NOTICE!

ALL DRAWINGS ARE LOCATED AT THE END OF THE DOCUMENT

DRAFT FINAL

Phase III RFI/RI Report

Rocky Flats Plant
881 Hillside Area
(Operable Unit No. 1)

Volume VII

Appendix B1
Hydrogeologic Data

U.S. Department of Energy
Rocky Flats Plant
Golden, Colorado

October 1992

Appendix B

OU1 OU1 OU
881 Hillside
OU1 OU1 O
Hillside 881
1 OU1 OU1
side 881 Hill
U1 OU1 OU
881 Hillside
OU1 OU1 O
Hillside 881

Hydrogeologic Data

Phase III
RFI/RI Report

APPENDIX B - TABLE OF CONTENTS

Section | Page

HYDROGEOLOGIC DATA

B1 BOREHOLE AND SINGLE WELL TEST DATA

B1.1 INTRODUCTION B1-1

B1.2 PACKER TESTS (IN SITU PUMP-IN TESTS) B1-2
B1.2.1 General Description B1-2
B1.2.2 Data Collection Methods B1-4
B1.2.3 Data Reduction Methods B1-7
B1.2.4 Data Analysis Methods B1-8

B1.3 SINGLE WELL TESTS B1-9
B1.3.1 General Description B1-9
B1.3.2 Data Collection Methods B1-10
B1.3.3 Data Reduction Methods B1-13
B1.3.4 Data Analysis Methods B1-14
B1.3.4.1 Bouwer and Rice Method B1-14
B1.3.4.2 Hvorslev Method B1-19

B1.4 RESULTS B1-22
B1.4.1 Location-Specific Test Summary B1-22
B1.4.2 Conclusions B1-36

B1.5 REFERENCES B1-39

B2 MULTIPLE-WELL TEST DATA

B2.1 INTRODUCTION B2-1

B2.2 PUMPING TESTS B2-4
B2.2.1 Single-Well Step-Drawdown Tests B2-4
B2.2.1.1 Well Installation B2-4
B2.2.1.2 Well Development and Sampling B2-6
B2.2.1.3 Test Procedures B2-7
B2.2.1.4 Analysis of Test Data B2-9
B2.2.2 Multiple-Well Tests B2-13
B2.2.2.1 Well Installation B2-13
B2.2.2.2 Well Development B2-14

APPENDIX B - TABLE OF CONTENTS
(continued)

Section | Page

B2.2.2.3 Test Procedures B2-15
B2.2.2.4 Analysis of Test Data B2-17

B2.3 TRACER TESTS B2-26
B2.3.1 Single-Well Tracer Tests B2-26
B2.3.1.1 Test Procedures B2-26
B2.3.1.2 Analysis of Test Data B2-30
B2.3.2 Multiple-Well Tests B2-32
B2.3.2.1 Test Procedures B2-32
B2.3.2.2 Analysis of Test Data B2-41
B2.3.2.3 Well Abandonment and Decontamination B2-51

B2.4 SUMMARY OF RESULTS AND CONCLUSIONS B2-52
B2.4.1 Pumping Tests B2-52
B2.4.2 Tracer Tests B2-55

B2.5 REFERENCES B2-57

B3 GROUND WATER ELEVATION DATA

B4 FRENCH DRAIN HYDROGEOLOGIC ASSESSMENT

APPENDIX B - LIST OF TABLES

Table

B1-1 Fourth Quarter 1991 Well Status Summary
B1-2 Summary of Packer Test Information and Results
B1-3 Single Well Test Summary
B1-4 Summary of Input Parameters for AQTESOLV
B1-5 AQTESOLV Output Summary for Bouwer and Rice Analysis
B1-6 Hvorslev Analysis Parameters and Results
B1-7 Hydraulic Conductivity and Field Permeability Summary
B1-8 Comparison of Phase III RFI/RI Results to Previous Results at OU1
B1-9 Summary of Aquifer Test Results at OU1

B2-1 Wellpoint Installation Summary
B2-2 Wellpoint Development Summary
B2-3 Water Quality Sample Results
B2-4 Data Logger Standard Log Schedule
B2-5 Multiple-Well Pumping Test Analysis - Cooper-Jacob, Neuman, and Theis Recovery Methods
B2-6 Distance-Drawdown Method
B2-7 Summary of Multiple-Well Pumping Test Analyses
B2-8 Summary of Average Linear Velocity and Longitudinal Dispersion Values
B2-9 Summary of Effective Porosity Values

APPENDIX B - LIST OF FIGURES

Figure

B1-1 Borehole and Well Location Map for OU1 Phase III RFI/RI Field Investigation

B2-1 Pumping and Tracer Test Locations
B2-2 General Wellpoint Construction
B2-3 Single-Well Step-Drawdown Test Setup
B2-4 Step-Drawdown Test Results December 3, 1991
B2-5 Step-Drawdown Test Results December 6, 1991
B2-6 Step-Drawdown Test December 6, 1991 Hantush-Bierschenk Analysis
B2-7 Multiple-Well Pumping Test Setup
B2-8 Single-Well Tracer Evaluation Test - Distilled Water Tracer Test Setup
B2-9 Single-Well Tracer Evaluation Test - Bromide Tracer Test Setup
B2-10 Single-Well Tracer Evaluation Tests Breakthrough Curves
B2-11 Multiple-Well Tracer Test Setup 1
B2-12 Multiple-Well Tracer Test Setup 2
B2-13 Multiple-Well Tracer Test Bromide Concentration vs. Time for Wells E1-E5
B2-14 Type Curves for Velocity = 0.1 ft/min
B2-15 Type Curves for Velocity = 0.05 ft/min
B2-16 Type Curves for Velocity = 0.01 ft/min
B2-17 Type Curves for Velocity = 0.001 ft/min
B2-18 Multiple-Well Tracer Test Breakthrough Curve for Wells I1 - E1
B2-19 Multiple-Well Tracer Test Breakthrough Curve for Wells I2 - E2
B2-20 Multiple-Well Tracer Test Breakthrough Curve for Wells I3 - E3
B2-21 Multiple-Well Tracer Test Breakthrough Curve for Wells I4 - E4
B2-22 Multiple-Well Tracer Test Breakthrough Curve for Wells I5 - E5
B2-23 Multiple-Well Tracer Test Breakthrough Curve for Wells I1 - E1
B2-24 Multiple-Well Tracer Test Breakthrough Curve for Wells I2 - E2
B2-25 Multiple-Well Tracer Test Breakthrough Curve for Wells I3 - E3
B2-26 Multiple-Well Tracer Test Breakthrough Curve for Wells I4 - E4
B2-27 Multiple-Well Tracer Test Breakthrough Curve for Wells I5 - E5
B2-28 Summary of Estimated Hydraulic Conductivities by Wellpoint
B2-29 Estimated Specific Yields vs. Distance from Pumping Wellpoint

APPENDIX B - ATTACHMENTS

Attachments

B1-1 Field Data and Calculations

B2-1 Field Activities Chronology

B2-2 Single-Well Test Equipment:
- Well Installation
- Well Development and Sampling
- Step-Drawdown Test
- Tracer Evaluation Tests

B2-3 Single-Well Field Data Sheets:
- Well Installation
- Well Development and Sampling
- Step-Drawdown Test

B2-4 Single-Well Time-Drawdown Measurements:
- Table 1. Step-Drawdown Test December 3, 1991
- Table 2. Step-Drawdown Test December 6, 1991

B2-5 Multiple-Well Test Equipment:
- Well Installation
- Well Development
- Pumping Test
- Tracer Test
- Well Abandonment

B2-6 Multiple-Well Field Data Sheets:
- Well Installation
- Well Development
- Pumping Test
- Tracer Test
- Well Abandonment

B2-7 Multiple-Well Pumping Test Time-Drawdown Data and Graphical Solutions
- Table 1. Multiple-Well Pumping Test Time-Drawdown Data
- Table 2. Multiple-Well Pumping Test Recovery Data

APPENDIX B - ATTACHMENTS
(continued)

Attachments

B2-8 Bromide Analytical Methods:
Table 1. Bromide ISE Calibration Data
Table 2. Comparison of Laboratory and Field Bromide Concentrations
Figure 1. Effect of Temperature on Bromide Calibration Curves

B2-9 Single-Well Tracer Evaluation Tests - Test Parameters and Results:
Table 1. Summary of Test Parameters
Table 2. Distilled Water Tracer Results
Table 3. Bromide Tracer Results

B2-10 Multiple-Well Tracer Test - Test Parameters and Results
Table 1. Corrected Flow Accumulator Readings (gallons)
Table 2. Injection and Extraction Rates
Table 3. Relative Water Column Heights
Table 4. Summary of Relative Water Column Heights
Table 5. Bromide Tracer Results
Figure 1. Pumping Rates
Figure 2. Gradient for Wells I1, 01, E1
Figure 3. Gradient for Wells I2, 02, E2
Figure 4. Gradient for Wells I3, 03, E3
Figure 5. Gradient for Wells I4, 04, E4
Figure 6. Gradient for Wells I5, 05, E5

B2-11 Surveyed Well Locations

B3-1 Ground Water Elevation Data Table (1989-1991)

B3-2 Well Hydrographs

APPENDIX B - LIST OF ACRONYMS AND ABBREVIATIONS

Appendix B1

ASTM	American Society for Testing and Materials
BGS	below ground surface
cm/sec	centimeters per second
ft/min	feet per minute
GW	ground water
(I)	development by injection methods
IHSS	Individual Hazardous Subtance Site
MW	monitoring well designation
N/A	not applicable
OU1	Operable Unit No. 1
(P)	bedrock boreholes in which packer tests were performed prior to well installation
psi	pounds per square inch
PVC	polyvinyl chloride
PZ	piezometer designation
RCRA	Resource Conservation and Recovery Act
RFI/RI	RCRA Facility Investigation/Remedial Investigation
RFP	Rocky Flats Plant
SOP	Standard Operating Procedure

Appendix B2

cm/sec	centimeter per second
C	concentration of bromide in extracted fluid
°C	degree Celsius
DOE	Department of Energy
EMD	Environmental Management Department
ft	feet or foot
ft/min	feet per minute
ft^2/min	square feet per min
ft^3/min	cubic feet per minute
gpm	gallons per minute
HDPE	high density polyethylene
I.D.	inside diameter
ISA	ionic strength adjuster
ISE	ion selective electrode
kW	kilowatt
mg/l	milligrams per liter

Appendix B2

ml	milliliter
O.D.	outside diameter
OU1	Operable Unit No. 1
pH	negative logarithm of hydrogen ion concentration
PPE	personal protective equipment
psi	pounds per square inch
PVC	polyvinyl chloride
Q	discharge rate
RCRA	Resource Conversation and Recovery Act
RFI/RI	RCRA Facility Investigation/Remedial Investigation
RFP	Rocky Flats Plant
rpm	revolutions per minute
SC	specific conductance
SOP	standard operating procedures
S_W	drawdown
μmhos/cm	micromhos per centimeter

Appendix B1 · Text

Borehole and Single Well Test Data

Phase III
RFI/RI Report

B1 BOREHOLE AND SINGLE WELL TEST DATA

B1.1 INTRODUCTION

During the Operable Unit No. 1 (OU1) Phase III Resource Conservation and Recovery Act (RCRA) Facility Investigation/Remedial Investigation (RFI/RI) field investigation at the Rocky Flats Plant (RFP) a total of 26 monitoring wells and 5 piezometers were installed at the 881 Hillside area. Packer tests (in situ pump-in tests) were performed to estimate the hydraulic conductivity of specific depth intervals in four bedrock boreholes in which wells and piezometers were subsequently constructed. Single well tests were performed in 11 monitoring wells and three piezometers to estimate the hydraulic conductivity of surficial and bedrock materials in the vicinity of these wells and piezometers. Figure B1-1 presents a borehole and well location map.

Environmental and borehole drilling conditions encountered at OU1 precluded the estimation of bedrock formation parameters during packer testing with the exception of one borehole. However, hydraulic conductivity estimates were obtained for the bedrock formation from single well tests performed in bedrock monitoring wells subsequently installed in the packer-tested boreholes. Single well tests also provided hydraulic conductivity estimates for alluvial and colluvial materials. Table B1-1 is a fourth quarter 1991 well status summary, listing boreholes, monitoring wells and piezometers in which packer and single well tests were conducted.

This appendix presents procedures and results for tests conducted at OU1 during the Phase III RFI/RI field investigation. Section B1.2 of this appendix focuses on the procedures and applications of the packer tests. Section B1.3 discusses the single well slug injection, slug withdrawal, and bail down/recovery tests. Section B1.4 summarizes and compares the results of all tests at each borehole, well, and piezometer. Section B1.5 presents references for literature and software used in the determination of results. Attachment B1-1 presents all supporting raw field data, reduced data, analytical methods, calculations, and results for each test.

B1.2 PACKER TESTS (IN SITU PUMP-IN TESTS)

To collect aquifer parameter data, the OU1 Phase III RFI/RI work plan (EG&G 1991b) required that packer tests be conducted in boreholes drilled for bedrock monitoring well construction. The advantage of using packer tests to estimate aquifer characteristics is that well effects do not influence the resulting estimate as they do in slug tests and bail down/recovery tests performed in cased wells and piezometers. However, disadvantages of packer tests (e.g., lack of development and difficulty in obtaining good packer seals) often offset the advantages of performing such tests.

B1.2.1 General Description

During the field program, packer tests were attempted at four bedrock boreholes to determine in situ hydraulic conductivities using methods provided in the Environmental Management Department Standard Operating Procedure (SOP) for Ground Water (SOP GW.03) (EG&G 1991a). As specified by the sampling requirements in the chemical analysis plan (DOE 1991), bedrock boreholes at OU1 were drilled by auger methods. The packer tests, performed in open boreholes, were designed so that water could be injected at a constant pressure into the test interval. This design reflects equipment performance standards as presented in American Society for Testing and Materials (ASTM) D4630-86 (1987). By analyzing the response of flow rates with time, an estimate of hydraulic conductivity would be determined using an analytical method presented by Jacob and Lohman (1952).

Five boreholes were originally scheduled for constant head packer tests prior to completion of the wells or piezometers. These boreholes were drilled for installation of monitoring wells 37891 (MW27), 37991 (MW29), 39191 (MW28), and piezometers 38991 (PZ03) and 39291 (PZ01). Due to potentially hazardous access during bad weather conditions, packer tests at the borehole for piezometer 38991 (PZ03) were canceled to complete construction of the piezometer as quickly as possible. Of the four remaining boreholes originally designated for packer testing, borehole conditions allowed only one test to be completed within the equipment performance standards. That test, however, was completed in an interval above the water table, which resulted in an estimate of field permeability rather than an estimate of hydraulic conductivity. The conditions that contributed to the inability to collect satisfactory data at 37891 (MW27), 37991 (MW29), and 39291 (PZ01) were borehole collapse, excessive borehole diameters, and rough and irregular borehole walls. In addition, the presence of drilling-induced or natural high-permeability material in the borehole did not permit adequate seals between the test interval and the intervals above the packer.

The following section describes the test methods followed and discusses the factors influencing equipment performance.

The original workplan required the use of a straddle packer (two packer) configuration, but after the first few test attempts it was determined that a single packer configuration would be more successful and yield comparable data for these relatively shallow boreholes. Tests were therefore conducted at each of the four boreholes using the simplest test configuration, a single packer. Based on geophysical logging results, the geologic borehole log and the drill core, two or three intervals were selected as the most favorable to seat the packer in each borehole.

After the interval was selected and the equipment configured, the packer was lowered to the appropriate zone and inflated. Packer inflation pressures up to 200 pounds per square inch (psi) were expected to be sufficient, but the only adequate seal was attained at an inflation pressure of approximately 350 psi. After the packer was inflated and physically seated (i.e., allowed to stand free in the borehole after inflation), the test was initiated by slowly pressurizing the test interval at pressures below anticipated test pressures. The pressures in the test interval and the zone above the test interval were monitored during pressurization. As required by Ground Water SOP GW.03, if pressures increased in both of these zones, the seal was determined to be inadequate. During every test below the water table, in each borehole, the packer seal appeared to be inadequate based on the indication of quickly rising pressure above the packer.

For low-conductivity material, the packer seal is considered critical to accurately determine hydraulic conductivities because very low flow rates are used. Several conditions encountered in the OU1 bedrock boreholes may have precluded an adequate seal: disruption and fracturing of the localized area around the borehole during auger drilling, naturally occurring fractures in the claystone material, and excessive borehole diameters (the packers were designed to seal a 7-inch borehole at 200 psi or less.) During attempts to reseat and seal the packer at other intervals, the borehole wall typically caved in, which made accurate determination of borehole dimensions impossible without relogging. If an adequate seal could not be attained once a well was constructed, single well slug injection, slug withdrawal, or bail down/recovery tests were conducted instead. This action was appropriate, since retrofitting the packer or constructing additional packer equipment would not have necessarily rectified the problem and allowed a successful test under the conditions encountered. Other options (e.g., drilling an offset well) were also not considered feasible.

For the only successful test, conducted in the borehole for monitoring well 39191 (MW28), a packer inflation pressure of approximately 350 psi was used to seat the packer just below the surface casing. An adequate seal was apparently attained, although unsaturated conditions may have merely made the seal appear to be adequate. This is because the unsaturated material "takes" the water pumped into the test interval into void spaces until the material is saturated rather than transmit the pressure elsewhere in the flow system. In this instance, a U.S. Department of the Interior analytical method (1974) was used to estimate field permeability of the tested unsaturated material. Table B1-2 is a summary of the packer test information and results.

B1.2.2 Data Collection Methods

All packer tests were performed according to the chemical analysis plan, applicable SOPs, and ASTM D4630-86, with the exception of the drilling method constraints required by the chemical analysis plan (DOE 1991). After auger drilling a borehole to the specified total depth, geophysical logging was conducted in the borehole using a caliper tool and a natural gamma tool.

The geophysical logs, geologic borehole logs, and core were evaluated to determine favorable intervals within which to conduct the packer test. Initially favorable intervals included the following: below water table zones, sand-bearing zones, distinctly weathered zones and, if possible, unweathered zones. Two or three zones were typically selected for testing in each borehole based on the use of a straddle packer test configuration to isolate the test zone. However, single packer configurations became necessary after initial test attempts resulted in the collapse of the borehole and in the inadequate packer seals. Thereafter, test intervals were selected where borehole diameters were small and integrity was good enough to allow an adequate seal for a valid test.

After the test interval was selected, all of the equipment necessary to conduct the test was transported to the test location. This equipment included the packer, riser pipes, reservoir and nitrogen tanks, rotameter panel, as well as all fittings, gages, and tools necessary to build, operate, and disassemble the packer. Initial water level and total depth measurements were collected with a water level meter and weighted tape. Based on this information, the packer was assembled to appropriate dimensions to perform the test. These dimensions were recorded on the Packer Test Setup Form; test parameters were recorded on the Packer Test Data Form. This information included anticipated test pressures, packer inflation pressure, reservoir water temperature and water level, air temperature, aquifer water temperature (measured from a small volume of bailed water), gages used, transducers used, and borehole dimensions. Attachment B1-1 includes the completed Packer Test Setup and Packer Test Data Forms.

The Hermit SE 2000 data logger (INSITU, Inc. 1990) was programmed so that transducer readings would be collected every minute. All transducer-specific parameters such as scale, offset, linearity, and mode were programmed into the logger for each transducer. The transducers were attached to the data logger and the packer above and within the test interval and referenced to zero while at the surface. The assembled packer was then lowered into the borehole and the riser pipe attached to reach the test depth. Once at depth, a water level was measured to make certain the packer was submerged. If the packer was not submerged, water was slowly added to the borehole through the packer's downhole shut-in valve until the entire packer was submerged. Once submerged, transducers were read and water levels verified against the water level meter. These readings were used to verify the test depth and the appropriate operation of the transducers set above and below the packer.

Next, the packer was slowly inflated to the previously calculated inflation pressure. Once inflated to the appropriate pressure, the packer was checked to verify that it was physically seated by letting it stand freely in the borehole. If it did not stand freely, the inflation pressure was increased by 10 to 20 percent until the packer was physically seated. Once seated, the transducers were read until pressures had stabilized to expected pressures based on new water level readings collected after seating the packer.

