed at the surface so that, when lowered to just above the pumping port, the arms will come out of the tool body pointing downward. When in position, the tool is "snapped" to bring the arms out. The tool is then dropped a few times so that the arms tap on the upper shoulder of the valve and slide the valve into the closed position. The tool is then removed from the casing.

E.1.5 MOSDAX Pressure Probes and Datalogger

The seven MOSDAX pressure probes (Figure E.4) are used to simultaneously record formation pressure in the seven monitoring zones. A probe uses a retractable location arm to locate the probe's valve at the measurement port valve in the MP55 measurement port coupling. The probe is lowered to a point just above the measurement port and the location arm is released. As the probe is then lowered, the location arm contacts the helical shoulder of the coupling and the probe's weight causes it to rotate along the helical shoulder into position to operate the intake valve. Once the probe is located correctly, a backing shoe is activated on the opposite side of the probe from the probe's valve. When fully extended, the backing shoe presses the probe's valve against the measurement port valve, sealing the valve with an O-ring seal, and opening the valve to the screened interval. The probe's pressure transducer then monitors the formation pressure. The probes are lowered and raised manually.

The movement of the location arm and backing shoe is controlled by MLog32 software, run on a portable field computer, and operated at the surface by trained personnel. Pressures monitored by the pressure probes' transducers are displayed on the system display. Scan and collection rates, as well as data storage, downloading, and viewing, are handled by the MLog32 software.

(After Westbay Instruments, Inc. 1992)

Figure E.4. MOSDAX Pressure Probe

Appendix F

CPT Logs

BATTELLE

Date: 10-03-95
Location: HPL00200

Geologist : B. SCHÄAL
Contractor: GREGG IN SITU

Max. Depth: 86.78 (ft)

Depth Inc.: 0.164 (ft)

SBT: Soil Behavior Type (Robertson and Campanella 1988)

Estimated Phreatic Surface

BATTELLE

Date: 10/05/95
Location: HPL00203

Geologist : B. SCHAL
Contractor: GREGG IN SITU

Max. Depth: 84.32 (ft)

Depth Inc.: 0.164 (ft)

SBT: Soil Behavior Type (Robertson and Campanella 1988)

Estimated Phreatic Surface

Geologist : B. SCHALL
Contractor: GREGG IN SILU

Date: 10-06-95
Location: HPL00211

Max. Depth: 34.15 (ft)

Depth Inc.: 0.164 (ft)

SST: Soil Behavior Type (Robertson and Campanella 1988)

Estimated Phreatic Surface

BATTELLE

Date: 10/06/95
Location: HPI.00213

Geologist : B. SCHAI.
Contractor: GREGG IN SITU

BATTELLE

Date: 11/16/95
Location: HPL00219

Geologist: B. SCHAAL
Contractor: GREGG IN SITU

Max. Depth: 84.48 (ft)

Depth Inc.: 0.164 (ft)

SBT: Soil Behavior Type (Robertson and Campanella 1988)

Estimated Phreatic Surface

BATTELLE

Date: 11/16/95
Location: HPL00219

Engineer : B. SCHALL
Contractor: GREGG IN SITU

BATTELLE

Date: 03/19/96
Location: CPT-1 (APL25)
Geologist: B. SCHÄHL
Contractor: GREGG IN SITU

Max. Depth: 93.99 (ft)
Depth Inc: 0.164 (ft)

BATTELLE

SITE : LEHR SITE
 LOCATION : CPT-1 (HPL 252)
 DATE : 03/19/96
 Tot. Unit Wt. (avg) : 120 pcf

CONTRACTOR : GREGG IN SITU
 GEOLOGIST : B. SCHAAAL
 Water table (feet) : 20.01312

DEPTH (feet)	Qc (avg) (tsf)	Fs (avg) (tsf)	Rf (avg) (%)	SIGV' (tsf)	SOIL BEHAVIOUR TYPE	Eq - Dr (%)	PHI deg.	SPT N	Su tsf
1	40.47	0.20	0.50	0.03	silty sand to sandy silt	>90	>48	13	UNDEFINED
2	24.63	0.66	2.67	0.09	clayey silt to silty clay	UNDFND	UNDFD	12	1.8
3	9.92	0.29	2.94	0.15	silty clay to clay	UNDFND	UNDFD	6	.7
4	8.24	0.13	1.52	0.22	clayey silt to silty clay	UNDFND	UNDFD	4	.6
5	18.55	0.09	0.50	0.28	silty sand to sandy silt	<40	34-36	6	UNDEFINED
6	8.69	0.13	1.44	0.33	clayey silt to silty clay	UNDFND	UNDFD	4	.6
7	28.10	0.12	0.42	0.39	silty sand to sandy silt	40-50	36-38	9	UNDEFINED
8	7.71	0.16	2.10	0.45	silty clay to clay	UNDFND	UNDFD	5	.5
9	9.04	0.25	2.75	0.51	silty clay to clay	UNDFND	UNDFD	6	.6
10	11.62	0.49	4.22	0.57	clay	UNDFND	UNDFD	11	.8
11	26.24	1.12	4.28	0.63	silty clay to clay	UNDFND	UNDFD	17	1.9
12	25.53	1.49	5.82	0.69	clay	UNDFND	UNDFD	24	1.9
13	18.92	1.11	5.86	0.75	clay	UNDFND	UNDFD	18	1.3
14	10.68	0.65	6.09	0.81	clay	UNDFND	UNDFD	10	.7
15	8.31	0.44	5.27	0.87	clay	UNDFND	UNDFD	8	.5
16	19.08	1.07	5.60	0.93	clay	UNDFND	UNDFD	18	1.3
17	15.76	1.04	6.60	0.98	clay	UNDFND	UNDFD	15	1.1
18	16.96	1.01	5.97	1.04	clay	UNDFND	UNDFD	16	1.2
19	25.26	1.27	5.04	1.10	clay	UNDFND	UNDFD	24	1.8
20	25.94	1.60	6.18	1.16	clay	UNDFND	UNDFD	25	1.9
21	34.95	1.94	5.56	1.21	clay	UNDFND	UNDFD	33	2.5
22	36.12	2.20	6.10	1.24	clay	UNDFND	UNDFD	35	2.6
23	36.52	2.08	5.69	1.27	clay	UNDFND	UNDFD	35	2.7
24	39.47	2.52	6.39	1.30	clay	UNDFND	UNDFD	38	2.9
25	35.75	2.23	6.23	1.33	clay	UNDFND	UNDFD	34	2.6
26	19.09	1.05	5.47	1.36	clay	UNDFND	UNDFD	18	1.3
27	23.96	1.27	5.29	1.39	clay	UNDFND	UNDFD	23	1.7
28	29.12	1.39	4.76	1.42	clay	UNDFND	UNDFD	28	2.1
29	22.56	0.91	4.02	1.45	silty clay to clay	UNDFND	UNDFD	14	1.6
30	128.62	2.10	1.64	1.47	sand to silty sand	60-70	36-38	31	UNDEFINED
31	145.42	2.92	2.01	1.50	silty sand to sandy silt	70-80	38-40	46	UNDEFINED
32	34.14	1.24	3.63	1.53	clayey silt to silty clay	UNDFND	UNDFD	16	2.4
33	21.56	0.86	3.98	1.56	silty clay to clay	UNDFND	UNDFD	14	1.5
34	18.34	0.50	2.70	1.59	clayey silt to silty clay	UNDFND	UNDFD	9	1.2
35	29.76	1.06	3.55	1.62	clayey silt to silty clay	UNDFND	UNDFD	14	2.1
36	28.37	1.29	4.55	1.64	silty clay to clay	UNDFND	UNDFD	18	2.0
37	27.66	1.25	4.51	1.67	silty clay to clay	UNDFND	UNDFD	18	1.9
38	32.45	1.75	5.39	1.70	clay	UNDFND	UNDFD	31	2.3
39	21.85	0.93	4.26	1.73	silty clay to clay	UNDFND	UNDFD	14	1.5
40	23.39	0.77	3.29	1.76	clayey silt to silty clay	UNDFND	UNDFD	11	1.6

Dr - All sands (Jamiolkowski et al. 1985)

PHI -

Durgunoglu and Mitchell 1975

Su: Nk= 13

**** Note: For interpretation purposes the PLOTTED CPT PROFILE should be used with the TABULATED OUTPUT from CPTINTR1 (v 3.02) ****