When pressures had equilibrated a constant head test was initiated. This was done by pressurizing the reservoir to an initial pressure of about 5 to 10 psi. The rotameter was purged of air bubbles and the initial readings on the rotameter were verified to be zero, which indicated that there were no leaks in the flow system. The logger was started and the downhole shut-in valve opened. After a few seconds the pressure readings from both transducers were checked on the logger. If increases were noted in the upper interval, the packer was inflated another 10 to 20 percent to preclude any leaks. This process continued at pressures below anticipated injection test pressures until an appropriate seal was achieved. If an appropriate seal was achieved, the reservoir pressure and downhole injection pressure was increased to yield the predetermined test pressure and a test was started. If a seal was not attained at less than anticipated test pressures, the test was curtailed and the packer moved to a new test interval. This latter situation was the case at boreholes 37891, 37991, and 39291, which also experienced borehole collapse after an attempt was made to move the packer to a new test interval.

For the test at borehole 39191, a seal was apparently attained at a packer inflation pressure of approximately 350 psi (about twice the calculated inflation pressure). A test was conducted by pressurizing the test interval to roughly 24.8 feet of water head (not more than 0.07 psi per foot above gravity head to the center of the test interval). The transducers were read as continuously as possible and the test pressure maintained by adjusting the appropriate flow meter on the rotameter. Flow data were recorded at 1-minute intervals for the first 10 minutes of the test, and at 5-minute intervals for the remainder of the test. The test was continued for 60 minutes, at which time air bubbles in the most sensitive flow meter started to appear, causing wide fluctuation in flow readings. Best results would typically be achieved for such a test after a period of several hours.

Once the test was completed, all remaining test data were recorded on the Packer Test Data Form. These data include time of test completion, reservoir water temperature, aquifer water temperature, and air temperature. The data logger was shut off, the rotameter shut down, and hoses to the packer disconnected. The packer was removed from the borehole and all downhole parts and tools used were wrapped in plastic for transport to the decon pad for decontamination. Head (pressure) versus time data from the data logger were downloaded to a diskette and printed on the field printer as backup. Copies of all recorded data were also made.

B1.2.3 Data Reduction Methods

Two data files were downloaded from the data logger for each attempted and completed packer test. One file, identified by the extension .DAT, consisted of head versus time data and was produced in a flat ASCII two-column format. The other file, identified by the extension .TST, consisted of programmed test and transducer information, as well as head versus time data. The .TST file format was specific to the data logger and was used to print data in the field.

The .DAT files were loaded into a spreadsheet program that was used to summarize and graph head versus time data to illustrate both the constant head maintained during the test and the flow rates (injection rates). These output were used to calculate parameters for data analysis.

Files were named according to the well or piezometer number and an added suffix of "_1A." For example, data files associated with the packer test at borehole 39191 are designated as 39191_1A.DAT and 39191_1A.TST.

B1.2.4 Data Analysis Methods

Data from the test conducted at 39191 were evaluated using a method presented by the U.S. Department of the Interior (1974) for constant head packer injection tests performed in unsaturated materials. Since this test was performed in unsaturated materials above the water table, this method of data analysis yielded an estimate of field permeability for the materials tested. If tests had been successfully conducted below the water table, the curve-matching technique presented by Jacob and Lohman (1952) would have been used to determine hydraulic conductivities as required by Ground Water SOP GW.03 (EG&G 1991a).

The U.S. Department of the Interior (1974) analytical method is based on an equation that relates borehole geometry and test parameters (e.g., injected flow and the head applied to the test interval) to a field permeability. This equation is presented below:

$$k = \frac{Q}{2 L \pi H} \ln\left(\frac{L}{r}\right) \qquad (1)$$

where:

k = permeability in feet/minute
Q = constant injection flow rate in cubic feet/minute
L = length of test interval in feet
H = total head applied to test interval in feet of water
r = radius of the borehole in the test interval in feet

The flow rate (Q) is the injection rate, as measured on the rotameter panel, minus any identified and quantified leaks. The length of the test interval (L) is obtained from measurements of the packer after inflation and the bottom of the borehole (for the single packer configuration). The total head applied to the test interval (H) is generally determined as the sum of the pressures applied to the test interval throughout the test. For the single packer test configuration used, however, H is taken as the reading on the test interval transducer. Finally the radius of the borehole within the test interval (r) is best determined as an average dimension from the caliper log since borehole diameters varied significantly in OU1 boreholes.

B1.3 SINGLE WELL TESTS

All 14 single well tests conducted during the OU1 Phase III RFI/RI field investigation were performed according to the procedures documented in the OU1 Phase III RFI/RI work plan (EG&G 1991b) and Ground Water SOP GW.04 (EG&G 1991a). Tests were conducted after well development, ground water sampling, and apparent stabilization of the water level (24 to 48 hours after sampling).

B1.3.1 General Description

Slug injection, slug withdrawal, and bail down/recovery tests were performed to estimate horizontal hydraulic conductivities in the vicinity of well and piezometer screens because previously determined hydraulic conductivities for aquifer materials at OU1 were too low to sustain reasonable pumping rates for single well pumping tests. Since water table (unconfined) conditions were exhibited at each well tested, estimates of hydraulic conductivity were obtained from the slug test and bail down/recovery test data using conventional methods presented by Bouwer (1989), Bouwer and Rice (1976), and Hvorslev (1951). These analytical methods yield "order of magnitude" estimates of hydraulic conductivity.

Slug injection and withdrawal tests are most appropriate for those conditions where the water level in the well or piezometer is above the screened interval, whereas bail down/recovery tests are applicable for those conditions where the water level is within the screened interval. To determine the most appropriate testing procedure for each well or piezometer, water levels collected during the fourth quarter of 1991 were evaluated. Water levels were above screened intervals for monitoring wells 31891, 34791, 35691, 37191, and 37891 and for piezometers 38191 and 39291, so procedures for slug injection and withdrawal tests were used in these holes. For wells 36191, 37591, 37791, 37991, 38591 and 39191 and piezometer 38991, bail down/recovery test procedures were used because water levels at these locations were not above the top of the screen. All other wells installed during the Phase III RFI/RI field investigation did not exhibit water levels above or within their screened intervals and, therefore, were not tested.

Table B1-3 lists the wells and piezometer tested along with tested intervals, water levels, lithologies, and the types of tests performed at each location.

B1.3.2 Data Collection Methods

After removing the well or piezometer slip cap, followed by screening and clearance by health and safety personnel, the static water level at the well or piezometer was measured and verified to the nearest one-hundredth of a foot from the measuring point using a previously decontaminated Solinst™ water level meter. The total depth of the well or piezometer was measured and verified using a previously decontaminated weighted tape. The water level and total depth measurements were recorded and compared to well installation, development, and sampling records to confirm that water levels had stabilized. When it was determined that the water level had stabilized, the type of test was selected and the test setup was initiated.

As part of the test setup for either of the slug or bail down test procedures, a transducer (sensitive within the 0 to 10 psi range) was connected to the Hermit SE 2000 data logger. Transducers with this sensitivity can be read by the logger to approximately three thousandths of a foot of head. The data logger was programmed to sample water levels within the well or piezometer in a logarithmic mode so that the sample interval after 100 minutes was 10 minutes. All transducer specifications provided by the manufacturer such as serial number, linearity, scale, and offset were programmed into the data logger. The previously decontaminated transducer was referenced to zero at the surface and lowered to its predetermined depth within the well or piezometer (below the depth at which the bottom of the slug would be during a slug injection test or below the bottom of the screen for a bail down test). Because the transducer and the transducer line displaces water within the well, the water level meter was used to measure the new water level in the well. The transducer reading was then checked against the water level meter reading; the reference level on the data logger was then set to the new water level. Next, the transducer line was secured to the well casing and marked with electrical tape to maintain the referenced depth.

A 10-minute calibration test (pre-run check-out test) was performed in each well or piezometer tested. This test consisted of starting the data logger and moving the transducer up approximately 1 foot once every minute for 5 minutes. After the first 5 minutes, the transducer was moved down 1 foot once every minute for 5 minutes. If the water column in the well or piezometer was less than 5 feet, the transducer was moved down 1 foot once every minute until it reached bottom. After the transducer had reached the bottom of the well it was moved up 1 foot once every minute until it reached the water level. This process was repeated until 10 minutes had elapsed. The water level meter was used to measure water levels from the measuring point and verify the transducer readings. The well test was begun only after these calibration results were reviewed and the data logger and transducer were determined to be functioning properly.

For the slug injection test, a previously decontaminated 4-foot-long by 1.625-inch-diameter stainless steel slug was attached to an appropriate length of unused or previously decontaminated nylon rope. A strip of electrical tape was attached to the rope at a location that ensured that the slug would hang just above the water in the well. Another strip of tape was attached to the rope at a location measured to ensure full submersion of the slug as close to 2 feet below the water as well conditions permitted. The slug was lowered into the well until the first tape marker lined up with the top of the casing. The rope was tied off to secure the slug in a position above the water in the well or piezometer. The data logger was then set up for another test with the same programmed variables as the previous 10-minute test. Water levels were re-verified using the water level meter and the transducer referenced, if necessary, to the new water level. With all equipment in place and the data logger and transducer operating properly, the logger was started and the slug lowered as smoothly as possible to its position marked by the second piece of tape on the rope. Once the slug was in place, the rope was tied off at the top to secure the position of the slug in the well. The data logger was read periodically as it recorded data during the test.

Readings were checked against readings collected periodically with the water level meter to verify that all equipment was functioning properly. The start time and initial test displacement were also recorded.

Once water levels had recovered to within 10 percent of the static water level measured prior to the slug injection or when 48 hours had elapsed, the slug injection test was terminated. The water level versus time data from the data logger were reviewed. Data collection was terminated by stopping the test on the data logger, and a new test was then programmed into the data logger with all programmed variables the same as the injection test. This new test was set up for the slug withdrawal. Although not specifically outlined in the SOPs, this test was performed to provide additional data to verify the slug injection test results.

After programming the new test on the data logger, the data logger was started as the slug was smoothly removed from the well. As with the slug injection test, water levels were periodically measured with the water level meter and verified against the readings of the data logger. The slug withdrawal test was terminated when water levels returned to within 10 percent of the static water levels recorded prior to the test or when 48 hours had elapsed, whichever came first.

The same setup procedures used for the slug injection/slug withdrawal tests were used for the bail down/recovery tests. Once the test was set up and a calibration test performed, a previously decontaminated 3-foot-long by 1.5-inch-diameter stainless steel bailer was attached to unused or previously decontaminated nylon rope. The bailer was used to bail water out of the well until a water level was at or slightly below the bottom of the screened interval of the well or piezometer. Bailed water was containerized for disposal. When the appropriate water level was achieved, the data logger was started. The hydrogeologist monitored the water level recovery by reading the logger and the water level meter. Bailing rates and initial displacement were recorded and recovery allowed to continue until water levels had recovered to within 10 percent of the static water level measured prior to the bailing or when 48 hours had elapsed, whichever occurred first.

For slug injection/slug withdrawal, or bail down/recovery tests that continued for more than 2 or 3 hours, water level recovery was recorded automatically by the data logger. The well head was secured and marked to allow the test to continue without the hydrogeologist present. Periodically, the hydrogeologist returned to read the data logger until the test was complete.

After each test, all down-hole equipment (slug, rope, bailer, transducers, and water level meter) was decontaminated or disposed. Once a test was completed, data files were printed out on the field printer and data files downloaded from the data logger.

B1.3.3 Data Reduction Methods

Two data files were downloaded from the data logger for each test; a file designated by its extension ".DAT" and a file designated by the extension ".TST". The ".DAT" file consists of time versus water level data and is in an flat ASCII two column format. The ".TST" file is in a format specific to the data logger and consists of the programmed information for the test and transducer as well as the time versus water level data.

Files were given a time-sequential suffix, depending on the type of test performed. Files associated with the initial 10-minute calibration test were named according to the well (MW) or piezometer (PZ) number with an added suffix "_1A". Slug injection test files were named according to the well or piezometer number and an added suffix "_1B," and slug withdrawal tests were named according to the well number followed and an added suffix "_1C". Bail down recovery test files were named according to the well number and an added suffix "_1B".

For example, data files associated with a slug injection/slug withdrawal test at well 31891 (MW02) are designated as follows:

MW02_1A.DAT, MW02_1A.TST	Ten-minute calibration test data
MW02_1B.DAT, MW02_1B.TST	Slug injection test data
MW02_1C.DAT, MW02_1C.TST	Slug withdrawal test data

The following data files are associated with the bail down/recovery test at 36191 (MW05):

MW05_1A.DAT, MW05_1A.TST	Ten-minute calibration test data
MW05_1B.DAT, MW05_1B.TST	Bail down recovery test data

The ".TST" files were printed out in the field, while the ".DAT" files were loaded into a computerized spreadsheet that summarizes the data in a format comparable to the Slug Test Data Form (Form No. GW.4A). The spreadsheet program was also used to graph the excess head versus time data to illustrate the water level recovery response in the well or piezometer. The data contained in these spreadsheets were used to estimate hydraulic conductivities.

B1.3.4 Data Analysis Methods

Two methods of data analysis were used to estimate hydraulic conductivities, the Bouwer and Rice method and the Hvorslev method.

The Bouwer and Rice analytical method introduces less error than other methods, such as the Hvorslev method. Estimates of error based on comparison between different methods of hydraulic conductivity estimation indicate error of up to 30 percent for Bouwer and Rice (Kruseman and deRidder 1991). This error is based on error in determining unitless parameters derived from the electrical models that allow the Theim equation to be solved.

Estimates of potential error in the Hvorslev method can exceed 50 percent (Bouwer and Rice 1976). Most error in using the Hvorslev method is due to application (or inappropriateness) of general assumptions (e.g., the infinite vertical extent of the borehole). Although both estimation methods are presented, it is recommended that the Hvorslev estimates be used as approximations to verify Bouwer and Rice estimates in cases where the Hvorslev method can be applied.

B1.3.4.1 Bouwer and Rice Method

The primary method used to estimate hydraulic conductivity values for the slug injection/slug withdrawal and bail down/recovery tests was the method presented by Bouwer and Rice (1976).

This method yields an "order of magnitude" estimate of hydraulic conductivity, and was developed specifically for slug withdrawal tests for wells and piezometers of specified geometries from the Theim equation (Kruseman and deRidder 1991). According to an update on the methodology (Bouwer 1989), this method is also applicable to slug injection tests if the static water level in the well is above the screened interval and water table conditions prevail. The Bouwer and Rice method can easily be adapted for fully and partially penetrating conditions.

Assumptions for the appropriate use of the Bouwer and Rice method are best summarized by Kruseman and deRidder (1991). The assumptions include standard Theim equation assumptions, which require the aquifer to be unconfined, infinite in areal extent, homogeneous, isotropic, and of uniform thickness; the water table is also assumed to be horizontal in the vicinity of the test well. Additional assumptions include the following: the head in the well is changed instantaneously at the start of the test, the well diameter is assumed to be finite, and flow to the well is under steady state conditions.

The Bouwer and Rice equation, which requires well geometries similar to those for wells installed at OU1, determines hydraulic conductivity (K) as follows:

$$K = \frac{r_c^2 \ln (R_e/r_w)}{2\,L_e} \frac{1}{t} \ln (y_0/y_t) \qquad (2)$$

where:

r_c	=	radius of casing or riser pipe where the head is rising (or falling)
r_w	=	horizontal distance to the undisturbed aquifer (bore hole radius)
R_e	=	effective radial distance over which the head is dissipated
L_e	=	length of open section (screen)
y_0	=	head at time t_0 (start of test)
y_t	=	head at time t ($t>t_0$)
t	=	time

The parameters r_w and L_e were determined from the well construction geometry. For slug injection/withdrawal tests and bail down/recovery tests, the radius of the well (r_w) was taken as the radius of the borehole. L_e was taken as the vertical length between the top slot and bottom slot of the slotted-screen section of polyvinyl chloride (PVC). If the top and bottom slot depths were not identified on the well construction diagram, 0.4 feet was subtracted from the screen length to compensate for the unslotted portion of the screen at the top and bottom of the PVC section. For bail down/recovery tests, L_e was taken as the length of saturated screen interval to the bottom slot of the screen.

In general, the parameter r_c was taken as the radius of the screen when the screen was fully saturated. This was the case for wells subjected to slug injection and withdrawal tests. For bail down/recovery tests, r_c was taken as an effective radius of the screen. An adjustment was made to the value used for the casing radius (r_c) to compensate for the relatively large, more permeable sand pack around the well screen. The sand pack drains at a faster rate than the surrounding aquifer during a withdrawal or bail down recovery test because the sand pack and screen are not fully saturated. The effective screen radius was calculated based on the equation presented by Bouwer (1989) with an estimated sand pack porosity of 30 percent. The 30 percent sand pack porosity is based on well development assumptions rather than the reported laboratory permeability of 38 to 45 percent for the 16-40 gradation sand because the laboratory permeability of this material is expected to decrease when mixed with the fine-grained native materials around the borehole.

The parameters y_0, t, and y_t were obtained from semi-logarithmic plots of excess head or displaced head (h) (on the logarithmic scale) versus time (t) (on the linear scale). A straight line was fitted through the plotted points and y_0 was read as the y intercept. Parameters y_t and t were read at a convenient point along the straight line through the plotted points. With these parameters determined, a value of $(1/t) \ln (y_0/y_t)$ was evaluated.

Bouwer (1989) indicates that in some cases, the displacement versus time graph illustrates an initially steep straight line response followed by a less steep straight line. This second straight line is more indicative of aquifer conditions because the first straight line represents the relatively quick draining of the sand pack or most developed zone around the well. This effect was apparent for all bail down/recovery tests except for the test in well 39191 (MW28). Therefore, the straight line was fitted through the second definitive straight line for all bail down/recovery test data except for test data from well 39191 (MW28). For all bail down/recovery tests, the parameter r_c was also adjusted to yield an effective radius dimension as described above.

To determine R_e, empirical equations developed from electrical analog flow models were used (Bouwer and Rice 1976). These equations allow for analysis of test data from partially and fully penetrating wells. Equation (3) was used for determination of $\ln(R_e/r_w)$ under fully penetrating conditions and Equation (4) was used for partially penetrating conditions.

$$\ln \frac{R_e}{r_w} = \left[\frac{1.1}{\ln (L_w / r_w)} + \frac{C}{L_e / r_w} \right]^{-1} \tag{3}$$

$$\ln \frac{R_e}{r_w} = \left[\frac{1.1}{\ln (L_w / r_w)} + \frac{A + B \ln [(H-L_w)/r_w]}{L_e / r_w} \right]^{-1} \tag{4}$$

where:

R_e	=	effective radial distance over which the head is dissipated
r_w	=	horizontal distance to undisturbed aquifer (borehole radius)
L_w	=	depth to bottom of screen below water table
L_e	=	length of open section (screen)
A,B,C	=	dimensionless parameters

For each of these equations, L_w is the depth below the water table of the bottom of the intake or screened section of the well. The parameter H represents the depth from the water table to the base of the water table aquifer. For Equation (3), L_w equals H, and represents fully penetrating conditions. Equation (4) was used for partially penetrating wells where L_w is less than H. Parameters A, B, and C are dimensionless and are determined graphically from empirical curves developed by Bouwer and Rice (1976).

For wells screened in surficial materials (i.e., Rocky Flats Alluvium, colluvium, and Woman Creek valley fill alluvium), screens were installed at or partially penetrating the bedrock contact and are therefore considered to fully penetrate surficial materials. For these wells, L_w and H are equal and values were taken as the interval from the static water level to the bottom slot of the well screen. For wells installed in bedrock materials, partially penetrating conditions prevail since the bedrock aquifer is expected to be at least 100 feet or more in depth. However, because of the extremely low permeabilities exhibited by previously tested bedrock wells and the relatively small displacement achieved during these slug tests, significant aquifer effects are not expected below the depth of bottom of the borehole. Therefore, for bedrock wells, L_w was taken as the interval from the static water level to the bottom slot of screen, while H was taken as the interval from the static water level to the bottom of the sand pack.

Using graphical methods to solve for $1/t \ln(y_0/y_t)$ and $\ln(R_e/r_w)$, Equation (3) and (4) were solved manually for K. This manual procedure was used to determine an initial value for each test, although a computer program was used to generate the final estimate presented for each test.

To reduce possible calculation errors and assist with data management, processing, and presentation, the AQTESOLV computer program was used to estimate hydraulic conductivities for slug injection/slug withdrawal, and bail down/recovery tests. AQTESOLV has a module specifically designed to accommodate data management, evaluation, and presentation of slug test data analyzed using the Bouwer and Rice method (Geraghty and Miller 1989, updated 1991). Although the program can automatically calculate hydraulic conductivity values using well geometry input values and iterative numerical methods to perform curve fitting, this automation is most effective on ideal time versus displacement data sets. Because most of the OU1 data are not ideal, the automated, curve-fitting aspect of AQTESOLV was not used. Instead, hydraulic conductivity values were calculated with the user-assisted visual curve fitting application of the AQTESOLV program after well geometry parameters were input. Output values and plots prepared in this manner compared favorably to calculations and plots generated manually.

Table B1-4 summarizes all inputs for running the Bouwer and Rice hydraulic conductivity analysis used in the AQTESOLV program, and Table B1-5 presents the intermediate parameters and output values. Output summaries and plots generated by AQTESOLV are included in Attachment B1-1 and illustrate input values, output values, and the visual curve fit used during analysis. Parameter names presented above for the Bouwer and Rice equations (Equations 3 and 4) differ slightly from those used and presented as output by AQTESOLV. The following is a list of parameters as used by Bouwer and Rice (1976) and the AQTESOLV program and their corresponding definitions.

Parameter Descriptions	Bouwer and Rice Parameters	AQTESOLV Parameters
Screen length	L_e	L
Static water level in well (above bottom of screen)	L_w	H
Aquifer saturated thickness	H	b
Initial displacement (read as y intercept after curve fitting)	y_0	y_0
Radius of casing	r_c	r_c
Radius of well	r_w	r_w

B1.3.4.2 Hvorslev Method

The Hvorslev method of evaluating slug injection or withdrawal data was used as a secondary method to estimate hydraulic conductivity of the aquifer materials around each tested well or piezometer. This method is described in detail in the original paper (Hvorslev 1951) and in numerous hydrogeological text books such as Fetter (1988), Freeze and Cherry (1979), and

Cedergren (1967). Due to testing and analytical approach limitations, this method yields an "order of magnitude" approximation of hydraulic conductivity around a tested well or piezometer, and is considered valid for specific well or piezometer geometries (Kraemer et al. 1990) if the qualifying test assumptions are met. Sevee (1991) points out that "the lack of conceptual rigor limits the accuracy of this method." Therefore, estimates determined using the Hvorslev method were used for general validation of the estimates determined using the more rigorous Bouwer and Rice method. For example, the Hvorslev analysis method requires that the intake portion of the tested well (i.e., sand pack and screen) is below the water table. This prerequisite limited the applicability of this estimation method at all but three wells and piezometers tested at OU1 during the Phase III RFI/RI program.

The derivation of the Hvorslev equation used to estimate hydraulic conductivity includes the following assumptions: the material tested is assumed to be homogeneous, isotropic and infinite in extent; the water and soil are incompressible; the water table around the well is not influenced by the test; and the intake is a cylinder of infinite vertical extent. For alluvial wells at OU1, the relatively less permeable bedrock zone directly below the screen was not expected to satisfy the assumption of an intake of infinite vertical extent and therefore the Hvorslev equation results in erroneously low conductivity estimates.

In general, the geometry of the wells and piezometers installed at OU1 correspond to that presented by Hvorslev as a well point filter in uniform soil. The major difference is the presence of the sediment sump in OU1 wells. However, the sump does not introduce significant error in the determination of hydraulic conductivities at OU1 wells and piezometers since the Hvorslev method can accommodate adjustment of the sand pack length parameter (i.e., intake length).

Based on the above assumptions, Hvorslev-derived formulas can be used to estimate hydraulic conductivity for wells or piezometers under water table conditions. Equation (5) is an adaptation of the Hvorslev formula for well geometries where the length of the screen is at least eight times the radius of the well (L/R>8). This formula was used for estimating hydraulic conductivities at three wells, which meets the qualifying assumptions required by the Hvorslev method:

$$K = \frac{r^2 \ln (L/R)}{2\ L\ T_0} \tag{5}$$

where:

r	=	radius of casing in borehole
L	=	length of intake
R	=	radius of intake
T_0	=	basic lag time

All parameters except T_0 were obtained from the well construction and installation records reflecting the geometry of the tested well or piezometer. Values of r, R, and L were assigned values analogous to those used in the Bouwer and Rice analysis so results from the two analytical methods could be compared effectively. The parameter (r), radius of casing, was taken as the radius of the PVC casing and is analogous to the parameter (r_c) used in the Bouwer and Rice method. The radius of the intake (R) was taken as the radius of the borehole and is analogous to the parameter (R_w) used in the Bouwer and Rice method. The value for the length of the intake was analogous to the length of the screened interval (L_e) used in the Bouwer and Rice method and represents the distance from the top slot to the bottom slot of screened section of PVC in the well.

T_0 is the basic time lag or time required for the water level to completely equilibrate after water is injected or withdrawn, assuming that the original rate of outflow or inflow was maintained. The basic time lag is derived graphically from a semilogarithmic plot of excess head divided by initial head (H/H_0) of the test (on the logarithmetic scale) versus time (on the linear scale). As done with other parameters used in the Hvorslev analysis method, the initial head H_o was taken as an analogous value presented as y_o or initial displacement in the Bouwer and Rice analysis. For an ideal aquifer response, a straight line is fitted through the plotted data so that the line extends from the point where H/H_0 equals 1.0 (100 percent) and time (t) equals 0 through the remaining data points. T_0 is read from the graph at the point on the time axis where H/H_0 equals 0.37 (see H/H_0 versus time plots in Attachment B1-1 for examples). For plots that did not exhibit a distinct straight line, the data was adjusted so that the line passed "through the origin [H/H_0 = 1.0 and t = 0] of the diagram and parallel to the lower [straight line] portions of the diagram (Hvorslev 1951)."

Table B1-6 is a summary of all parameters used for each test in estimating hydraulic conductivities using the Hvorslev method. This table also illustrates that conditions at only three wells allowed the valid use of the Hvorslev method. Attachment B1-1 contains tables of displacement and time data, graphs of H/H_0 versus time used to calculate T_0, and calculations showing parameters and resulting conductivity estimates for well tests that were analyzed using the Hvorslev method.

B1.4 RESULTS

This section presents a summary of results from aquifer parameter tests for the OU1 Phase III RFI/RI field investigation. Summaries of tests conducted at each borehole, well, or piezometer are presented to illustrate the significance of the results. Subsequent discussion includes an overall summary of results in which test and analytical methods are evaluated by comparing results obtained during this investigation and previous investigations.

B1.4.1 Location-Specific Test Summary

31891 (MW02)

Monitoring well 31891 (MW02) is located along the southern berm of the South Interceptor Ditch downgradient of Individual Hazardous Substance Site (IHSS) 102. According to the well construction diagram (Appendix A1), the well is screened at a depth of 16.6 to 18.6 feet below ground surface and the sand pack ranges from 14.6 to 19.0 feet below ground surface. Based on the borehole log (Appendix A1), the screened interval consists of colluvial sandy clay and bedrock clayey sandstone that is bounded below by bedrock claystone at 18.6 feet. The water level prior to testing was 15.51 feet below ground surface and indicates water table conditions at the time of the test. Hydraulic conductivity estimates derived using the Bouwer and Rice method for the slug injection and withdrawal tests yield the same value of 2×10^{-4} centimeters/second (cm/sec) (4×10^{-4} feet/minute [ft/min]) (Table B1-5). A valid estimate using the Hvorslev method could not be determined since the water level was within the sand pack interval.

The hydraulic conductivity estimates are within the range of values for bedrock sandstones at OU1 determined during previous investigations. However, the values presented for well 31891 (MW02) appear to represent the high portion of this range. This is most likely due to the degree of weathering of this shallow sand zone and the presence of overlying colluvial material tested in conjunction with the bedrock sand zone. All estimates fall within general hydraulic conductivity range for silty sand presented by Freeze and Cherry (1979) and are within the range for silty sand and fine sand presented by Fetter (1980).

34791 (MW13)

Monitoring well 34791 (MW13) is located along the southeastern border of IHSS 119.2. According to the well construction diagram (Appendix A1), the well is screened at a depth of 6.0 to 8.0 feet below ground surface and the sand pack ranges from 5.9 to 9.5 feet below ground surface. Based on the borehole log (Appendix A1), the screened interval consists of colluvial silty, sandy gravel that is bounded below by bedrock claystone at 8.0 feet. The water level prior to testing was 2.44 feet below ground surface and indicates water table conditions at the time of the test. Hydraulic conductivity estimates range from 6×10^{-6} to 1×10^{-5} cm/sec (1×10^{-5} to 2×10^{-5} ft/min), derived using the Bouwer and Rice method for the slug injection and withdrawal tests, respectively (Table B1-5). Estimates could not be obtained using the Hvorslev method since $L/R < 8$.

The slug withdrawal test estimate is approximately 50 percent lower than the slug injection test estimate. This most likely results from elevation of the localized water table in the vicinity of the well such that the unsaturated sand pack becomes saturated relatively quickly during the injection test. Alternatively, inadequacies in well construction may result in void spaces in the sand pack, well seal, and the localized area around the borehole that rapidly fill with water during the slug injection. This is exhibited in the steep initial slope of the drawdown versus time plot for this test. The slug withdrawal test plot does not exhibit this tendency.

Both estimates fall within general hydraulic conductivity ranges for colluvial materials at OU1 determined during previous investigations and within ranges for silty sand presented by Freeze and Cherry (1979). These estimates are also within the range for silt, sandy silts, and clayey sand presented by Fetter (1980).

35691 (MW17)

Monitoring well 35691 (MW17) is located south of Building 881, east of IHSS 107. According to the well construction diagram (Appendix A1), the well is screened at a depth of 15.6 to 26.6 feet below ground surface and the sand pack ranges from 13.4 to 30.3 feet below ground surface. Based on the well construction diagram and borehole log (Appendix A1), the screened interval consists of disturbed colluvial silty clay with some sand, gravelly sandy clay, and clayey gravel. This mixture of materials may result from construction activities in the area since the well is located on a berm. Below 25.2 feet is weathered bedrock claystone. The water level prior to testing was 9.34 feet below ground surface and indicates water table conditions at the time of the test. Hydraulic conductivity estimates derived using the Bouwer and Rice method result in values of 1×10^{-6} cm/sec (2×10^{-6} ft/min) and 9×10^{-7} cm/sec (2×10^{-6} ft/min) for the slug injection test and slug withdrawal test, respectively (Table B1-5). Estimates derived using the Hvorslev method result in hydraulic conductivity estimates of 8×10^{-7} cm/sec (2×10^{-6} ft/min) and 6×10^{-7} cm/sec (1 x 10 ft/min) for the slug injection and withdrawal tests, respectively (Table B1-6).

For both analytical methods, estimates for the injection and withdrawal tests are approximately the same; however, the estimates derived using the Hvorslev method are slightly lower than those determined using the Bouwer and Rice analytical method. All estimates seem low compared to estimates for colluvial materials from previously conducted investigations at OU1. Estimates are within the range for clay presented by Fetter (1980) and within the range for silt presented by Freeze and Cherry (1979), but the presence of sands and gravel within the test interval indicate that hydraulic conductivities should be higher.

The low estimates may be due to ineffective well development, low-permeability skin effects, or emplacement and compaction of non-native materials during construction of Building 881 and roads in the vicinity of the well. Also, water levels at this well indicate that the colluvial aquifer is recharged by water from the nearby skimming pond in IHSS 107. The water table near this well may be more steeply sloped in this area than in the vicinity of other tested wells. The slope in the water table limits the directions which water moves into or out of the well and may reduce estimates derived using either the Hvorslev or the Bouwer and Rice analytical method.

36191 (MW05)

Monitoring well 36191 (MW05) is located east of Building 881, outside the fence and downgradient of IHSS 103. According to the well construction diagram (Appendix A1), the well is screened at a depth of 9.5 to 14.6 feet below ground surface and the sand pack ranges from 7.4 to 14.9 feet below ground surface. Based on the borehole log (Appendix A1), the screened interval consists of a colluvial, well-graded gravelly sand with a 0.6-foot layer of clay from 12.2 to 12.8 feet below ground surface. Below 14.0 feet is bedrock claystone. The water level prior to testing was 11.94 feet below ground surface and indicates water table conditions at the time of the test. Hydraulic conductivity estimates derived using the Bouwer and Rice method for the bail down/recovery test yield a value of 1 x 10^{-6} cm/sec (2 x 10^{-6} ft/min) (Table B1-5). A valid estimate could not be obtained using the Hvorslev method since the water level was not above the sand pack interval.

The Bouwer and Rice estimate required a correction to r_c and a curve match on the second distinct straight line of the displacement versus time plot to accommodate the fast draining sand pack. This estimate seems low compared to other estimates for colluvial materials from previously conducted investigations at OU1. The results for well 36191 (MW05) also appear low for the types of materials tested compared to ranges presented by Fetter (1980) and Freeze and Cherry (1979). This may be due to the small amount of head displacement applied during the test, less extensive well development, or low-permeability skin effects. Alternatively, near-surface materials may have been compacted during construction of Building 881 and the roads in the vicinity of the well, reducing hydraulic conductivities in the localized area surrounding the well. Also, because this well is located near an identified surface seep or alluvial recharge area, the water table may be more steeply sloped than in the vicinity of other colluvial wells. This steeply sloped water table could be responsible for the low values of hydraulic conductivity estimated at this well.

37191 (MW16)

Monitoring well 37191 (MW16) is located along the southeastern boundary of IHSS 130. According to the well construction diagram (Appendix A1), the well is screened at a depth of 11.1 to 21.1 feet below ground surface and the sand pack ranges from 9.2 to 22.0 feet below ground surface. Based on the borehole log (Appendix A1), the screened interval consists of colluvial gravelly sandy clay and is bounded below by bedrock claystone at 20.6 feet. The water level prior to testing was 7.13 feet below ground surface and indicates water table conditions at the time of the test. Hydraulic conductivity estimates derived using the Bouwer and Rice method for slug injection and withdrawal tests yield values of 1×10^{-4} cm/sec (2×10^{-4} ft/min) and 4×10^{-5} cm/sec (8×10^{-5} ft/min) for the slug injection and slug withdrawal tests, respectively (Table B1-5). Estimates derived using the Hvorslev method indicate hydraulic conductivities of 1×10^{-4} cm/sec (2×10^{-4} ft/min) and 5×10^{-5} cm/sec (1×10^{-4} ft/min) for the slug injection and withdrawal tests, respectively (Table B1-6).

The agreement between the results derived from the two methods is very good, although the results of the slug withdrawal test are approximately 50 percent of those of the injection test. This difference arises from faster recovery during the slug injection test than during the slug withdrawal test. The faster recovery most likely resulted from localized elevation of the water table in the vicinity of the well such that the capillary fringe above the water table became saturated relatively quickly during the injection test. Alternatively, inadequacies in well construction may result in void spaces in the sand pack, well seal, or the localized area surrounding the borehole that rapidly filled with water during the slug injection. It should also be noted that during the slug withdrawal test the slower response may be due to the water level being displaced to a level below the sand pack. This results in slower recovery while the water level rises to fully resaturate the sand pack.

All estimates fall within general hydraulic conductivity ranges for silty sand presented by Freeze and Cherry (1979) and for silt, sandy silts, and clayey sands presented by Fetter (1980). Also, all estimates are within the range presented for alluvial and colluvial materials obtained during previous OU1 investigations.

37591 (MW22)

Monitoring well 37591 (MW22) is located in the contractor yard north of OU1 and east of Building 881. According to the well construction diagram (Appendix A1), the well is screened at a depth of 7.6 to 12.6 feet below ground surface and the sand pack ranges from 5.6 to 14.6 feet below ground surface. Based on the borehole log (Appendix A1), the screened interval consists of an alluvial gravel-sand-clay mixture in the Rocky Flats Alluvium. Below 12.0 feet is bedrock claystone. The water level prior to testing was 11.19 feet (3.41 meters) below ground surface and indicates water table conditions at the time of the test. Hydraulic conductivity estimated using the Bouwer and Rice method for the bail down/recovery test yielded a value of 7×10^{-6} cm/sec (1×10^{-5} ft/min) (Table B1-5). A valid estimate using the Hvorslev method could not be obtained since the water level was within the sand pack interval.

The Bouwer and Rice estimate required a correction to r_c and a curve match on the second distinct straight line of the displacement versus time plot to accommodate the fast-draining sand pack.

Since well tests have not been conducted in RFP alluvial materials in the vicinity of OU1 prior to this investigation, no comparative values of hydraulic conductivity exist from previous investigations. However, the estimated value appears low for the types of materials tested compared to values presented by Fetter (1980) and Freeze and Cherry (1979). This may be due to the small amount of head displacement applied during the test and/or insufficient well development. Alternatively, near-surface materials may have been compacted during construction and heavy usage of the contractor's yard. The well recovered to a level 0.3 feet above the static water level measured before the bail down/recovery test. This indicates that the initial static water level measurement may have been inaccurate, that the well may not have fully recovered after sampling, or that the water table was rising since heavy snows occurred roughly one week before the test was conducted.

37791 (MW21)

Monitoring well 37791 (MW21) is located near the northwestern corner of Building 881. According to the well construction diagram (Appendix A1), the well is screened at a depth of 10.6 to 20.6 feet below ground surface and the sand pack ranges from 8.8 to 22.6 feet below ground surface. Based on the borehole log (Appendix A1), the screened interval consists of colluvial clay with varying amounts of silt, sand, and gravel in the Woman Creek valley fill alluvium. Bedrock claystone is at 20.0 feet. The water level prior to testing was 20.01 feet below ground surface and indicates water table conditions at the time of the test. Due to limited access to the well and discrepancies in reported water levels, a test was conducted in spite of low observed water levels. Although a bail down/recovery test was performed, estimates of hydraulic conductivity could not be reliably obtained. For the Bouwer and Rice method, $\ln(R_e/r_w)$ values were negative, indicating that water level displacement was not sufficient to allow estimation of hydraulic conductivity. It is recommended that bail down tests be performed in this well when there is at least 3.6 feet of water in the monitoring well.

37891 (MW27)

Monitoring well 37891 (MW27) is located along the southern boundary of IHSS 119.1. Packer tests were attempted in the borehole drilled for this well (Table B1-2). The borehole collapsed prior to the first test and had to be reamed. After reaming, the packer was set up at depth to test the interval from 37.2 to 56.3 feet (the top of the water table). An effective seal could not be attained. The packer was then moved to test the interval from 29.2 to 57.0 feet and again an adequate seal could not be attained. The borehole collapsed again, and no further packer tests were attempted. A single well slug test was recommended after the well was completed in this borehole.

According to the well construction diagram (Appendix A1), the well is screened at a depth of 43.2 to 53.2 feet below ground surface and the sand pack ranges from 40.0 to 55.2 feet below ground surface. Based on the borehole log (Appendix A1), the screened interval consists of weathered bedrock silty claystone, clayey siltstone, and siltstone with clay and trace sand. The water level prior to testing was 41.90 feet below ground surface and indicates water table conditions at the time of the test. Hydraulic conductivity estimates derived using the Bouwer and Rice method yield values of 5×10^{-7} cm/sec (1×10^{-6} ft/min) and 1×10^{-6} cm/sec (3×10^{-6} ft/min) for the slug injection and slug withdrawal tests, respectively (Table B1-5). A valid estimate could not be obtained using the Hvorslev method since the water level was not above the sand pack interval.

The estimate for the slug injection test is approximately 50 percent lower than that for the slug withdrawal test. This is the only slug injection/slug withdrawal test for which the results for the injection test are less than the results for the withdrawal test. This may be because the recovery of the injection test was less than the static water level prior to the test, indicating that the water level in the well may not have been equilibrated since sampling. Alternatively, the well may have been better developed by the surging effect of the slug injection. Regardless, the results obtained are consistent with those of previously performed tests in the weathered bedrock at OU1 and the determined values fall within the high portion of the general conductivity range for unweathered marine clay presented by Freeze and Cherry (1979). These estimates also fall within the general range for clay as presented by Fetter (1980).