BATTELLE

SITE : LEHR SITE LOCATION : CPT-1 (HPL 252) Page No. 2

DEPTH (feet)	Qc (avg) (tsf)	Fs (avg) (tsf)	Rf (avg) (%)	SIGV' (tsf)	SOIL BEHAVIOUR TYPE	Eq - Dr (%)	PHI deg.	SPT N	Su tsf
41	32.87	1.51	4.58	1.79	silty clay to clay	UNDFND	UNDFD	21	2.3
42	43.01	2.31	5.37	1.82	clay	UNDFND	UNDFD	41	3.1
43	48.69	2.54	5.21	1.85	clay	UNDFND	UNDFD	47	3.5
44	50.03	2.66	5.31	1.88	clay	UNDFND	UNDFD	48	3.6
45	27.09	1.23	4.54	1.91	silty clay to clay	UNDFND	UNDFD	17	1.8
46	24.58	0.88	3.59	1.94	clayey silt to silty clay	UNDFND	UNDFD	12	1.6
47	41.87	1.72	4.12	1.97	clayey silt to silty clay	UNDFND	UNDFD	20	3.0
48	36.65	1.41	3.85	1.99	clayey silt to silty clay	UNDFND	UNDFD	18	2.6
49	31.03	1.15	3.71	2.02	clayey silt to silty clay	UNDFND	UNDFD	15	2.1
50	42.59	2.09	4.91	2.05	silty clay to clay	UNDFND	UNDFD	27	3.0
51	48.96	2.51	5.13	2.08	clay	UNDFND	UNDFD	47	3.5
52	50.05	2.41	4.82	2.11	silty clay to clay	UNDFND	UNDFD	32	3.6
53	49.58	2.64	5.32	2.14	clay	UNDFND	UNDFD	47	3.5
54	38.86	1.97	5.06	2.16	clay	UNDFND	UNDFD	37	2.7
55	28.08	1.38	4.91	2.19	clay	UNDFND	UNDFD	27	1.9
56	33.40	1.57	4.71	2.22	silty clay to clay	UNDFND	UNDFD	21	2.3
57	25.45	1.06	4.18	2.25	silty clay to clay	UNDFND	UNDFD	16	1.6
58	19.73	0.76	3.86	2.28	silty clay to clay	UNDFND	UNDFD	13	1.2
59	19.55	0.81	4.16	2.31	silty clay to clay	UNDFND	UNDFD	12	1.2
60	18.22	0.63	3.44	2.33	silty clay to clay	UNDFND	UNDFD	12	1.1
61	42.88	1.94	4.52	2.36	silty clay to clay	UNDFND	UNDFD	27	3.0
	65.66	3.28	4.99	2.39	very stiff fine grained (*)	UNDFND	UNDFD	>50	UNDEFINED
63	49.80	2.66	5.34	2.42	clay	UNDFND	UNDFD	48	3.5
64	140.61	7.67	5.46	2.45	very stiff fine grained (*)	UNDFND	UNDFD	>50	UNDEFINED
65	215.64	6.13	2.84	2.48	silty sand to sandy silt	70-80	36-38	>50	UNDEFINED
66	169.41	4.06	2.39	2.51	silty sand to sandy silt	60-70	34-36	>50	UNDEFINED
67	88.39	2.82	3.19	2.54	sandy silt to clayey silt	UNDFND	UNDFD	34	6.4
68	45.48	1.55	3.40	2.57	clayey silt to silty clay	UNDFND	UNDFD	22	3.1
69	34.76	1.18	3.40	2.60	clayey silt to silty clay	UNDFND	UNDFD	17	2.3
70	26.16	0.91	3.50	2.63	clayey silt to silty clay	UNDFND	UNDFD	13	1.6
71	51.58	2.17	4.20	2.65	clayey silt to silty clay	UNDFND	UNDFD	25	3.6
72	57.25	3.24	5.67	2.68	clay	UNDFND	UNDFD	>50	4.0
73	53.99	3.08	5.71	2.71	clay	UNDFND	UNDFD	>50	3.8
74	47.82	2.12	4.44	2.74	silty clay to clay	UNDFND	UNDFD	31	3.3
75	39.96	2.02	5.06	2.77	clay	UNDFND	UNDFD	38	2.7
76	29.87	1.41	4.72	2.80	silty clay to clay	UNDFND	UNDFD	19	1.9
77	25.83	0.86	3.34	2.82	clayey silt to silty clay	UNDFND	UNDFD	12	1.6
78	23.36	0.70	3.00	2.85	clayey silt to silty clay	UNDFND	UNDFD	11	1.4
79	27.97	1.40	4.99	2.88	clay	UNDFND	UNDFD	27	1.7
80	32.16	1.67	5.18	2.91	clay	UNDFND	UNDFD	31	2.1
81	31.65	1.58	4.98	2.94	clay	UNDFND	UNDFD	30	2.0
82	52.82	2.94	5.57	2.97	clay	UNDFND	UNDFD	>50	3.6
83	39.35	2.24	5.68	2.99	clay	UNDFND	UNDFD	38	2.6
84	33.02	1.66	5.04	3.02	clay	UNDFND	UNDFD	32	2.1
85	28.88	1.20	4.16	3.06	silty clay to clay	UNDFND	UNDFD	18	1.8