37991 (MW29)

Monitoring well 37991 (MW29) is located in the western section of IHSS 119.1. Packer tests were attempted at the borehole drilled for this monitoring well even though the borehole was dry (Table B1-2). The first test was set up to test the interval from 42.1 to 51.9 feet. For this interval, an adequate seal was not attained and the packer was moved to another interval. During the movement of the packer, the borehole collapsed and had to be reamed. A second test was set up at the interval from 42.1 to 57.5 feet. Again, an adequate seal was not attained. A single well test was recommended if the subsequently installed monitoring well had adequate water levels.

According to the well construction diagram (Appendix A1), the well is screened at a depth of 45.2 to 55.2 feet below ground surface and the sand pack ranges from 43.0 to 57.2 feet below ground surface. Based on the borehole log (Appendix A1), the screened interval consists of weathered bedrock claystone, clayey siltstone, sandy clayey siltstone, and silty claystone. The water level prior to testing was 48.78 feet below ground surface and indicates that the sandy clayey siltstone and silty claystone were saturated under water table conditions at the time of the test. Hydraulic conductivity estimated using the Bouwer and Rice method for the bail down/recovery test yield a value of 7×10^{-6} cm/sec (1×10^{-5} ft/min) (Table B1-5). A valid estimate using the Hvorslev method could not be obtained since the water level was not above the sand pack interval.

The Bouwer and Rice estimate required a correction to r_c and a curve match was made on the second distinct straight line on the displacement versus time plot to accommodate for the fast-draining sand pack.

The estimate obtained is within the range of conductivity values presented for weathered claystone during previous investigations. The estimate is also within the range of hydraulic conductivities for silt as presented by Freeze and Cherry (1979) and the range for clay and silt as presented by Fetter (1980).

38191 (PZ05)

Piezometer 38191 (PZ05) is located near the southern border of IHSS 119.1. According to the well construction diagram (Appendix A1), the piezometer is screened at a depth of 10.0 to 15.0 feet below ground surface and the sand pack ranges from 8.1 to 14.9 feet below ground surface. Based on the borehole log (Appendix A1), the screened interval consists of colluvial sand-silt-clay mixture with gravel and silty gravelly sand. Weathered bedrock claystone is located below at 14.7 feet. The water level prior to testing was 9.38 feet below ground surface and indicates water table conditions at the time of the test. Hydraulic conductivity estimates derived using the Bouwer and Rice method yield values of 1 x 10^{-5} cm/sec (2 x 10^{-5} ft/min) and 2 x 10^{-6} cm/sec (4 x 10^{-6} ft/min) for the slug injection and slug withdrawal tests, respectively (Table B1-5). A valid estimate could not be obtained using the Hvorslev method since the water level was not above the sand pack interval.

The results of the slug injection test are approximately ten times greater than those of the withdrawal test. This difference arises from faster recovery during the slug injection test than during the slug withdrawal test. The faster recovery most likely results from localized elevation of the water table in the vicinity of the well such that unsaturated sandpack becomes saturated relatively quickly during the injection test. Also, the displacement versus time plots of the slug injection test indicate that full recovery after the slug injection was not achieved, and that the well may not have fully stabilized after sampling or that the water table was rising during the injection test.

The results are consistent with those of tests conducted in colluvial materials during the OU1 Phase III RFI/RI field investigation, but are slightly low compared to results of tests previously performed in colluvial wells at OU1. This may have occurred because development of piezometers is not as extensive as development of sampled wells, or because the static water level was not accurately determined before the slug was withdrawn for the slug withdrawal test. However, the estimated values are in the general range for hydraulic conductivities for silt and silty sand presented by Freeze and Cherry (1979) and for clay and silt, silty sand, and clayey sand presented by Fetter (1980).

38591 (MW34)

Monitoring well 38591 (MW34) is located in the southern portion of OU1, on the northern bank of Woman Creek. According to the well construction diagram (Appendix A1), the well is screened at a depth of 5.7 to 7.7 feet below ground surface and the sand pack ranges from 5.0 to 8.0 feet below ground surface. Based on the borehole log (Appendix A1), the screened interval consists of alluvial silty sand with clay and gravel in the Woman Creek valley fill alluvium. Below 7.3 feet is weathered bedrock claystone. The water level prior to testing was 6.50 feet below ground surface and indicates water table conditions at the time of the test. Hydraulic conductivity estimated using the Bouwer and Rice method for the bail down/recovery test yield a value of 4×10^{-4} cm/sec (7×10^{-4} ft/min) (Table B1-5). A valid estimate could not be obtained using the Hvorslev method since the water level was not above the sand pack interval.

The Bouwer and Rice estimate required a correction to r_c and a curve match on the second distinct straight line of the displacement versus time plot to accommodate the fast-draining sand pack.

The result is within the range of hydraulic conductivity values presented for Woman Creek valley fill alluvium obtained during previous investigations. The estimate is also within the general ranges for clean sands and silty sands presented by Freeze and Cherry (1979) and silty sands and fine sands presented by Fetter (1980).

38991 (PZ03)

Piezometer 38991 (PZ03) is located south of the french drain in the central portion of OU1. The borehole for 38991 (PZ03) was scheduled for packer testing because it was drilled into weathered bedrock materials (Table B1-2). However, access to the borehole was limited during the construction of the french drain. This limited access, as well as winter storm conditions when the borehole was drilled, precluded conducting packer tests at this location. It was recommended that a single well test be conducted in the subsequently installed piezometer after completion of the french drain.

According to the well construction diagram (Appendix A1), the piezometer is screened at a depth of 26.8 to 36.8 feet below ground surface and the sand pack ranges from 24.8 to 37.8 feet below ground surface. Based on the borehole log (Appendix A1), the screened interval consists of weathered bedrock claystone, siltstone with clay and sand, silty claystone, and clayey siltstone. The water level prior to testing was 27.80 feet below ground surface and indicates water table conditions at the time of the test. Hydraulic conductivity estimated using the Bouwer and Rice method for the bail down/recovery test yield a value of 1×10^{-6} cm/sec (3×10^{-6} ft/min) (Table B1-5). A valid estimate could not be obtained using the Hvorslev method since the water level was not above the sand pack interval.

The Bouwer and Rice estimate required a correction to r_c and a curve match on the second distinct straight line of the displacement versus time plot to accommodate the fast-draining sand pack.

The estimate obtained is within the range of conductivity values presented for weathered claystone during previous investigations, and is within the ranges of hydraulic conductivities for silt as presented by Freeze and Cherry (1979) and clay and silt as presented by Fetter (1980).

39191 (MW28)

Monitoring well 39191 (MW28) is located south of IHSS 119.1 and north of the french drain. A packer test was conducted in the borehole for this bedrock monitoring well (Table B1.2-1). Due to borehole collapse, this test was performed in an interval above the water table and, therefore, only a field permeability estimate of the material tested was obtained. For the test at well 39191, the injection rate (Q) was determined as the time weighted average of the measured flow rate. The length of the test interval (L) was based on the depth of the packer seal and bottom of the borehole during the test. The time weighted average of the head measured by the data logger in the test interval was used for H. The radius of the borehole (r) was determined from the caliper log by estimating an average borehole diameter within the test interval. The resulting estimate of field permeability is 1.7 x 10^{-6} cm/sec (3.3 x 10^{-6} ft/min).
Attachment B1-1 presents a summary of these parameters and the calculation of field permeability.

This estimate is based on the assumption that all of the injected flow was "taken" by the tested interval. Based on the graph of head versus time, a small increase in head observed in the zone above the packer may indicate a small leak around the packer seal. The presence of this leak would diminish the estimated field permeability value, which was calculated using Equation (1) in Section B1.2.4. Also, because the borehole collapsed after geophysical logging with the caliper tool, the radius of the borehole within the test interval (r) may be underestimated, which may have resulted in a slightly increased value of field permeability. Furthermore, because the borehole collapsed to fill the depths below 26.8 feet, the collapsed material in the bottom of the borehole is not native and may have contained void spaces that may have been filled with injected water during the test. This condition would effectively result in underestimating the test interval length (L) in Equation (1). A larger test interval would have diminished the estimate of field permeability originally calculated. Because of these unquantified sources of error due to the conditions encountered in the field, the field permeability value should be used with caution, although it represents the best and only estimate determined from packer testing for the OU1

Phase III RFI/RI field investigation. It was therefore recommended that single well tests be performed in the bedrock monitoring well installed in this borehole.

According to the well construction diagram (Appendix A1), the well is screened at a depth of 32.8 to 42.8 feet below ground surface and the sand pack ranges from 30.0 to 45.0 feet below ground surface. Based on the borehole log (Appendix A1), the screened interval consists of weathered bedrock clayey siltstone with organics, claystone with silt, and siltstone with clay. The water level prior to testing was 35.36 feet below ground surface and indicates water table conditions within the various lithologies identified within the screened interval at the time of the test. Hydraulic conductivity estimated using the Bouwer and Rice method for the bail down/recovery test yielded a value of 2 x 10^{-5} cm/sec (4 x 10^{-5} ft/min) (Table B1-5). A valid estimate could not be obtained using the Hvorslev method since the water level was not above the sand pack interval.

The Bouwer and Rice estimate required a correction to r_c and a curve match on the first distinct straight line of the displacement versus time plot since no secondary straightline curve was noted. The estimate obtained is within the range of hydraulic conductivity values determined for weathered claystone during previous investigations at OU1. The hydraulic conductivity is an order of magnitude above the upper portion of the general range of conductivities for unweathered marine clay as presented by Freeze and Cherry (1979) and within the range presented for silt. The estimate is also within the upper portion of the clay range and the lower portion of the ranges for silt, sandy silt, and clayey sand ranges specified by Fetter (1980).

39291 (PZ01)

Piezometer 39291 (PZ01) is located south of IHSS 119.1 and north of the french drain. A packer test was attempted in the borehole for this piezometer, but an adequate seal was not attained and the borehole collapsed. Since reaming boreholes had not been shown to enhance conditions for an adequate seal, additional packer tests were not performed. It was recommended that a single well test be conducted in the subsequently installed piezometer.

According to the well construction diagram (Appendix A1), the piezometer is screened at a depth of 34.0 to 44.0 feet below ground surface and the sand pack ranges from 31.7 to 46.0 feet below ground surface. Based on the borehole log (Appendix A1), the screened interval consists of weathered bedrock claystone, silty claystone, clayey siltstone. The water level prior to testing was 30.25 feet below ground surface and indicates water table conditions at the time of the test. Hydraulic conductivity estimates derived using the Bouwer and Rice method for the slug injection and withdrawal tests yield values of 3×10^{-5} cm/sec (7×10^{-5} ft/min) for the slug injection and 3×10^{-5} cm/sec (5×10^{-5} ft/min) for the slug withdrawal tests (Table B1-5). Estimates obtained using the Hvorslev method indicate a hydraulic conductivity of 3×10^{-5} cm/sec (6×10^{-5} ft/min) for the slug injection and withdrawal tests also (Table B1-6).

The agreement between the results derived from the two methods for the two tests is very good. These results are consistent with those of previously performed tests in the weathered bedrock at OU1, although they are within the high portion of this range. This may be indicative of the degree of weathering or fracturing in the localized area. The estimates are also within the range for silt presented by Freeze and Cherry (1979) and within the upper portion of the clay range and the lower portion of the ranges for silt, sandy silt, and clayey sands specified by Fetter (1980).

B1.4.2 Conclusions

Table B1-7 presents all results obtained during the OU1 Phase III RFI/RI borehole and single well slug injection/withdrawal, and bail down/recovery tests conducted at OU1. Although it is difficult to ascertain specific sources of error in these estimates, some generalizations can be made for future applications.

All estimates of hydraulic conductivity calculated during this study fall within the material-specific ranges presented by Freeze and Cherry (1979) and Fetter (1980). The Hvorslev method estimates of hydraulic conductivity are in agreement with the Bouwer and Rice method estimates for tests for which the Hvorslev analysis method was valid. The variability between the two analytical techniques can generally be attributed to the difference in the assumptions and possible error associated with each method (see Sections B1.3.4 and B1.4.1). Hydraulic conductivity estimates derived from slug injection (falling head) tests are generally equal to or higher than results of slug withdrawal (rising head) tests for both analytical methods used. This relationship is expected (Sevee 1991) and adds credence to the OU1 Phase III RFI/RI results.

Tables B1-8 and B1-9 illustrate that, with few exceptions, all estimated hydraulic conductivities obtained during the OU1 Phase III RFI/RI field investigation fall within ranges determined during previous investigations. The exceptions include results of two single well tests conducted in monitoring wells 35691 and 36191, which are screened in disturbed colluvial materials that exhibit uncharacteristically low hydraulic conductivities. These low estimates may be due to specific conditions surrounding these wells: low-permeability borehole skin effects, compaction of colluvial material by construction activities, the presence of roads, and a drastically sloped water table surface in the vicinity of these wells.

From these results, the Bouwer and Rice method appears suitable to analyze the single well test data because of its adaptability, rigor, and acceptance in the literature. The Hvorslev method does provide a good initial verification of field data and a relative check of the hydraulic conductivity estimate derived using Bouwer and Rice for test configurations that meet the required method application criteria.

If conditions permit, it is recommended that future single well tests include the additional slug withdrawal (rising head) step as a verification of the slug injection (falling head) test since discrepancies between results at any well or piezometer can be evaluated to determine the degree of well integrity or confidence in the test data. Also, results indicate that water levels at a few wells may not have fully stabilized 48 hours after sampling. After sampling or development, therefore, a period of 72 hours should be allowed for water level stabilization before tests are conducted.

Since single well tests do not require much time or equipment, repetitive tests can be conducted on existing wells. This would allow evaluation of monitoring well and piezometer performance through time and would permit statistical evaluation of results that could be used in a contamination assessment.

Wells that were dry or exhibited water levels too low to warrant testing should be periodically evaluated to determine whether single well tests could be conducted in the future. Hydraulic conductivities derived at these locations would also enhance contamination assessment results at OU1.

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Appendix B1 · Tables

Borehole and Single Well Test Data

Phase III
RFI/RI Report

Table B1-1 Fourth Quarter 1991 Well Status Summary

Well/Piezometer Number	Work Plan Designation	*Screened Interval (feet BGS)	**4th Quarter 1991 WL (feet BGS)	Date Developed	Date Sampled	Date Tested	Comments
30991	MW35	5.1-9.9	Dry	N/A	N/A	N/A	
31491	MW30	13.9-18.9	Dry	N/A	N/A	N/A	
31791	MW36	6.8-11.8	13.61	N/A	N/A	N/A	Well developed 2/5/92
31891	MW02	16.6-18.6	15.42	10/16/91	11/11/91	12/6/91	
32591	MW24	11.5-16.5	17.7	N/A	N/A	N/A	
33491	MW09	6.7-8.7	Dry	N/A	N/A	N/A	
33691	MW10	6.2-8.1	10.42	N/A	N/A	N/A	
33891	MW08	6.7-8.1	Dry	N/A	N/A	N/A	
34591	MW12	6.9-8.9	Dry	N/A	N/A	N/A	
34791	MW13	6.0-8.0	3.15	11/4/91	12/16/91–12/18/91	12/20/91	
35391	MW19	6.1-8.1	8.52	10/21/91 (I)	12/17/91	N/A	
35691	MW17	15.6-26.6	9.40	10/21/91	11/11/91	12/7/91	
35991	MW18	8.7-13.7	Dry	N/A	N/A	N/A	
36191	MW05	9.5-14.6	12.37	10/21/91 (I)	11/11/91	12/9/91	
36391	MW14	17.4-27.4	29.58	N/A	N/A	N/A	
36691	MW15	15.8-25.8	Dry	N/A	N/A	N/A	Well developed 2/20/92

N/A = Not applicable due to insufficient water in well (piezometer)
BGS = Below ground surface
* = Depth of top and bottom of slotted PVC section from well construction diagram
** = Highest reported WL in fourth quarter 1991
(P) = Indicates bedrock boreholes in which packer tests were performed prior to well installation
(I) = Development by injection methods

Table B1-1 Fourth Quarter 1991 Well Status Summary

Well/Piezometer Number	Work Plan Designation	*Screened Interval (feet BGS)	**4th Quarter 1991 WL (feet BGS)	Date Developed	Date Sampled	Date Tested	Comments
36991	MW04	6.6-8.6	Dry	N/A	N/A	N/A	
37191	MW16	11.1-21.1	7.18	10/22/91	11/12/91	12/7/91	
37591	MW22	7.6-12.6	7.22	12/14/91	12/16/91–12/18/91	12/21/91	
37691	MW23	6.5-16.5	16.14	N/A	N/A	N/A	
37791	MW21	10.6-20.7	19.86	12/16/91	12/19/91	12/24/91	
37891 (P)	MW27 offset	43.2-53.2	40.52	12/12/91	12/14/91–12/16/91	12/20/91	
37991 (P)	MW29	45.2-55.2	47.46	12/12/91	12/14/91–12/16/91	12/18/91	
38191	PZ05	10.0-15.0	8.30	12/12/91	Not required	12/14/91	Piezometer
38291	PZ06	6.7-8.7	Dry	N/A	Not required	N/A	Piezometer
38591	MW34	5.7-7.7	6.43	12/16/91	12/17/91	12/20/91	
38891	PZ02	7.3-9.3	Dry	N/A	Not required	N/A	Piezometer
38991 (P)	PZ03	26.8-36.8	27.80	12/14/91	Not required	12/16/91	Piezometer
39191 (P)	MW28 offset	32.8-42.8	32.10	12/13/91	12/17/91	12/21/91	
39291 (P)	PZ01	34.0-44.0	30.32	12/13/91	Not required	12/15/91	Piezometer
39691	MW20 offset	7.0-9.0	Dry	N/A	N/A	N/A	Well developed 2/5/92

N/A = Not applicable due to insufficient water in well (piezometer)
BGS = Below ground surface
* = Depth of top and bottom of slotted PVC section from well construction diagram
** = Highest reported WL in fourth quarter 1991
(P) = Indicates bedrock boreholes in which packer tests were performed prior to well installation
(I) = Development by injection methods

Table B1-2 Summary of Packer Tests Information and Results

Borehole Number	Water Level (feet BGS)	Test Interval (feet BGS)	Lithology	Hydraulic Conductivity/Field Permeability in cm/sec (ft/min)	Comments
37891	40.50	37.2-56.3	Claystone, clayey siltstone, silty claystone, siltstone with trace clay and sand	N/A	Borehole collapsed before test; inadequate seal after reaming
		29.2-57.0	Claystone, clayey siltstone, silty claystone, siltstone with trace clay and sand	N/A	Inadequate seal after reaming; recommended single well test in water producing zone
37991	Dry	42.1-51.9	Clayey siltstone, claystone, sandy clayey siltstone, silty claystone	N/A	Inadequate seal; borehole collapse
		42.1-57.5	Clayey siltstone, claystone, sandy clayey siltstone, silty claystone	N/A	Inadequate seal after reaming; recommended single well test in water producing zone
38991	No test due to possibly hazardous access and poor weather conditions				Recommended single well test in water producing zone
39191	Dry	17.6–26.8	Claystone with varying amounts of silt	$1.7x10^{-6}$ ($3.3x10^{-6}$)	Borehole collapsed prior to test; not reamed; recommended single well test in water producing zone
39291	43.17	43.2–47.6	Silty claystone	N/A	Inadequate seal; borehole collapsed after first attempt; recommended single well test in water producing zone

* Field permeability calculated using method presented by U.S. Department of the Interior (1974)

N/A = Not applicable due to environmental conditions
BGS = Below ground surface
cm/sec = centimeters per second
ft/min = feet per minute

Table B1-3 Single Well Test Summary

Well/Piezometer Number	Work Plan Designation	Sand Pack* Interval (feet BGS)	Screened** Interval (feet BGS)	Static Water Level for Test (feet BGS)	Lithologic Zone	Saturated Lithology Tested	Type of Test
31891	MW02	14.6-19.0	16.6-18.6	15.51	Disturbed Sandstone	Alluvial sandy clay; bedrock clayey sandstone	Slug injection/slug withdrawal
34791	MW13	5.9-9.5	6.0-8.0	2.44	Colluvium	Silty sand, gravel	Slug injection/slug withdrawal
35691	MW17	13.4-29.0	15.6-26.6	9.34	Disturbed Colluvium	Silty clay with some sand and gravel; sandy clay and clayey gravel	Slug injection/slug withdrawal
36191	MW05	7.4-14.9	9.5-14.6	11.94	Disturbed Colluvium	Well graded gravelly sand with a 0.06 foot layer of clay	Bail down/ recovery
37191	MW16	9.2-22.0	11.1-21.1	7.13	Colluvium	Gravelly, sandy clay	Slug injection/slug withdrawal
37591	MW22	5.6-14.6	7.6-12.6	11.19	Rocky Flats Alluvium	Gravel-sand-clay	Bail down/ recovery
37791	MW21	8.8-22.6	10.6-20.6	20.01	Colluvium	Clay with silt sand and gravel	Bail down/ recovery
37891	MW27	40.0-55.2	43.2-55.2	41.90	Weathered Bedrock	Silty claystone, clayey siltstone; siltstone with clay, trace sand	Slug injection/slug withdrawal