Dr - All sands (Jamiolkowski et al. 1985)

PHI - Durgunoglu and Mitchell 1975

Su: Nk= 13

(*) overconsolidated or cemented

**** Note: For interpretation purposes the PLOTTED CPT PROFILE should be used with the TABULATED OUTPUT from CPTINTR1 (v 3.02) ****

BATTELLE

1

SITE : LEHR SITE LOCATION : CPT-1 (HPL 252) Page No. 3

DEPTH (feet)	Qc (avg) (tsf)	Fs (avg) (tsf)	Rf (avg) (%)	SIGV' (tsf)	SOIL BEHAVIOUR TYPE	Eq - Dr (%)	PHI deg.	SPT N	Su tsf
86	28.28	1.41	4.97	3.08	clay	UNDFND	UNDEFD	27	1.7
87	30.01	1.03	3.44	3.11	clayey silt to silty clay	UNDFND	UNDEFD	14	1.9
88	31.91	1.05	3.28	3.15	clayey silt to silty clay	UNDFND	UNDEFD	15	2.0
89	37.78	1.14	3.01	3.17	sandy silt to clayey silt	UNDFND	UNDEFD	14	2.4
90	31.12	0.96	3.10	3.20	clayey silt to silty clay	UNDFND	UNDEFD	15	1.9
91	27.39	0.91	3.31	3.23	clayey silt to silty clay	UNDFND	UNDEFD	13	1.6
92	192.28	2.12	1.10	3.26	sand	60-70	34-36	37	UNDEFINED
93	453.27	2.10	0.46	3.29	gravelly sand to sand	>90	40-42	>50	UNDEFINED
94	458.02	2.08	0.45	3.32	gravelly sand to sand	>90	40-42	>50	UNDEFINED

Dr - All sands (Jamolkowski et al. 1985)

PHI -

Durgunoglu and Mitchell 1975

Su: Nk= 13

**** Note: For interpretation purposes the PLOTTED CPT PROFILE should be used with the TABULATED OUTPUT from CPTINTR1 (v 3.02) ****

BATTELLE

Date: 03/20/96

Location: CPT-2 (HPL254)

Geologist: B. SCHAAL

Contractor: GREGG IN SITU

Max. Depth: 102.20 (ft)

Depth Inc.: 0.164 (ft)

SBT: Soil Behavior Type (Robertson and Campanella 1988)