BGS = Below ground surface
* = Depth of top and bottom of sand pack
** = Depth of top and bottom of slotted PVC section

Table B1-3 Single Well Test Summary

Well/Piezometer Number	Work Plan Designation	Sand Pack* Interval (feet BGS)	Screened** Interval (feet BGS)	Static Water Level for Test (feet BGS)	Lithologic Zone	Saturated Lithology Tested	Type of Test
37991	MW29	43.0-57.2	45.2-55.2	48.78	Weathered Bedrock	Claystone, sandy clayey siltstone	Bail down/ recovery
38191	PZ05	8.1-14.9	10.0-15.0	9.38	Colluvium	Sand-silt-clay mixture with gravel and silty gravelly sand	Slug injection/slug withdrawal
38591	MW34	5.0-8.0	5.7-7.7	6.50	Woman Creek Valley Fill Alluvium	Silty sand with clay and gravel	Bail down/ recovery
38991	PZ03	24.8-37.8	26.8-36.8	27.80	Weathered Bedrock	Claystone, siltstone with clay and sand, silty claystone and clayey siltstone	Bail down/ recovery
39191	MW28	30.0-45.0	32.8-42.8	35.36	Weathered Bedrock	Clayey siltstone with organics (lignite?); claystone with silt, siltstone with clay	Bail down/ recovery
39291	PZ01	31.7-46.0	34.0-44.0	30.25	Weathered Bedrock	Claystone, silty claystone, clayey siltstone	Slug injection/slug withdrawal

BGS = Below ground surface
* = Depth of top and bottom of sand pack
** = Depth of top and bottom of slotted PVC section

Table B1-4 Summary of Input Parameters for AQTESOLV

Well/Piezometer Number	Work Plan Designation	Type of Test	Radius of casing (r_c) in feet	Radius of well (r_w) in feet	Saturated Thickness (b) in feet	*Screen Length (L) in feet	Height of Static Water Level Above Bottom of Screen (H) in feet
31891	MW02	Slug injection/	0.0863	0.458	3.09	1.60	2.89
		slug withdrawal	0.0863	0.458	3.09	1.60	2.89
34791	MW13	Slug injection/	0.0863	0.458	5.56	1.54	5.28
		slug withdrawal	0.0863	0.458	5.56	1.54	5.28
35691	MW17	Slug injection/	0.0863	0.458	17.02	10.52	17.02
		slug withdrawal	0.0863	0.458	17.02	10.52	17.02
36191	MW05	Bail down/recovery	0.261**	0.458	2.46	2.46***	2.46
37191	MW16	Slug injection/	0.0863	0.458	13.74	9.55	13.74
		slug withdrawal	0.0863	0.458	13.74	9.55	13.74
37591	MW22	Bail down/recovery	0.261**	0.458	1.21	1.21***	1.21
37791	MW21	Bail down/recovery	0.261**	0.458	0.39	0.39***	0.39
37891	MW27	Slug injection/	0.0863	0.292	13.30	9.60	11.10
		slug withdrawal	0.0863	0.292	13.30	9.60	11.10
37991	MW29	Bail down/recovery	0.1755**	0.292	8.50	6.22***	6.22
38191	PZ05	Slug injection/	0.0863	0.458	5.52	4.80	5.52
		slug withdrawal	0.0863	0.458	5.52	4.80	5.52
38591	MW34	Bail down/recovery	0.261**	0.458	1.16	1.16***	1.16

* = For use in calculations, screen lengths presented in this table and Table B1.3-4 are precisely determined as length from top slot to bottom slot or water level to bottom slot. In Tables B1.1-1 and B1.3-1, screen lengths are less precisely presented as the length of the slotted section of PVC.

** = Corrected as presented in Bouwer and Rice (1976). A value of 0.261 indicates correction to an 11-inch borehole in alluvial wells; a value of 0.1755 indicates correction to a 7-inch borehole in bedrock wells.

*** = Saturated screen length (water level to bottom slot)

Table B1-4 Summary of Input Parameters for AQTESOLV

Well/Piezometer Number	Work Plan Designation	Type of Test	Radius of casing (r_c) in feet	Radius of well (r_w) in feet	Saturated Thickness (b) in feet	*Screen Length (L) in feet	Height of Static Water Level Above Bottom of Screen (H) in feet
38991	PZ03	Bail down/recovery	0.1755**	0.292	10.00	8.80***	8.80
39191	MW28	Bail down/recovery	0.1755**	0.292	9.64	7.20***	7.20
39291	PZ01	Slug injection/	0.0863	0.292	15.40	9.60	13.5
		slug withdrawal	0.0863	0.292	15.40	9.60	13.5

* = For use in calculations, screen lengths presented in this table and Table B1.3-4 are precisely determined as length from top slot to bottom slot or water level to bottom slot. In Tables B1.1-1 and B1.3-1, screen lengths are less precisely presented as the length of the slotted section of PVC.

** = Corrected as presented in Bouwer and Rice (1976). A value of 0.261 indicates correction to an 11-inch borehole in alluvial wells; a value of 0.1755 indicates correction to a 7-inch borehole in bedrock wells.

*** = Saturated screen length (water level to bottom slot)

Table B1-5 AQTESOLV Output Summary for Bouwer and Rice Analysis

Well/Piezometer Number	Work Plan Designation	Type of Test	A	B	C	$\ln(R_e/r_w)$	Calculated* Initial Test Displacement y_0 (feet)	Calculated* Hydraulic Conductivity K (ft/min)	Hydraulic Conductivity Estimate K (cm/sec)	Curve Match
31891	MW02	Slug injection/ slug withdrawal	1.668 1.668	0.253 0.253	– –	0.986 0.986	1.472 1.623	4.064×10^{-4} 4.802×10^{-4}	2×10^{-4} 2×10^{-4}	First straight line
34791	MW13	Slug injection/ slug withdrawal	1.663 1.663	0.253 0.253	– –	1.102 1.102	1.404 1.906	1.875×10^{-5} 1.273×10^{-5}	1×10^{-5} 6×10^{-6}	Second straight line for slug injection; first straight line for slug withdrawal test
35691	MW17	Slug injection/ slug withdrawal	– –	– –	1.751 1.751	2.628 2.628	1.505 1.245	1.885×10^{-6} 1.749×10^{-6}	1×10^{-6} 9×10^{-7}	First straight line
36191	MW05	Bail down/ recovery	–	–	0.916	1.212	1.454	2.192×10^{-6}	1×10^{-6}	Second straight line
37191	MW16	Slug injection/ slug withdrawal	– –	– –	1.687 1.687	2.473 2.473	1.645 1.922	2.266×10^{-4} 7.946×10^{-5}	1×10^{-4} 4×10^{-5}	First straight line
37591	MW22	Bail down/ recovery	–	–	0.623	0.731	0.966	1.472×10^{-5}	7×10^{-6}	Second straight line
37791	MW21	Bail down/ recovery	–	–	0.400	-4.340	–	–	–	N/A (not adequate displacement for valid test)
37891	MW27	Slug injection/ slug withdrawal	2.534 2.534	0.413 0.413	– –	2.470 2.470	1.506 1.738	1.011×10^{-6} 2.684×10^{-6}	5×10^{-7} 1×10^{-6}	Second straight line

* = Calculated by AQTESOLV software
N/A = Not applicable
R_e/r_w = Effective radius/radius of well

cm/sec = centimeters per second
ft/min = feet per minute
1 ft/min = 0.508 cm/sec (unit conversion factor)

OU1. 9/92 pf

Table B1-5 AQTESOLV Output Summary for Bouwer and Rice Analysis

Well/Piezometer Number	Work Plan Designation	Type of Test	A	B	C	$\ln(R_e/r_w)$	Calculated* Initial Test Displacement y_o (feet)	Calculated* Hydraulic Conductivity K (ft/min)	Hydraulic Conductivity Estimate K (cm/sec)	Curve Match
37991	MW29	Bail down/ recovery	2.186	0.346	–	1.799	4.027	1.338×10^{-5}	7×10^{-6}	Second straight line
38191	PZ05	Slug injection/ slug withdrawal	– –	– –	1.308 1.308	1.765 1.765	1.641 1.473	2.183×10^{-5} 3.888×10^{-6}	1×10^{-5} 2×10^{-6}	First straight line
38591	MW34	Bail down/ recovery	–	–	0.618	0.700	4.624	7.439×10^{-4}	4×10^{-4}	Second straight line
38991	PZ03	Bail down/ recovery	2.448	0.398	–	2.365	4.493	2.680×10^{-6}	1×10^{-6}	Second straight line
39191	MW28	Bail down/ recovery	2.282	0.367	–	2.140	7.371	4.178×10^{-5}	2×10^{-5}	First straight line
39291	PZ01	Slug injection/ slug withdrawal	2.534 2.534	0.413 0.413	– –	2.581 2.581	1.495 1.270	6.639×10^{-5} 5.240×10^{-5}	3×10^{-5} 3×10^{-5}	Second straight line

* = Calculated by AQTESOLV software
N/A = Not applicable
R_e/r_w = Effective radius/radius of well

cm/sec = centimeters per second
ft/min = feet per minute
1 ft/min = 0.508 cm/sec (unit conversion factor)

Table B1-6 Hvorslev Analysis Parameters and Results

Well/ Piezometer Number	Work Plan Designation	Type of Test	*Radius of Intake Casing r (feet)	*Radius of Intake Sand Pack R (feet)	*Length of Intake Sand Pack L (feet)	L/R	T_O From Graph (minutes)	*Initial Displacement H_O (feet)	Hydraulic Conductivity Estimate K in cm/sec (ft/min)
31891	MW02	Slug injection/	–	–	–	–	–	–	N/A
		slug withdrawal	–	–	–	–	–	–	N/A
34791	MW13	Slug injection/	0.0863	0.458	1.54	3.36	–	–	N/A
		slug withdrawal	0.0863	0.458	1.54	3.36	–	–	N/A
35691	MW17	Slug injection/	0.0863	0.458	10.52	22.97	745	1.505	$8x10^{-7}$ ($2x10^{-6}$)
		slug withdrawal	0.0863	0.458	10.52	22..97	1000	1.245	$6x10^{-7}$ ($1x10^{-6}$)
36191	MW05	Bail down/ recovery	–	–	–	–	–	–	N/A
37191	MW16	Slug injection/	0.0863	0.458	9.55	20.85	4.5	1.645	$1x10^{-4}$ ($2x10^{-4}$)
		slug withdrawal	0.0863	0.458	9.55	20.85	12.5	1.922	$5x10^{-5}$ ($1x10^{-4}$)
37591	MW22	Bail down/ recovery	–	–	–	–	–	–	N/A
37791	MW21	Bail down/ recovery	–	–	–	–	–	–	N/A
37891	MW27	Slug injection/	–	–	–	–	–	–	N/A
		slug withdrawal	–	–	–	–	–	–	N/A
37991	MW29	Bail down/ recovery	–	–	–	–	–	–	N/A
38191	PZ05	Slug injection/	–	–	–	–	–	–	N/A
		slug withdrawal	–	–	–	–	–	–	N/A

L/R = Length of intake divided by radius of intake: Hvorslev analysis equation only valid for L/R >8
N/A = Not applicable because L/R <8 or intake is not below water table
* = dimensions same as for Bouwer and Rice analysis (see Tables B1.3-2 and B1.3-3)
1 ft/min = 0.508 cm/sec (unit conversion factor)

Table B1-6 Hvorslev Analysis Parameters and Results

Well/ Piezometer Number	Work Plan Designation	Type of Test	*Radius of Intake Casing r (feet)	*Radius of Intake Sand Pack R (feet)	*Length of Intake Sand Pack L (feet)	L/R	T_O From Graph (minutes)	*Initial Displacement H_O (feet)	Hydraulic Conductivity Estimate K in cm/sec (ft/min)
38591	MW34	Bail down/ recovery	–	–	–	–	–	–	N/A
38991	PZ03	Bail down/ recovery	–	–	–	–	–	–	N/A
39191	MW28	Bail down/ recovery	–	–	–	–	–	–	N/A
39291	PZ01	Slug injection/ slug withdrawal	0.0863 0.0863	0.292 0.292	9.60 9.60	32.88 32.88	25.7 26.3	1.479 1.303	$3x10^{-5}$ ($6x10^{-5}$) $3x10^{-5}$ ($6x10^{-5}$)

L/R = Length of intake divided by radius of intake: Hvorslev analysis equation only valid for L/R >8
N/A = Not applicable because L/R <8 or intake is not below water table
* = dimensions same as for Bouwer and Rice analysis (see Tables B1.3-2 and B1.3-3)
1 ft/min = 0.508 cm/sec (unit conversion factor)

Table B1-7 Hydraulic Conductivity and Field Permeability Summary

Well/Piezometer Number	Work Plan Designation	Type of Test	Lithologic Zone	Hvorslev Conductivity Estimate K in cm/sec (ft/min)	Bouwer & Rice Conductivity Estimate K in cm/sec (ft/min)	Field Permeability k in cm/sec* (ft/min)
31891	MW02	Slug injection	Bedrock Sandstone	N/A	$2x10^{-4}$ ($4x10^{-4}$)	–
		Slug withdrawal	Bedrock Sandstone	N/A	$2x10^{-4}$ ($5x10^{-4}$)	
34791	MW13	Slug injection	Colluvium	N/A	$1x10^{-5}$ ($2x10^{-5}$)	–
		Slug withdrawal	Colluvium	N/A	$6x10^{-6}$ ($1x10^{-5}$)	
35691	MW17	Slug injection	Disturbed Colluvium	$8x10^{-7}$ ($2x10^{-6}$)	$1x10^{-6}$ ($2x10^{-6}$)	–
		Slug withdrawal	Disturbed Colluvium	$6x10^{-7}$ ($1x10^{-6}$)	$9x10^{-7}$ ($2x10^{-6}$)	
36191	MW05	Bail down/recovery	Disturbed Colluvium	N/A	$1x10^{-6}$ ($2x10^{-6}$)	–
37191	MW16	Slug injection	Colluvium	$1x10^{-4}$ ($2x10^{-4}$)	$1x10^{-4}$ ($2x10^{-4}$)	–
		Slug withdrawal	Colluvium	$5x10^{-5}$ ($1x10^{-4}$)	$4x10^{-5}$ ($8x10^{-5}$)	
37591	MW22	Bail down/recovery	Rocky Flats Alluvium	N/A	$7x10^{-6}$ ($1x10^{-5}$)	–
37791	MW21	Bail down/recovery	Colluvium	N/A	N/A	–
37891	MW27	Slug injection	Weathered Bedrock	N/A	$5x10^{-7}$ ($1x10^{-6}$)	–
		Slug withdrawal	Weathered Bedrock	N/A	$1x10^{-6}$ ($3x10^{-6}$)	
37991	MW29	Bail down/recovery	Weathered Bedrock	N/A	$7x10^{-6}$ ($1x10^{-5}$)	–
38191	PZ05	Slug injection	Colluvium	N/A	$1x10^{-5}$ ($2x10^{-5}$)	–
		Slug withdrawal	Colluvium	N/A	$2x10^{-6}$ ($4x10^{-6}$)	

* = U.S. Department of Interior, Bureau of Land Management method (U.S. Department of Interior 1974) used to evaluate packer test data in unsaturated material.
K = Hydraulic conductivity
k = Field permeability
N/A = Not applicable - analytical results not valid due to violation of required analytical method assumptions
cm/sec = centimeters per second
ft/min = feet per minute

Table B1-7 Hydraulic Conductivity and Field Permeability Summary

Well/Piezometer Number	Work Plan Designation	Type of Test	Lithologic Zone	Hvorslev Conductivity Estimate K in cm/sec (ft/min)	Bouwer & Rice Conductivity Estimate K in cm/sec (ft/min)	Field Permeability k in cm/sec* (ft/min)
38591	MW34	Bail down/recovery	Woman Creek Valley Fill Alluvium	N/A	$4x10^{-4}$ $(7x10^{-4})$	–
38991	PZ03	Bail down/recovery	Weathered Bedrock	N/A	$1x10^{-6}$ $(2x10^{-6})$	–
39191	MW28	Bail down/recovery	Weathered Bedrock	N/A	$2x10^{-5}$ $(4x10^{-5})$	–
		Packer	Weathered Bedrock	NA	–	$1.7x10^{-6}$ $(3.3x10^{-6})$ (unsaturated interval)
39291	PZ01	Slug injection	Weathered Bedrock	$3x10^{-5}$ $(6x10^{-5})$	$3x10^{-5}$ $(7x10^{-5})$	
		Slug withdrawal	Weathered Bedrock	$3x10^{-5}$ $(6x10^{-5})$	$3x10^{-5}$ $(5x10^{-5})$	

* = U.S. Department of Interior, Bureau of Land Management method (U.S. Department of Interior 1974) used to evaluate packer test data in unsaturated material.
K = Hydraulic conductivity
k = Field permeability
N/A = Not applicable - analytical results not valid due to violation of required analytical method assumptions
cm/sec = centimeters per second
ft/min = feet per minute

Table B1-7 Hydraulic Conductivity and Field Permeability Summary

Well/Piezometer Number	Work Plan Designation	Type of Test	Lithologic Zone	Hvorslev Conductivity Estimate K in cm/sec (ft/min)	Bouwer & Rice Conductivity Estimate K in cm/sec (ft/min)	Field Permeability k in cm/sec* (ft/min)
31891	MW02	Slug injection	Bedrock Sandstone	N/A	$2x10^{-4}$ ($4x10^{-4}$)	–
		Slug withdrawal	Bedrock Sandstone	N/A	$2x10^{-4}$ ($5x10^{-4}$)	
34791	MW13	Slug injection	Colluvium	N/A	$1x10^{-5}$ ($2x10^{-5}$)	–
		Slug withdrawal	Colluvium	N/A	$6x10^{-6}$ ($1x10^{-5}$)	
35691	MW17	Slug injection	Disturbed Colluvium	$8x10^{-7}$ ($2x10^{-6}$)	$1x10^{-6}$ ($2x10^{-6}$)	–
		Slug withdrawal	Disturbed Colluvium	$6x10^{-7}$ ($1x10^{-6}$)	$9x10^{-7}$ ($2x10^{-6}$)	
36191	MW05	Bail down/recovery	Disturbed Colluvium	N/A	$1x10^{-6}$ ($2x10^{-6}$)	–
37191	MW16	Slug injection	Colluvium	$1x10^{-4}$ ($2x10^{-4}$)	$1x10^{-4}$ ($2x10^{-4}$)	–
		Slug withdrawal	Colluvium	$5x10^{-5}$ ($1x10^{-4}$)	$4x10^{-5}$ ($8x10^{-5}$)	
37591	MW22	Bail down/recovery	Rocky Flats Alluvium	N/A	$7x10^{-6}$ ($1x10^{-5}$)	–
37791	MW21	Bail down/recovery	Colluvium	N/A	N/A	–
37891	MW27	Slug injection	Weathered Bedrock	N/A	$5x10^{-7}$ ($1x10^{-6}$)	–
		Slug withdrawal	Weathered Bedrock	N/A	$1x10^{-6}$ ($3x10^{-6}$)	
37991	MW29	Bail down/recovery	Weathered Bedrock	N/A	$7x10^{-6}$ ($1x10^{-5}$)	–
38191	PZ05	Slug injection	Colluvium	N/A	$1x10^{-5}$ ($2x10^{-5}$)	–
		Slug withdrawal	Colluvium	N/A	$2x10^{-6}$ ($4x10^{-6}$)	

* = U.S. Department of Interior, Bureau of Land Management method (U.S. Department of Interior 1974) used to evaluate packer test data in unsaturated material.
K = Hydraulic conductivity
k = Field permeability
N/A = Not applicable - analytical results not valid due to violation of required analytical method assumptions
cm/sec = centimeters per second
ft/min = feet per minute

Table B1-7 Hydraulic Conductivity and Field Permeability Summary

Well/Piezometer Number	Work Plan Designation	Type of Test	Lithologic Zone	Hvorslev Conductivity Estimate K in cm/sec (ft/min)	Bouwer & Rice Conductivity Estimate K in cm/sec (ft/min)	Field Permeability k in cm/sec* (ft/min)
38591	MW34	Bail down/recovery	Woman Creek Valley Fill Alluvium	N/A	$4x10^{-4}$ $(7x10^{-4})$	–
38991	PZ03	Bail down/recovery	Weathered Bedrock	N/A	$1x10^{-6}$ $(2x10^{-6})$	–
39191	MW28	Bail down/recovery	Weathered Bedrock	N/A	$2x10^{-5}$ $(4x10^{-5})$	–
		Packer	Weathered Bedrock	NA	–	$1.7x10^{-6}$ $(3.3x10^{-6})$ (unsaturated interval)
39291	PZ01	Slug injection	Weathered Bedrock	$3x10^{-5}$ $(6x10^{-5})$	$3x10^{-5}$ $(7x10^{-5})$	
		Slug withdrawal	Weathered Bedrock	$3x10^{-5}$ $(6x10^{-5})$	$3x10^{-5}$ $(5x10^{-5})$	

* = U.S. Department of Interior, Bureau of Land Management method (U.S. Department of Interior 1974) used to evaluate packer test data in unsaturated material.
K = Hydraulic conductivity
k = Field permeability
N/A = Not applicable - analytical results not valid due to violation of required analytical method assumptions
cm/sec = centimeters per second
ft/min = feet per minute

Table B1-8 Comparison of Phase III RFI/RI Results to Previous Results at OU1

Lithologic Zone	Type of Test	Previous Test Results* K in cm/sec (ft/min)	Phase III RFI/RI Field Investigation Results: Hvorslev K in cm/sec (ft/min)	Bouwer & Rice Method K in cm/sec (ft/min)	U.S. Dept. of the Interior k (ft/min)
Rocky Flats Alluvium	Bail down/recovery	–	–	$7x10^{-6}$ [1] ($1x10^{-5}$)	–
Colluvium and Disturbed Colluvium	Bail down/recovery (also draw down/ recovery)	$5x10^{-4}$–$4x10^{-5}$ [3] ($1x10^{-3}$–$8x10^{-5}$)	–	$1x10^{-6}$ [1] ($2x10^{-6}$)	–
	Slug injection	$2x10^{-4}$–$3x10^{-5}$ [2] ($4x10^{-4}$–$6x10^{-5}$)	$1x10^{-4}$–$8x10^{-7}$ (2) ($2x10^{-4}$–$2x10^{-6}$)	$1x10^{-6}$–$1x10^{-6}$ [4] ($2x10^{-4}$–$2x10^{-6}$)	–
	Slug withdrawal	–	$5x10^{-5}$–$6x10^{-7}$ (2) ($1x10^{-4}$–$1x10^{-6}$)	$4x10^{-5}$–$9x10^{-7}$ [4] ($8x10^{-5}$–$2x10^{-6}$)	–
Woman Creek Valley Fill Alluvium	Bail down/recovery (also draw down/ recovery)	$3x10^{-3}$–$3x10^{-4}$ [4] ($6x10^{-6}x10^{y}$)	–	$4x10^{-4}$ [1] ($7x10^{-4}$)	–
Bedrock Sandstone	Bail down/recovery (also draw down/ recovery)	$2x10^{-4}$–$2x10^{-6}$ [4] ($4x10^{-4}$–$4x10^{-6}$)	–	–	–
	Slug injection	$7x10^{-5}$–$6x10^{-6}$ [2] ($1x10^{-4}$–$1x10^{-5}$)	–	$2x10^{-4}$ [1] ($4x10^{-4}$)	–

Number in [ ] = Number of tests performed
* = Previous results as presented in the Phase II Remedial Investigation Report for High Priority Sites (881 Hillside Area) (Rockwell 1988) and French Drain Geotechnical Investigation Report, EG&G 1990
** = Includes results from tests conducted in saturated and unsaturated intervals
K = Hydraulic conductivity
k = Field permeability as determined using U.S. Department of Interior (1974) method for analysis of packer tests in unsaturated material
cm/sec = centimeters per second
ft/min = feet per second

Table B1-8 Comparison of Phase III RFI/RI Results to Previous Results at OU1

Lithologic Zone	Type of Test	Previous Test Results* K in cm/sec (ft/min)	Phase III RFI/RI Field Investigation Results: Hvorslev K in cm/sec (ft/min)	Bouwer & Rice Method K in cm/sec (ft/min)	U.S. Dept. of the Interior k (ft/min)
Bedrock Sandstone (continued)	Slug withdrawal	–	–	$2x10^{-4}$ [1] ($5x10^{-4}$)	–
Weathered Bedrock	Bail down/recovery (also draw down/ recovery)	–	–	$2x10^{-5}$–$1x10^{-6}$ [3] ($4x10^{-5}$–$2x10^{-6}$)	–
	Slug injection	–	$3x10^{-5}$ [1] ($6x10^{-5}$)	$3x10^{-5}$–$5x10^{-7}$ [2] ($6x10^{-5}$–$1x10^{-6}$)	–
	Slug withdrawal	–	$3x10^{-5}$ [1] ($6x10^{-5}$)	$3x10^{-5}$–$1x10^{-6}$ [2] ($6x10^{-5}$–$2x10^{-6}$)	–
	**Packer injection	$2.3x10^{-3}$–$1.0x10^{-7}$ [67] ($4.5x10^{-3}$–$2.0x10^{-7}$)	–	–	$1.7x10^{-6}$ [1] ($3.3x10^{-6}$)
Unweathered Bedrock	Packer Injection	$3.0x10^{-6}$–$1.0x10^{-8}$ [12] ($5.9x10^{-6}$–$2.0x10^{-8}$)	–	–	–

Number in [ ] = Number of tests performed
* = Previous results as presented in the Phase II Remedial Investigation Report for High Priority Sites (881 Hillside Area) (Rockwell 1988) and French Drain Geotechnical Investigation Report, EG&G 1990
** = Includes results from tests conducted in saturated and unsaturated intervals
K = Hydraulic conductivity
k = Field permeability as determined using U.S. Department of Interior (1974) method for analysis of packer tests in unsaturated material
cm/sec = centimeters per second
ft/min = feet per second

Table B1-9 Summary of Aquifer Test Results at OU1

Lithologic Zone	Previous Test Results* K Range in cm/sec (ft/min)	Phase III RFI/RI** K Range in cm/sec (ft/min)	Comments
Rocky Flats Alluvium	–	$7x10^{-5}$ [1] ($1x10^{-4}$)	Lithologic zone not tested during previous investigations
Colluvium and Disturbed Colluvium	$5x10^{-4}$–$3x10^{-5}$ [5] ($1x10^{-3}$–$6x10^{-5}$)	$1x10^{-4}$–$9x10^{-7}$ [9] ($2x10^{-4}$–$2x10^{-6}$)	Lower portion of Phase III range attributed to lower values reported for disturbed colluvium not tested during previous investigations
Woman Creek Valley Fill Alluvium	$3x10^{-3}$–$3x10^{-5}$ [4] ($6x10^{-3}$–$6x10^{-5}$)	$4x10^{-4}$ [1] ($8x10^{-4}$)	Results show good agreement between investigative programs
Bedrock Sandstone	$2x10^{-4}$–$2x10^{-6}$ [6] ($4x10^{-4}$–$4x10^{-6}$)	$2x10^{-4}$ [2] ($4x10^{-4}$)	Results show good agreement between investigative programs
Weathered Bedrock	$2.3x10^{-3}$–$1.0x10^{-7}$ [67] ($4.5x10^{-3}$–$2.0x10^{-7}$)	$3x10^{-5}$–$5x10^{-7}$) [8] ($6x10^{-5}$–$1x10^{-6}$	High portion of range reported for previous investigations due to tests in highly weathered material or unsaturated conditions.
Unweathered Bedrock	$3.0x10^{-6}$–$1.8x10^{-8}$ [12] ($5.9x10^{-6}$–$2.0x10^{-8}$)	–	–

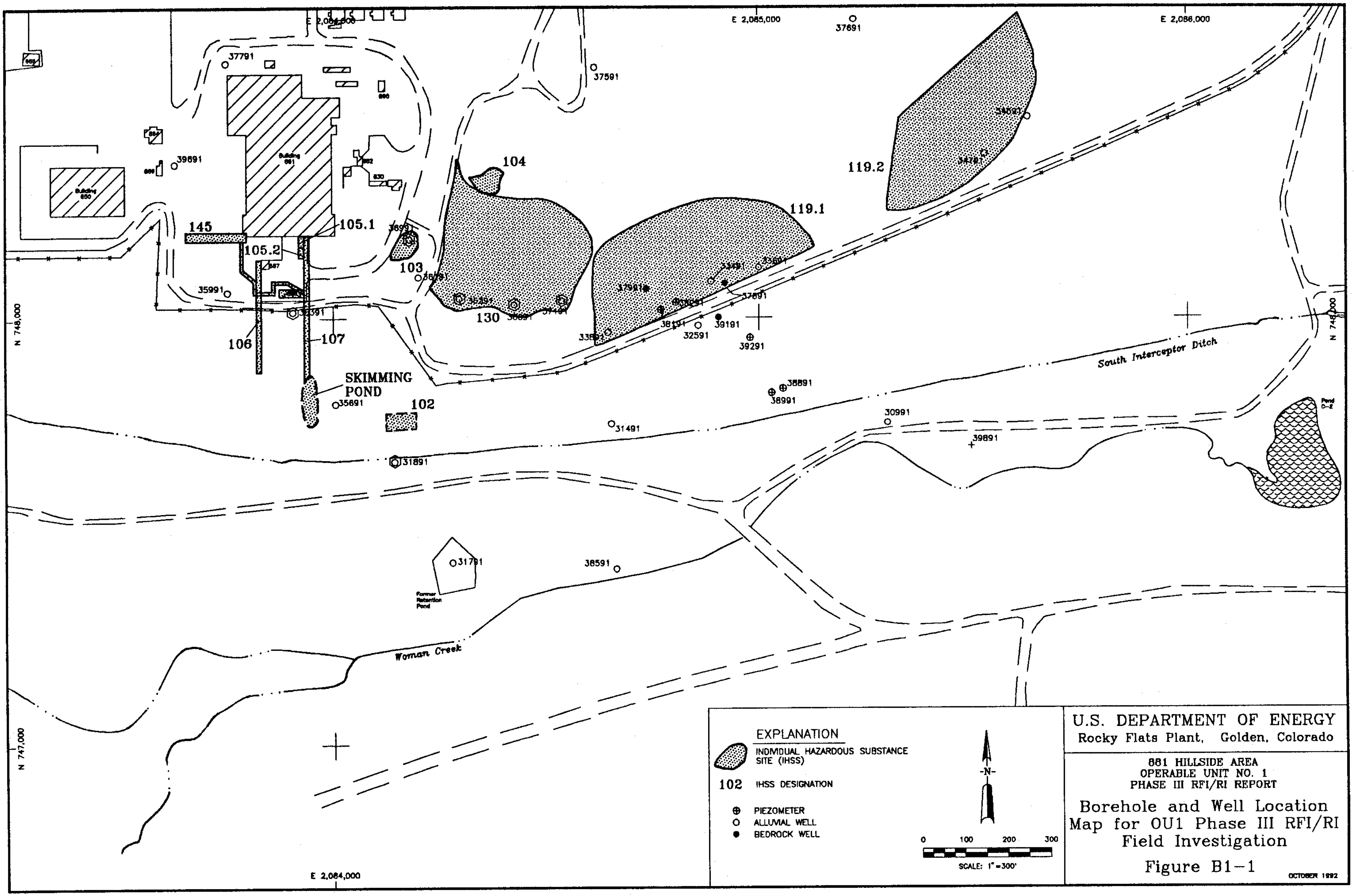
Number in [ ] = Number of tests performed
* = Previous investigation results presented in Draft Final [Phase II] Remedial Investigation Report for High Priority Sites (881 Hillside Area) (Rockwell 1988) and French Drain Geotechnical Investigation Report (EG&G 1990).
Tests included drawdown/recovery test methods and packer injection test methods analyzed using various analytical techniques.
** = Phase III RFI/RI results from bail down/recovery test methods, slug injection and slug withdrawal test methods and one packer injection test. Analysis of well tests reported for Bouwer and Rice analytical method. Packer test results analyzed using U.S. Department of the Interior methods referenced in this report.
cm/sec = centimeters per second
ft/min = feet per minute

Appendix B1 · Figures

Borehole and Single
Well Test Data

Phase III
RFI/RI Report

OU1 OU1 OU
881 Hillside
OU1 OU1 O
Hillside 881
1 OU1 OU1
side 881 Hill
U1 OU1 OU
881 Hillside
OU1 OU1 O
Hillside 881



U.S. DEPARTMENT OF ENERGY
Rocky Flats Plant, Golden, Colorado

881 HILLSIDE AREA
OPERABLE UNIT NO. 1
PHASE III RFI/RI REPORT

Borehole and Well Location Map for OU1 Phase III RFI/RI Field Investigation

Figure B1-1

OCTOBER 1992

Appendix B1
Attachments

Borehole and Single Well Test Data

Phase III
RFI/RI Report

INDEX OF BOREHOLE AND SINGLE WELL TEST DATA AND RESULTS

Borehole, well, or piezometer number: **31891 (MW02)**
(Work plan designation)

Data Available:

__ Packer Test – Set-up

__ Packer Test – Data Sheet (Flow vs. Time Data)

__ Packer Test – Data Logger Output (Head vs. Time Data)

__ Packer Test – Analysis and Results Calculation Sheet

✔ Single Well Test – Record of Initial Water Level Measurement

✔ Single Well Test – 10 Minute Calibration Plot

✔ Single Well Test – Head vs. Time Data Form

✔ Single Well Test – Head vs. Time Response Graph(s)

✔ Single Well Test – Bouwer and Rice Method Analytical Results

__ Single Well Test – Hvorslev Method Analytical Results

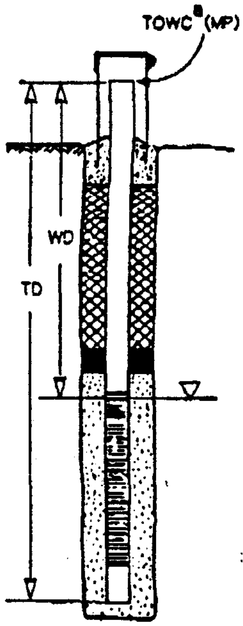
U.S. DEPARTMENT OF ENERGY ROCKY FLATS PLANT

FORM GW.1A

GROUNDWATER LEVELS
MEASUREMENTS/CALCULATIONS

ROCKY FLATS PROJECT . Revision 1.2
Project No. OU1 - 881 Hillside
Date 12/6/91
Personnel 1. J. Uhlinger
2. K. Maley

EQUIPMENT: Manufacturer Insitu Model TTX-16/D Serial No. 265825
CALIBRATION: Date Passed 6/91 Date Due
QC REVIEW: Name Date



Well No. 31891-AL	WD[b]	MTD[c]	Comments		
Measurement 1	18.00	23.71'	K. Maley		
Measurement 2	18.01	23.67'	J. Uhlinger		
Measurement 3	18.01	23.71'	K. Maley		
	18.01'	23.70	+ 0	= 23.7	
	Average WD	Average MTD	Probe End[d]	TD[e]	Chk'd by

Well No.	WD[b]	MTD[c]	Comments		
Measurement 1					
Measurement 2					
Measurement 3					
			+	=	
	Average WD	Average MTD	Probe End[d]	TD[e]	Chk'd by

Well No.	WD[b]	MTD[c]	Comments		
Measurement 1					
Measurement 2					
Measurement 3					
			+	=	
	Average WD	Average MTD	Probe End[d]	TD[e]	Chk'd by

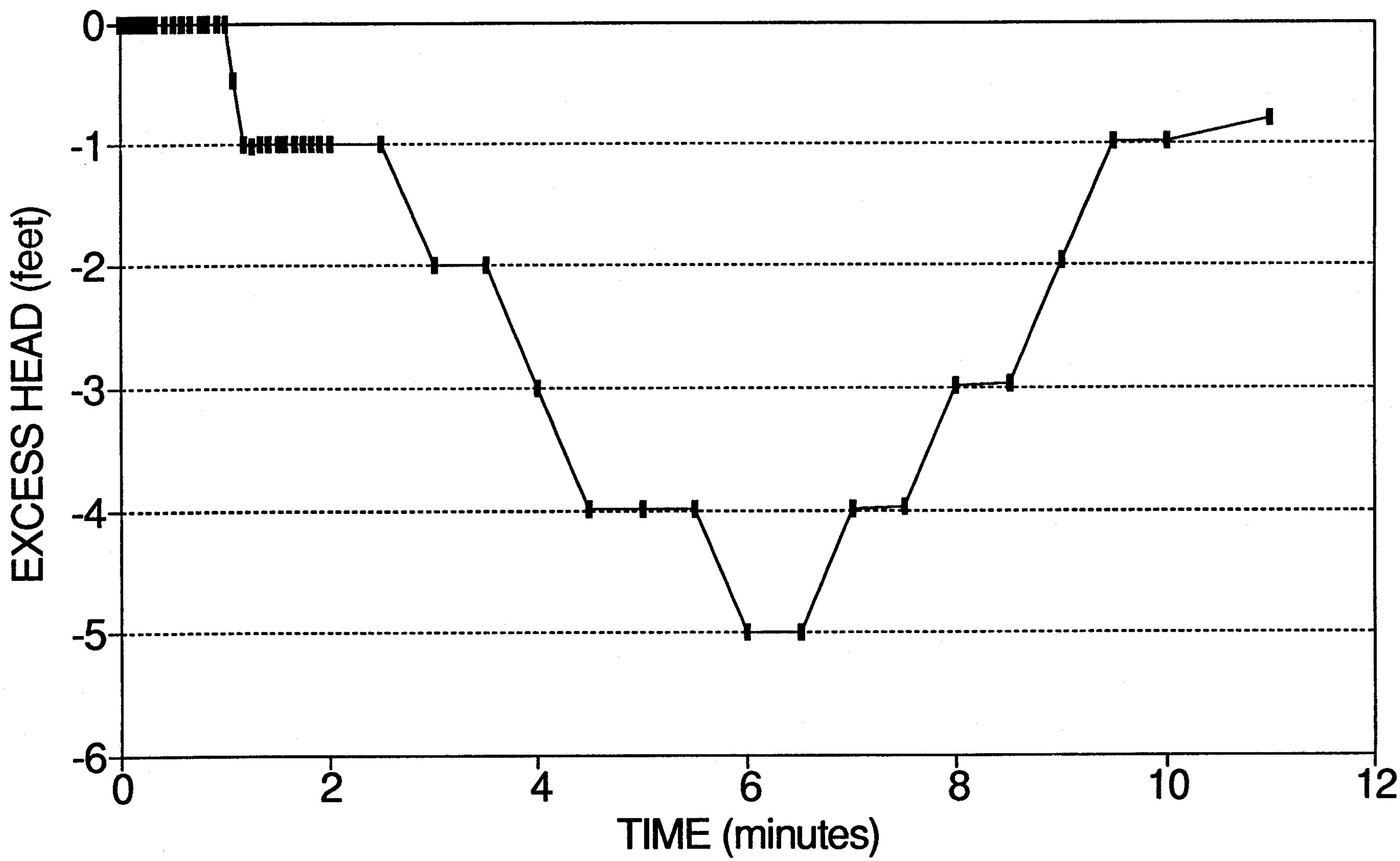
Footnotes:
a = TOWC = top of well casing
b = WD = depth to water from MP
c = MTD = measured total depth from MP
d = Probe End = length beyond measuring point on probe
e = TD = total depth of well from MP

Notes:
- All measurements are relative to Mark Point (MP) = north side of TOWC
- QC review by supervisor is a check of reasonableness
- Measurements 1 and 2 must be within .01 ft of a 3rd measurement must be taken

(4011-600-0022) (GW1-FORM.1A) (09-18-91) (4:18pm)

TEN MINUTE CALIBRATION TEST

31891 - MW02



SLUG TEST DATA FORM

Location OU1 881 Hillside
Name J. Uhlinger, K. Maley
Borehole No. 31891 (MW02)
Groundwater Elevation Before Test (11/4) 18.3' (12/6/91) 19.01'
Test Date 12/6/91
Total Casing Depth 23.667' measured vs 23.5' from Construct. [illegible]
Measuring Point T.O.P PVC casing
Borehole Diameter 11" to 21.5'
Type of Test Slug Inject/Withdrawl
Casing Diameter 2.07"
Transductor Probe Serial No. 265725
Screened Interval 19.1 - 21.1 from MP
Datalogger Test Run No.
Sand Pack Interval 17.1 - 21.5 from MP
(include time and date for identification purposes)
12/6/91 10:17:00 Test 1 MW02-1a.~~DAT~~ TST
12/6/91 10:46:57 TEST 2 MW02-1b.~~DAT~~ TST
12/6/91 11:20:44 TEST 3 MW02-1C.~~DAT~~ TST
Lithology Tested Sandy Clay, sand.