Estimated Phreatic Surface

BATTELLE

SITE : LEHR SITE

LOCATION : CPT-2

DATE : 03/20/96

Tot. Unit Wt. (avg) : 120 pcf

CONTRACTOR : GREGG IN SITU

GEOLOGIST : B. SCHAAAL

Water table (feet) : 20.01312

DEPTH (feet)	Qc (avg) (tsf)	Fs (avg) (tsf)	Rf (avg) (%)	SIGV' (tsf)	SOIL BEHAVIOUR TYPE	Eq - Dr (%)	PHI deg.	SPT N	Su tsf
1	46.46	0.21	0.45	0.03	sand to silty sand	>90	>48	11	UNDEFINED
2	15.95	0.52	3.26	0.09	silty clay to clay	UNDFND	UNDFD	10	1.2
3	5.92	0.17	2.82	0.15	clay	UNDFND	UNDFD	6	.4
4	9.31	0.17	1.84	0.22	clayey silt to silty clay	UNDFND	UNDFD	4	.6
5	18.32	0.04	0.23	0.28	silty sand to sandy silt	<40	34-36	6	UNDEFINED
6	9.49	0.12	1.30	0.33	clayey silt to silty clay	UNDFND	UNDFD	5	.7
7	29.81	0.10	0.33	0.39	silty sand to sandy silt	40-50	36-38	10	UNDEFINED
8	18.24	0.16	0.89	0.45	sandy silt to clayey silt	UNDFND	UNDFD	7	1.3
9	11.89	0.46	3.90	0.51	clay	UNDFND	UNDFD	11	.8
10	14.23	0.75	5.28	0.57	clay	UNDFND	UNDFD	14	1.0
11	13.96	0.78	5.61	0.63	clay	UNDFND	UNDFD	13	1.0
12	26.17	1.29	4.92	0.69	clay	UNDFND	UNDFD	25	1.9
13	33.38	1.96	5.86	0.75	clay	UNDFND	UNDFD	32	2.5
14	22.89	1.43	6.23	0.81	clay	UNDFND	UNDFD	22	1.6
15	22.80	1.29	5.66	0.87	clay	UNDFND	UNDFD	22	1.6
16	24.63	1.54	6.26	0.93	clay	UNDFND	UNDFD	24	1.8
17	30.06	1.95	6.50	0.98	clay	UNDFND	UNDFD	29	2.2
18	25.61	1.53	5.97	1.04	clay	UNDFND	UNDFD	25	1.8
19	38.29	2.00	5.22	1.10	clay	UNDFND	UNDFD	37	2.8
20	34.73	1.94	5.58	1.16	clay	UNDFND	UNDFD	33	2.5
21	32.91	1.56	4.75	1.21	silty clay to clay	UNDFND	UNDFD	21	2.4
22	31.64	1.67	5.27	1.24	clay	UNDFND	UNDFD	30	2.3
23	39.83	2.14	5.38	1.27	clay	UNDFND	UNDFD	38	2.9
24	39.74	1.93	4.87	1.30	silty clay to clay	UNDFND	UNDFD	25	2.9
25	61.70	3.07	4.98	1.33	very stiff fine grained (*)	UNDFND	UNDFD	>50	UNDEFINED
26	44.00	2.63	5.97	1.36	clay	UNDFND	UNDFD	42	3.2
27	23.15	0.96	4.13	1.39	silty clay to clay	UNDFND	UNDFD	15	1.6
28	27.38	0.96	3.49	1.42	clayey silt to silty clay	UNDFND	UNDFD	13	1.9
29	29.21	1.08	3.70	1.45	clayey silt to silty clay	UNDFND	UNDFD	14	2.1
30	43.69	2.26	5.18	1.47	clay	UNDFND	UNDFD	42	3.2
31	40.44	2.41	5.95	1.50	clay	UNDFND	UNDFD	39	2.9
32	45.49	2.52	5.54	1.53	clay	UNDFND	UNDFD	44	3.3
33	43.88	1.98	4.52	1.56	silty clay to clay	UNDFND	UNDFD	28	3.2
34	46.70	2.31	4.94	1.59	silty clay to clay	UNDFND	UNDFD	30	3.4
35	47.71	2.64	5.54	1.62	clay	UNDFND	UNDFD	46	3.5
36	35.60	1.86	5.21	1.64	clay	UNDFND	UNDFD	34	2.5
37	26.36	1.05	4.00	1.67	silty clay to clay	UNDFND	UNDFD	17	1.8
38	20.00	0.58	2.92	1.70	clayey silt to silty clay	UNDFND	UNDFD	10	1.3
39	27.55	1.03	3.74	1.73	clayey silt to silty clay	UNDFND	UNDFD	13	1.9
40	42.61	1.95	4.58	1.76	silty clay to clay	UNDFND	UNDFD	27	3.0

Dr - All sands (Jamiolkowski et al. 1985)

PHI - Durgunoglu and Mitchell 1975

Su: Nk= 13

(*) overconsolidated or cemented

**** Note: For interpretation purposes the PLOTTED CPT PROFILE should be used with the TABULATED OUTPUT from CPTINTR1 (v 3.02) ****