Actual Time	Elapsed Time	Depth to Water from Top of Casing (ft)	H Excess Head (ft)	H/HO

SEE TRANSDUCER RECORDS

(4011-600-0024)(GW4REV.1)(09-11-91)

SLUG INJECTION TEST DATA FORM 31891 - MW02

FILE: MW02_1B.WQ2
TEST DATE: 12/06/91
START TIME: 10:46:57 AM

REFERENCE: 18.01 FT

ELAPSED TIME (min)	HEIGHT OF H20 IN WELL (ft)	EXCESS HEAD (ft)
0	19.485	1.475
0.0083	19.602	1.592
0.0166	19.434	1.424
0.025	19.466	1.456
0.0333	19.51	1.5
0.0416	19.497	1.487
0.05	19.491	1.481
0.0583	19.488	1.478
0.0666	19.485	1.475
0.075	19.481	1.471
0.0833	19.475	1.465
0.1	19.472	1.462
0.1166	19.466	1.456
0.1333	19.459	1.449
0.15	19.453	1.443
0.1666	19.45	1.44
0.1833	19.44	1.43
0.2	19.434	1.424
0.2166	19.431	1.421
0.2333	19.428	1.418
0.25	19.437	1.427
0.2666	19.415	1.405
0.2833	19.409	1.399
0.3	19.403	1.393
0.3166	19.399	1.389
0.3333	19.393	1.383
0.4166	19.368	1.358
0.5	19.346	1.336
0.5833	19.327	1.317
0.6666	19.305	1.295
0.75	19.282	1.272
0.8333	19.264	1.254
0.9166	19.245	1.235
1	19.226	1.216
1.0833	19.207	1.197
1.1666	19.188	1.178
1.25	19.169	1.159
1.3333	19.153	1.143
1.4166	19.134	1.124
1.5	19.118	1.108
1.5833	19.102	1.092
1.6666	19.087	1.077
1.75	19.068	1.058
1.8333	19.058	1.048
1.9166	19.039	1.029

SLUG INJECTION TEST DATA FORM 31891 - MW02

ELAPSED TIME (min)	HEIGHT OF H20 IN WELL (ft)	EXCESS HEAD (ft)
2	19.027	1.017
2.5	18.935	0.925
3	18.85	0.84
3.5	18.777	0.767
4	18.708	0.698
4.5	18.648	0.638
5	18.594	0.584
5.5	18.546	0.536
6	18.499	0.489
6.5	18.461	0.451
7	18.423	0.413
7.5	18.398	0.388
8	18.37	0.36
8.5	18.341	0.331
9	18.319	0.309
9.5	18.294	0.284
10	18.281	0.271
11	18.25	0.24
12	18.221	0.211
13	18.196	0.186
14	18.174	0.164
15	18.158	0.148
16	18.148	0.138
17	18.139	0.129
18	18.13	0.12
19	18.12	0.11
20	18.117	0.107
21	18.107	0.097
22	18.104	0.094
23	18.098	0.088
24	18.095	0.085
25	18.098	0.088
26	18.085	0.075
27	18.085	0.075
28	18.085	0.075
29	18.079	0.069

SLUG WITHDRAWAL TEST DATA FORM 31891 - MW02

FILE: MW02_1C.WQ2
TEST DATE: 12/06/91
START TIME: 11:20:44 AM

REFERENCE: 18.01 FT

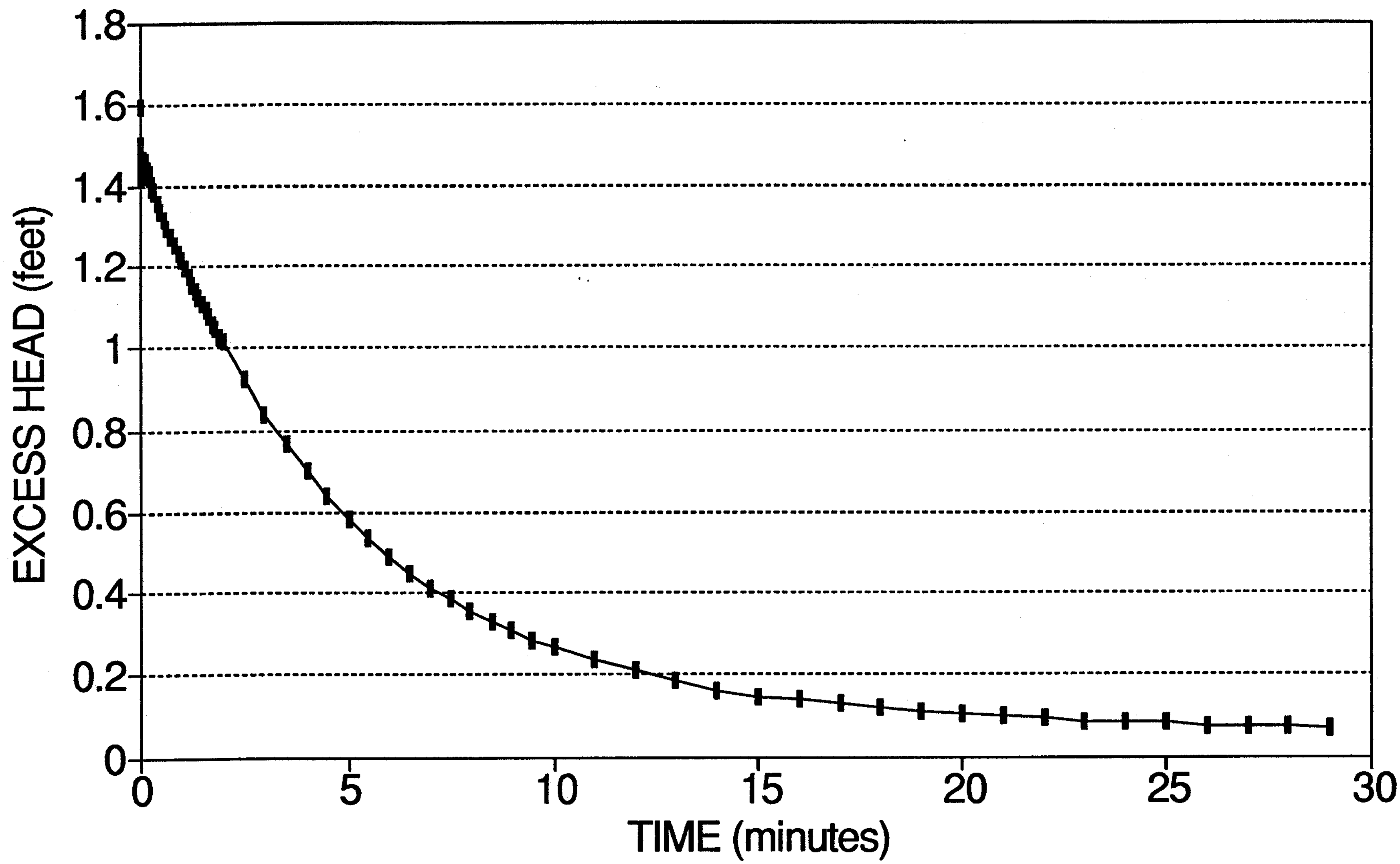
ELAPSED TIME (min)	HEIGHT OF H20 IN WELL (ft)	EXCESS HEAD (ft)
0	16.321	-1.689
0.0083	16.336	-1.674
0.0166	16.352	-1.658
0.025	16.362	-1.648
0.0333	16.368	-1.642
0.0416	16.377	-1.633
0.05	16.387	-1.623
0.0583	16.39	-1.62
0.0666	16.396	-1.614
0.075	16.403	-1.607
0.0833	16.406	-1.604
0.1	16.415	-1.595
0.1166	16.418	-1.592
0.1333	16.431	-1.579
0.15	16.437	-1.573
0.1666	16.362	-1.648
0.1833	16.45	-1.56
0.2	16.45	-1.56
0.2166	16.46	-1.55
0.2333	16.469	-1.541
0.25	16.478	-1.532
0.2666	16.485	-1.525
0.2833	16.491	-1.519
0.3	16.501	-1.509
0.3166	16.507	-1.503
0.3333	16.513	-1.497
0.4166	16.526	-1.484
0.5	16.561	-1.449
0.5833	16.589	-1.421
0.6666	16.621	-1.389
0.75	16.643	-1.367
0.8333	16.668	-1.342
0.9166	16.693	-1.317
1	16.706	-1.304
1.0833	16.738	-1.272
1.1666	16.756	-1.254
1.25	16.782	-1.228
1.3333	16.801	-1.209
1.4166	16.82	-1.19
1.5	16.839	-1.171
1.5833	16.861	-1.149
1.6666	16.88	-1.13
1.75	16.899	-1.111
1.8333	16.918	-1.092
1.9166	16.937	-1.073

SLUG WITHDRAWAL TEST DATA FORM 31891 - MW02

ELAPSED TIME (min)	HEIGHT OF H20 IN WELL (ft)	EXCESS HEAD (ft)
2	16.952	-1.058
2.5	17.063	-0.947
3	17.158	-0.852
3.5	17.243	-0.767
4	17.316	-0.694
4.5	17.385	-0.625
5	17.455	-0.555
5.5	17.499	-0.511
6	17.546	-0.464
6.5	17.587	-0.423
7	17.625	-0.385
7.5	17.66	-0.35
8	17.688	-0.322
8.5	17.717	-0.293
9	17.745	-0.265
9.5	17.767	-0.243
10	17.789	-0.221
11	17.821	-0.189
12	17.846	-0.164
13	17.868	-0.142
14	17.887	-0.123
15	17.906	-0.104
16	17.919	-0.091
17	17.932	-0.078
18	17.938	-0.072
19	17.947	-0.063
20	17.95	-0.06
21	17.957	-0.053
22	17.96	-0.05
23	17.963	-0.047
24	17.966	-0.044
25	17.973	-0.037
26	17.973	-0.037

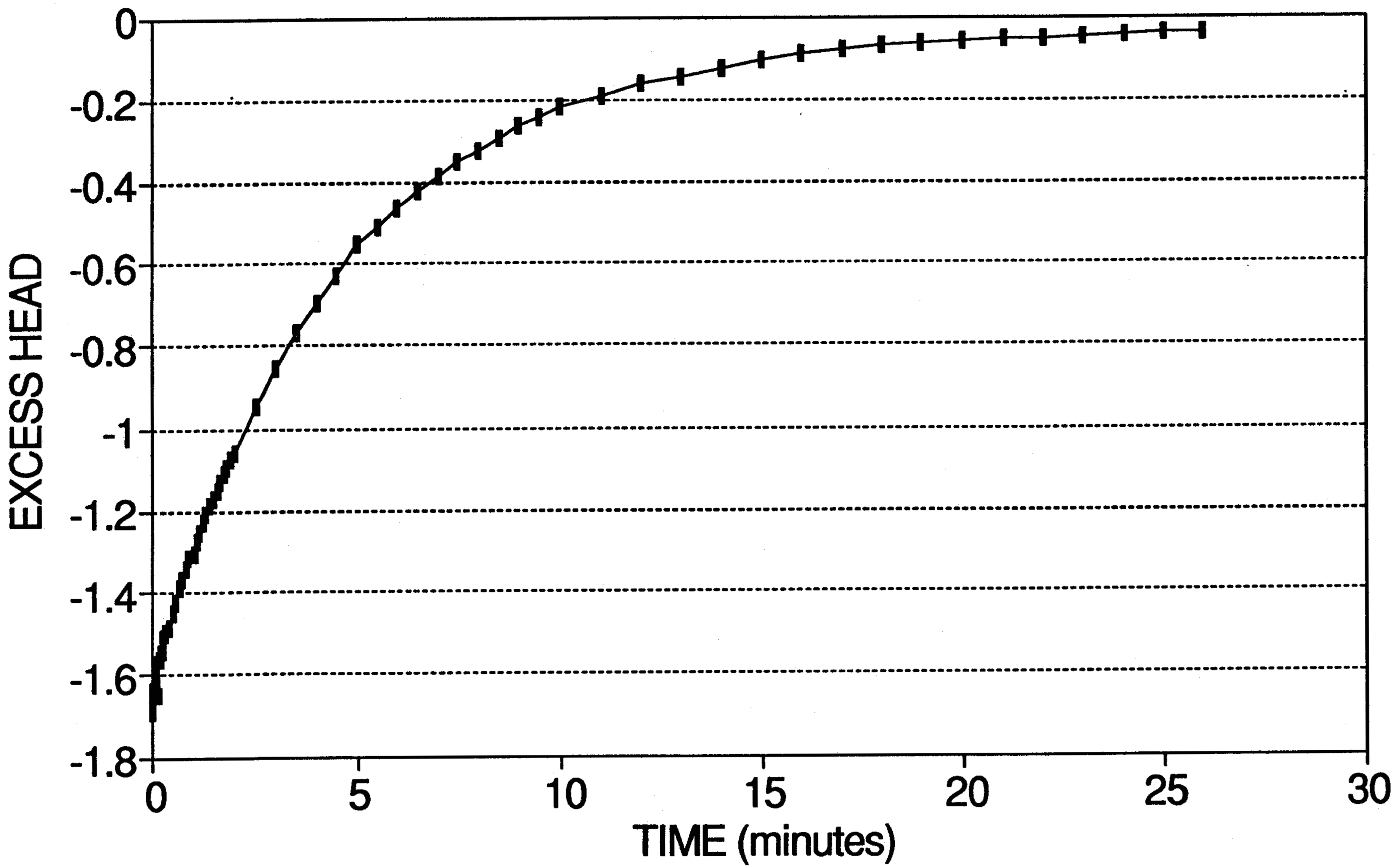
SLUG INJECTION TEST

31891 - MW02



SLUG WITHDRAWAL TEST

31891 - MW02



A Q T E S O L V   R E S U L T S
Version 1.10

03/06/92 11:53:47

TEST DESCRIPTION

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Data set........... mw02inj.dat
Data set title..... SLUG INJECTION TEST 31891 - MW02
Project............ OPERABLE UNIT 1
Client............. EG&G ROCKY FLATS
Location........... 881 HILLSIDE
Test date.......... 12/06/91

Knowns and Constants:
   No. of data points.................. 80
   Radius of well casing............... 0.0863
   Radius of well...................... 0.458
   Aquifer saturated thickness......... 3.09
   Well screen length.................. 1.6
   Static height of water in well...... 2.89
   Log(Re/Rw).......................... 0.9856
   A, B, C.............................  1.668,  0.253,  0.000
```

ANALYTICAL METHOD

Bouwer-Rice (Unconfined Aquifer Slug Test)

RESULTS FROM VISUAL CURVE MATCHING

VISUAL MATCH PARAMETER ESTIMATES

```
           Estimate
   K  =   4.0636E-004
   y0 =   1.4717E+000
```

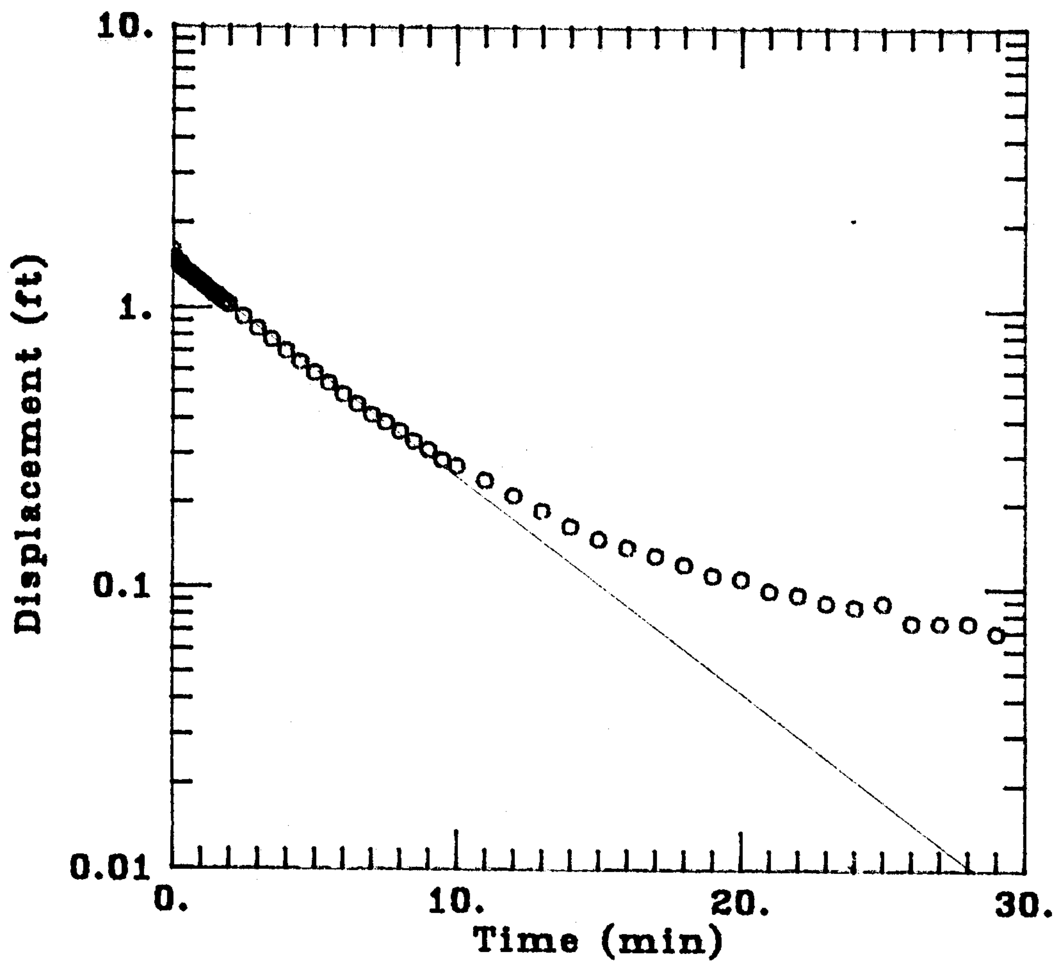
<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<>>

Client: EG&G ROCKY FLATS

Project No.: OPERABLE UNIT 1

Location: 881 HILLSIDE

SLUG INJECTION TEST 31891 – MW02



DATA SET:
mw02inj.dat
03/06/92

AQUIFER TYPE:
Unconfined

SOLUTION METHOD:
Bouwer-Rice

TEST DATE:
12/06/91

ESTIMATED PARAMETERS:
K = 0.0004064 ft/min
y0 = 1.472 ft

TEST DATA:

rc = 0.0863 ft
rw = 0.458 ft
L = 1.6 ft
b = 3.09 ft
H = 2.89 ft

```
                     A Q T E S O L V   R E S U L T S
                             Version  1.10

03/06/92                                                        10:13:20

================================================================================
                            TEST DESCRIPTION

Data set........... mw02wd.dat
Data set title..... SLUG WITHDRAWAL TEST 31891 - MW02
Project............ OPERABLE UNIT 1
Client............. EG&G ROCKY FLATS
Location........... 881 HILLSIDE
Test date.......... 12/06/91

Knowns and Constants:
   No. of data points.................. 77
   Radius of well casing............... 0.0863
   Radius of well...................... 0.458
   Aquifer saturated thickness......... 3.09
   Well screen length.................. 1.6
   Static height of water in well...... 2.89
   Log(Re/Rw).......................... 0.9856
   A, B, C.............................  1.668,   0.253,   0.000