BATTELLE

SITE : LEHR SITE

LOCATION : CPT-2

Page No. 2

DEPTH (feet)	Qc (avg) (tsf)	Fs (avg) (tsf)	Rf (avg) (%)	SIGV' (tsf)	SOIL BEHAVIOUR TYPE	Eq - Dr (%)	PHI deg.	SPT N	Su tsf
41	40.49	1.55	3.83	1.79	clayey silt to silty clay	UNDFND	UNDFD	19	2.9
42	45.35	2.01	4.43	1.82	silty clay to clay	UNDFND	UNDFD	29	3.2
43	49.81	2.98	5.99	1.85	clay	UNDFND	UNDFD	48	3.6
44	41.37	2.30	5.56	1.88	clay	UNDFND	UNDFD	40	2.9
45	45.76	2.18	4.76	1.91	silty clay to clay	UNDFND	UNDFD	29	3.3
46	36.31	1.52	4.18	1.94	silty clay to clay	UNDFND	UNDFD	23	2.5
47	38.19	1.35	3.54	1.97	clayey silt to silty clay	UNDFND	UNDFD	18	2.7
48	38.49	1.57	4.09	1.99	clayey silt to silty clay	UNDFND	UNDFD	18	2.7
49	24.68	0.84	3.41	2.02	clayey silt to silty clay	UNDFND	UNDFD	12	1.6
50	26.72	0.96	3.60	2.05	clayey silt to silty clay	UNDFND	UNDFD	13	1.8
51	35.76	1.44	4.03	2.08	clayey silt to silty clay	UNDFND	UNDFD	17	2.5
52	45.49	1.89	4.16	2.11	clayey silt to silty clay	UNDFND	UNDFD	22	3.2
53	42.57	1.66	3.90	2.14	clayey silt to silty clay	UNDFND	UNDFD	20	3.0
54	42.50	1.87	4.40	2.16	silty clay to clay	UNDFND	UNDFD	27	3.0
55	49.81	2.05	4.13	2.19	clayey silt to silty clay	UNDFND	UNDFD	24	3.5
56	31.56	1.42	4.49	2.22	silty clay to clay	UNDFND	UNDFD	20	2.1
57	28.38	1.03	3.64	2.25	clayey silt to silty clay	UNDFND	UNDFD	14	1.9
58	31.92	1.35	4.22	2.28	silty clay to clay	UNDFND	UNDFD	20	2.1
59	23.27	0.81	3.47	2.31	clayey silt to silty clay	UNDFND	UNDFD	11	1.5
60	55.61	2.62	4.72	2.33	silty clay to clay	UNDFND	UNDFD	36	4.0
61	41.54	2.17	5.22	2.36	clay	UNDFND	UNDFD	40	2.9
62	37.21	1.52	4.10	2.39	clayey silt to silty clay	UNDFND	UNDFD	18	2.5
63	64.24	3.34	5.20	2.42	very stiff fine grained (*)	UNDFND	UNDFD	>50	UNDEFINED
64	35.08	1.62	4.63	2.45	silty clay to clay	UNDFND	UNDFD	22	2.4
65	27.99	0.79	2.83	2.48	clayey silt to silty clay	UNDFND	UNDFD	13	1.8
66	30.87	0.89	2.90	2.51	clayey silt to silty clay	UNDFND	UNDFD	15	2.0
67	26.21	0.68	2.61	2.54	sandy silt to clayey silt	UNDFND	UNDFD	10	1.7
68	24.52	0.71	2.90	2.57	clayey silt to silty clay	UNDFND	UNDFD	12	1.5
69	20.21	0.39	1.95	2.60	sandy silt to clayey silt	UNDFND	UNDFD	8	1.2
70	20.68	0.40	1.94	2.63	sandy silt to clayey silt	UNDFND	UNDFD	8	1.2
71	21.25	0.49	2.31	2.65	sandy silt to clayey silt	UNDFND	UNDFD	8	1.3
72	33.12	0.97	2.93	2.68	clayey silt to silty clay	UNDFND	UNDFD	16	2.2
73	43.17	1.85	4.27	2.71	silty clay to clay	UNDFND	UNDFD	28	2.9
74	38.58	1.86	4.82	2.74	silty clay to clay	UNDFND	UNDFD	25	2.6
75	29.24	1.49	5.10	2.77	clay	UNDFND	UNDFD	28	1.9
76	27.60	0.99	3.57	2.80	clayey silt to silty clay	UNDFND	UNDFD	13	1.7
77	50.59	2.81	5.55	2.82	clay	UNDFND	UNDFD	48	3.5
78	69.27	3.77	5.44	2.85	very stiff fine grained (*)	UNDFND	UNDFD	>50	UNDEFINED
79	50.16	2.60	5.17	2.88	clay	UNDFND	UNDFD	48	3.4
80	108.91	2.59	2.38	2.91	silty sand to sandy silt	50-60	30-32	35	UNDEFINED
81	457.20	1.91	0.42	2.94	gravelly sand to sand	>90	40-42	>50	UNDEFINED
82	368.66	1.91	0.52	2.97	gravelly sand to sand	80-90	38-40	>50	UNDEFINED
83	279.11	1.40	0.50	2.99	gravelly sand to sand	80-90	36-38	45	UNDEFINED
84	360.44	2.05	0.57	3.02	gravelly sand to sand	80-90	38-40	>50	UNDEFINED
85	494.40	1.46	0.29	3.06	gravelly sand to sand	>90	40-42	>50	UNDEFINED

Dr - All sands (Jamiolkowski et al. 1985)

PHI - Durgunoglu and Mitchell 1975

Su: Nk= 13

(*) overconsolidated or cemented

**** Note: For interpretation purposes the PLOTTED CPT PROFILE should be used with the TABULATED OUTPUT from CPTINTR1 (v 3.02) ****

BATTELLE

SITE : LEHR SITE

LOCATION : CPT-2

Page No. 3

DEPTH (feet)	Qc (avg) (tsf)	Fs (avg) (tsf)	Rf (avg) (%)	SIGV' (tsf)	SOIL BEHAVIOUR TYPE	Eq - Dr (%)	PHI deg.	SPT N	Su tsf
86	402.24	2.34	0.58	3.08	gravelly sand to sand	>90	38-40	>50	UNDEFINED
87	400.59	2.39	0.60	3.11	gravelly sand to sand	>90	38-40	>50	UNDEFINED
88	327.73	1.32	0.40	3.15	gravelly sand to sand	80-90	38-40	>50	UNDEFINED
89	338.13	0.85	0.25	3.17	gravelly sand to sand	80-90	38-40	>50	UNDEFINED
90	276.61	1.26	0.46	3.20	gravelly sand to sand	70-80	36-38	44	UNDEFINED
91	443.09	2.35	0.53	3.23	gravelly sand to sand	>90	40-42	>50	UNDEFINED
92	324.58	1.71	0.53	3.26	gravelly sand to sand	80-90	38-40	>50	UNDEFINED
93	303.03	1.68	0.55	3.29	gravelly sand to sand	80-90	36-38	48	UNDEFINED
94	253.01	1.17	0.46	3.32	gravelly sand to sand	70-80	36-38	40	UNDEFINED
95	228.10	2.27	0.99	3.34	sand	70-80	34-36	44	UNDEFINED
96	494.97	2.37	0.48	3.37	gravelly sand to sand	>90	40-42	>50	UNDEFINED
97	501.40	3.65	0.73	3.40	gravelly sand to sand	>90	40-42	>50	UNDEFINED
98	468.43	3.40	0.73	3.43	gravelly sand to sand	>90	40-42	>50	UNDEFINED
99	383.95	2.57	0.67	3.46	gravelly sand to sand	80-90	38-40	>50	UNDEFINED
100	152.77	2.04	1.34	3.49	sand to silty sand	60-70	32-34	37	UNDEFINED
101	108.56	2.79	2.57	3.51	silty sand to sandy silt	50-60	30-32	35	UNDEFINED
102	425.42	3.40	0.80	3.54	gravelly sand to sand	>90	38-40	>50	UNDEFINED

Dr - All sands (Jamiolkowski et al. 1985)

PHI - Durgunoglu and Mitchell 1975

Su: Nk= 13

**** Note: For interpretation purposes the PLOTTED CPT PROFILE should be used with the TABULATED OUTPUT from CPTINTR1 (v 3.02) ****.

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	Information Release Office (5)	K1-06