================================================================================
                            ANALYTICAL METHOD

Bouwer-Rice (Unconfined Aquifer Slug Test)

================================================================================
                    RESULTS FROM VISUAL CURVE MATCHING

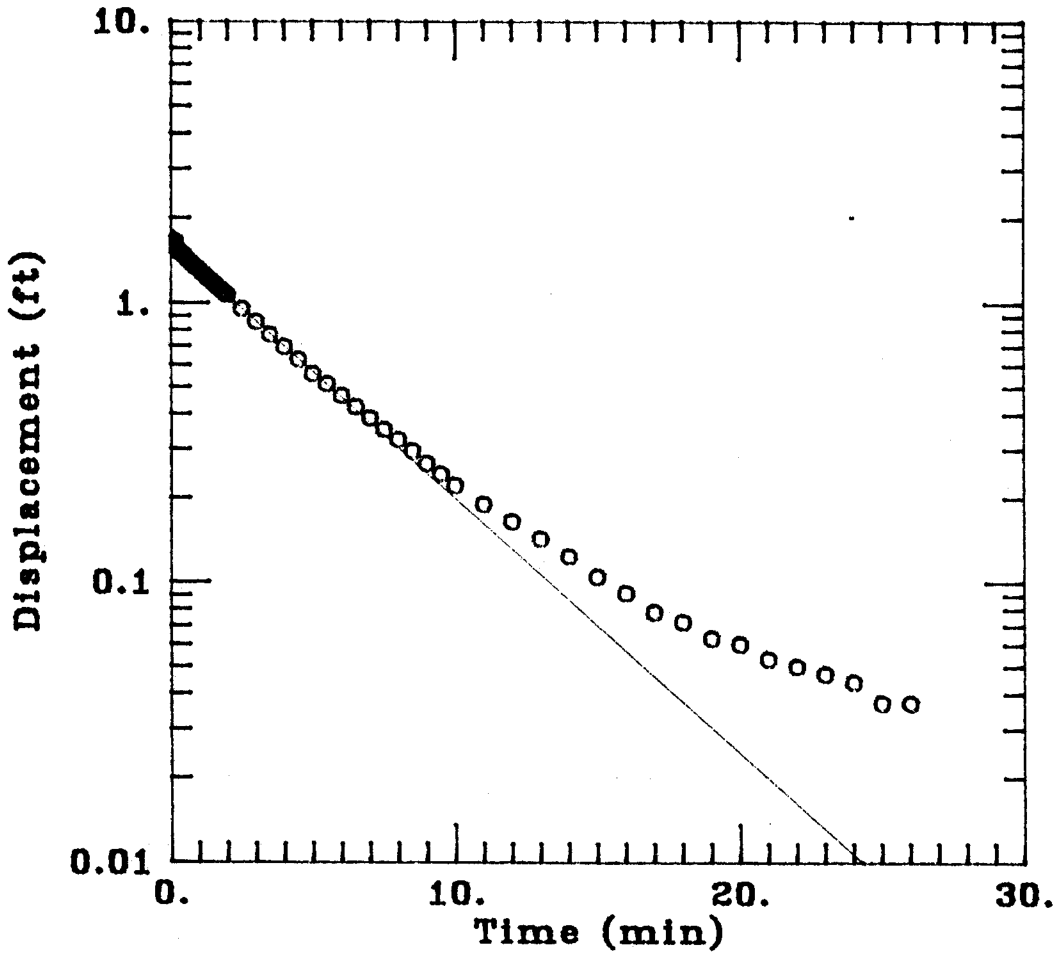
VISUAL MATCH PARAMETER ESTIMATES

          Estimate
   K  =   4.8018E-004
   y0 =   1.6233E+000

<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>
```

	Client: **EG&G ROCKY FLATS**
Project No.: **OPERABLE UNIT 1**	Location: **881 HILLSIDE**

SLUG WITHDRAWAL TEST 31891 – MW02



DATA SET:
mw02wd.dat
03/06/92

AQUIFER TYPE:
Unconfined

SOLUTION METHOD:
Bouwer-Rice

TEST DATE:
12/06/91

ESTIMATED PARAMETERS:
K = 0.0004802 ft/min
y0 = 1.823 ft

TEST DATA:

rc = 0.0863 ft
rw = 0.458 ft
L = 1.6 ft
b = 3.09 ft
H = 2.89 ft

INDEX OF BOREHOLE AND SINGLE WELL TEST DATA AND RESULTS

Borehole, well, or piezometer number: **34791 (MW13)**
(Work plan designation)

Data Available:

__ Packer Test – Set-up

__ Packer Test – Data Sheet (Flow vs. Time Data)

__ Packer Test – Data Logger Output (Head vs. Time Data)

__ Packer Test – Analysis and Results Calculation Sheet

✔ Single Well Test – Record of Initial Water Level Measurement

✔ Single Well Test – 10 Minute Calibration Plot

✔ Single Well Test – Head vs. Time Data Form

✔ Single Well Test – Head vs. Time Response Graph(s)

✔ Single Well Test – Bouwer and Rice Method Analytical Results

__ Single Well Test – Hvorslev Method Analytical Results

U.S. DEPARTMENT OF ENERGY ROCKY FLATS PLANT

FORM GW.1A

GROUNDWATER LEVELS MEASUREMENTS/CALCULATIONS

ROCKY FLATS PROJECT — Revision 1.2

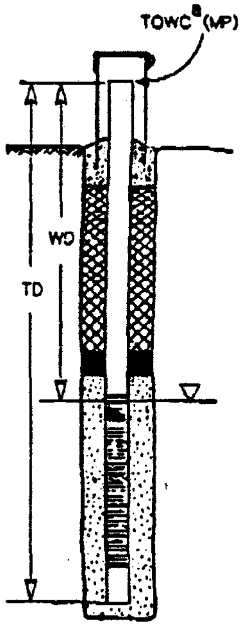
Project No. 881 Hillside OU1

Date 12/20/91

Personnel 1. J. Uhlinger

2. ______

EQUIPMENT:	Manufacturer Solinst	Model ______	Serial No. 10373
CALIBRATION:	Date Passed ______		Date Due ______
QC REVIEW:	Name ______		Date ______



Well No. 34791	WD[b]	MTD[c]	Comments		
Measurement 1	4.94	12.81			
Measurement 2	4.94	12.81			
Measurement 3	4.94	12.81			
	4.94	12.81	+ 0	= 12.81	
	Average WD	Average MTD	Probe End[d]	TD[e]	Chk'd by

Well No.	WD[b]	MTD[c]	Comments		
Measurement 1					
Measurement 2					
Measurement 3					
			+	=	
	Average WD	Average MTD	Probe End[d]	TD[e]	Chk'd by

Well No.	WD[b]	MTD[c]	Comments		
Measurement 1					
Measurement 2					
Measurement 3					
			+	=	
	Average WD	Average MTD	Probe End[d]	TD[e]	Chk'd by

Footnotes:

A = TOWC = top of well casing
b = WD = depth to water from MP
c = MTD = measured total depth from MP
d = Probe End = length beyond measuring point on probe
e = TD = total depth of well from MP

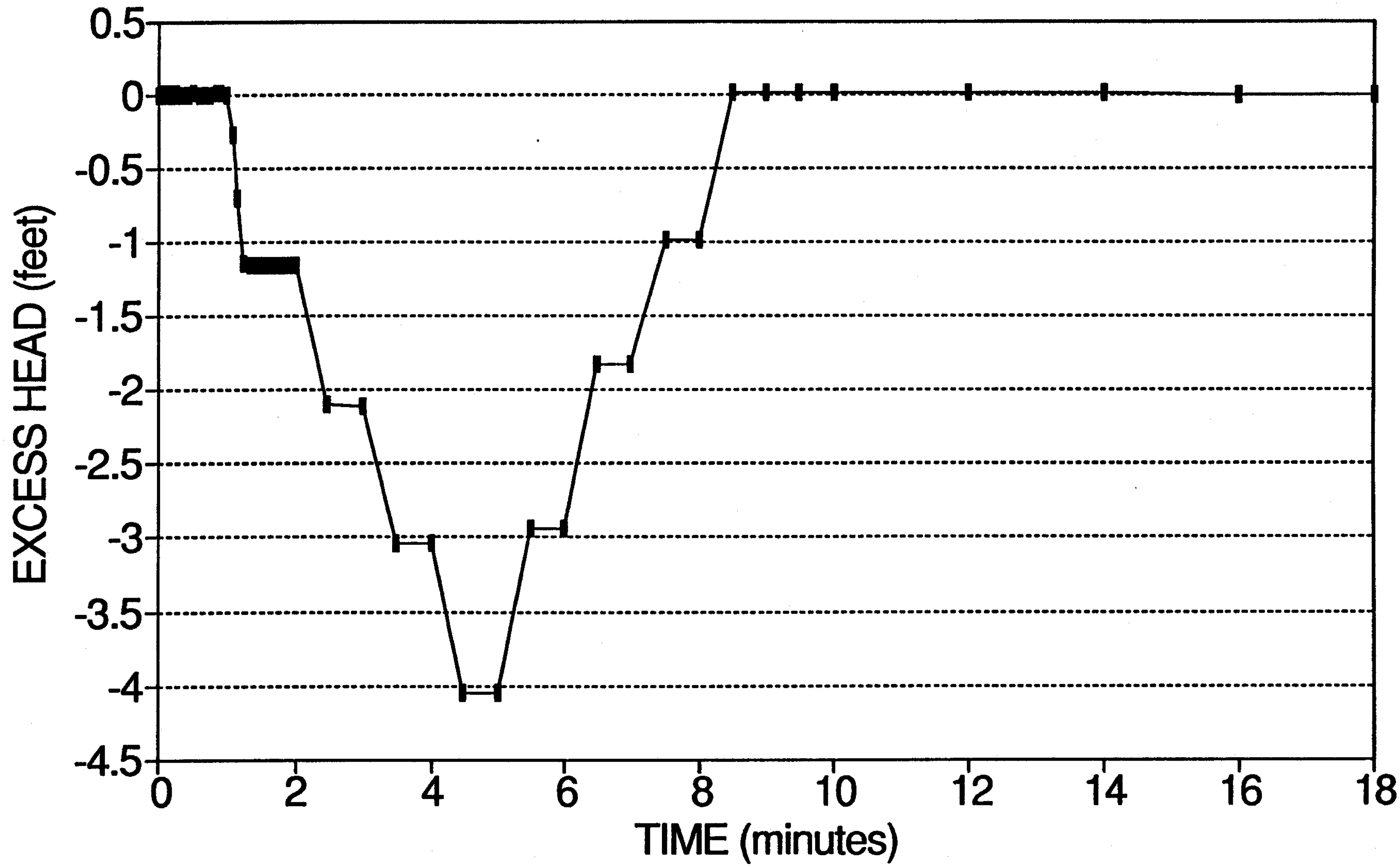
Notes:

- All measurements are relative to Mark Point (MP) = north side of TOWC
- QC review by supervisor is a check of reasonableness
- Measurements 1 and 2 must be within .01 ft of a 3rd measurement must be taken

(4011-600-0022) (GW1-FORM.1A) (09-18-91) (4:18pm)

TEN MINUTE CALIBRATION TEST

34791 - MW13



SLUG TEST DATA FORM

Location 881 Hillside
Borehole No. 34791 MW13
Test Date 12/20/91
Measuring Point Top PVC Casing
Type of Test Slug inj/withdrawal
Transductor Probe Serial No. 323235
Datalogger Test Run No. ____
(include time and date for identification purposes)
MW13_1a.TST
MW13_1b.TST
MW13_1c.TST

Name J. UHLINGER
Groundwater Elevation Before Test 4.94'
Total Casing Depth 12.81'
Borehole Diameter 11"
Casing Diameter 2.07"
Screened Interval 10.5 - 8.5
Sand Pack Interval 13.5 - 8.4
Lithology Tested Sandy gravel

Actual Time	Elapsed Time	Depth to Water from Top of Casing (ft)	H Excess Head (ft)	H/HO

See FD Records

SLUG INJECTION TEST DATA FORM 34791 - MW13

FILE: MW13_1B.WQ2
TEST DATE: 12/20/91
START TIME: 08:28:035 AM

REFERENCE: 4.80 FT

ELAPSED TIME (min)	DEPTH TO H20 FROM TOC (ft)	EXCESS HEAD (ft)
0	2.806	1.994
0.0083	2.587	2.213
0.0166	2.701	2.099
0.025	2.708	2.092
0.0333	2.685	2.115
0.0416	2.689	2.111
0.05	2.695	2.105
0.0583	2.692	2.108
0.0666	2.695	2.105
0.075	2.695	2.105
0.0833	2.695	2.105
0.1	2.714	2.086
0.1166	2.698	2.102
0.1333	2.695	2.105
0.15	2.701	2.099
0.1666	2.698	2.102
0.1833	2.698	2.102
0.2	2.698	2.102
0.2166	2.701	2.099
0.2333	2.701	2.099
0.25	2.701	2.099
0.2666	2.701	2.099
0.2833	2.701	2.099
0.3	2.704	2.096
0.3166	2.701	2.099
0.3333	2.701	2.099
0.4166	2.704	2.096
0.5	2.708	2.092
0.5833	2.708	2.092
0.6666	2.711	2.089
0.75	2.714	2.086
0.8333	2.711	2.089
0.9166	2.714	2.086
1	2.717	2.083
1.0833	2.717	2.083
1.1666	2.720	2.080
1.25	2.720	2.080
1.3333	2.723	2.077
1.4166	2.723	2.077
1.5	2.727	2.073
1.5833	2.727	2.073
1.6666	2.727	2.073
1.75	2.730	2.070
1.8333	2.730	2.070
1.9166	2.733	2.067

SLUG INJECTION TEST DATA FORM 34791 - MW13

ELAPSED TIME (min)	DEPTH TO H20 FROM TOC (ft)	EXCESS HEAD (ft)
2	2.733	2.067
2.5	2.749	2.051
3	2.762	2.038
3.5	2.774	2.026
4	2.787	2.013
4.5	2.800	2.000
5	2.816	1.984
5.5	2.832	1.968
6	2.844	1.956
6.5	2.860	1.940
7	2.873	1.927
7.5	2.889	1.911
8	2.898	1.902
8.5	2.917	1.883
9	2.917	1.883
9.5	2.946	1.854
10	2.959	1.841
12	3.013	1.787
14	3.067	1.733
16	3.118	1.682
18	3.169	1.631
20	3.216	1.584
22	3.267	1.533
24	3.318	1.482
26	3.378	1.422
28	3.452	1.348
30	3.518	1.282
32	3.582	1.218
34	3.642	1.158
36	3.696	1.104
38	3.728	1.072
40	3.744	1.056
42	3.757	1.043
44	3.769	1.031
46	3.782	1.018
48	3.798	1.002
50	3.811	0.989
52	3.827	0.973
54	3.839	0.961
56	3.852	0.948
58	3.865	0.935
60	3.878	0.922
62	3.890	0.910
64	3.903	0.897
66	3.916	0.884

SLUG INJECTION TEST DATA FORM 34791 - MW13

ELAPSED TIME (min)	DEPTH TO H20 FROM TOC (ft)	EXCESS HEAD (ft)
68	3.928	0.872
70	3.941	0.859
72	3.951	0.849
74	3.963	0.837
76	3.976	0.824
78	3.986	0.814
80	3.998	0.802
82	4.008	0.792
84	4.021	0.779
86	4.033	0.767
88	4.043	0.757
90	4.052	0.748
92	4.062	0.738
94	4.075	0.725
96	4.084	0.716
98	4.091	0.709
100	4.103	0.697
110	4.151	0.649
120	4.195	0.605
130	4.237	0.563
140	4.275	0.525
150	4.310	0.490
160	4.342	0.458
170	4.374	0.426
180	4.402	0.398
190	4.428	0.372
200	4.453	0.347
210	4.478	0.322
220	4.504	0.296
230	4.523	0.277
240	4.542	0.258
250	4.564	0.236
260	4.580	0.220
270	4.596	0.204

SLUG WITHDRAWL TEST DATA FORM 34791 - MW13

FILE: MW13_1C.WQ2
TEST DATE: 12/20/91
START TIME: 12:59:58 PM

REFERENCE: 4.80 FT

ELAPSED TIME (min)	DEPTH TO H20 FROM TOC (ft)	EXCESS HEAD (ft)
0	6.758	-1.958
0.0083	6.754	-1.954
0.0166	6.754	-1.954
0.025	6.754	-1.954
0.0333	6.754	-1.954
0.0416	6.751	-1.951
0.05	6.748	-1.948
0.0583	6.745	-1.945
0.0666	6.745	-1.945
0.075	6.745	-1.945
0.0833	6.745	-1.945
0.1	6.742	-1.942
0.1166	6.742	-1.942
0.1333	6.754	-1.954
0.15	6.754	-1.954
0.1666	6.735	-1.935
0.1833	6.739	-1.939
0.2	6.735	-1.935
0.2166	6.735	-1.935
0.2333	6.735	-1.935
0.25	6.735	-1.935
0.2666	6.735	-1.935
0.2833	6.732	-1.932
0.3	6.732	-1.932
0.3166	6.732	-1.932
0.3333	6.732	-1.932
0.4166	6.729	-1.929
0.5	6.716	-1.916
0.5833	6.713	-1.913
0.6666	6.710	-1.910
0.75	6.710	-1.910
0.8333	6.707	-1.907
0.9166	6.704	-1.904
1	6.704	-1.904
1.0833	6.700	-1.900
1.1666	6.700	-1.900
1.25	6.697	-1.897
1.3333	6.697	-1.897
1.4166	6.694	-1.894
1.5	6.691	-1.891
1.5833	6.691	-1.891
1.6666	6.688	-1.888
1.75	6.688	-1.888
1.8333	6.688	-1.888
1.9166	6.685	-1.885

SLUG WITHDRAWL TEST DATA FORM 34791 - MW13

ELAPSED TIME (min)	DEPTH TO H20 FROM TOC (ft)	EXCESS HEAD (ft)
2	6.681	-1.881
2.5	6.675	-1.875
3	6.665	-1.865
3.5	6.662	-1.862
4	6.656	-1.856
4.5	6.650	-1.850
5	6.646	-1.846
5.5	6.640	-1.840
6	6.634	-1.834
6.5	6.627	-1.827
7	6.624	-1.824
7.5	6.618	-1.818
8	6.615	-1.815
8.5	6.608	-1.808
9	6.602	-1.802
9.5	6.599	-1.799
10	6.592	-1.792
12	6.573	-1.773
14	6.557	-1.757
16	6.532	-1.732
18	6.522	-1.722
20	6.507	-1.707
22	6.491	-1.691
24	6.475	-1.675
26	6.459	-1.659
28	6.440	-1.640
30	6.427	-1.627
32	6.411	-1.611
34	6.398	-1.598
36	6.379	-1.579
38	6.367	-1.567
40	6.351	-1.551
42	6.338	-1.538
44	6.319	-1.519
46	6.306	-1.506
48	6.290	-1.490
50	6.278	-1.478
52	6.268	-1.468
54	6.249	-1.449
56	6.240	-1.440
58	6.224	-1.424
60	6.211	-1.411
62	6.198	-1.398
64	6.185	-1.385
66	6.173	-1.373

SLUG WITHDRAWL TEST DATA FORM 34791 - MW13

ELAPSED TIME (min)	DEPTH TO H20 FROM TOC (ft)	EXCESS HEAD (ft)
68	6.157	-1.357
70	6.147	-1.347
72	6.135	-1.335
74	6.122	-1.322
76	6.112	-1.312
78	6.096	-1.296
80	6.087	-1.287
82	6.074	-1.274
84	6.061	-1.261
86	6.052	-1.252
88	6.039	-1.239
90	6.027	-1.227
92	6.014	-1.214
94	6.004	-1.204
96	5.992	-1.192
98	5.982	-1.182
100	5.969	-1.169
110	5.918	-1.118
120	5.864	-1.064
130	5.814	-1.014
140	5.766	-0.966
150	5.718	-0.918
160	5.674	-0.874
170	5.632	-0.832
180	5.591	-0.791
190	5.553	-0.753
200	5.515	-0.715
210	5.477	-0.677
220	5.448	-0.648
230	5.416	-0.616
240	5.388	-0.588
250	5.356	-0.556
260	5.334	-0.534
270	5.305	-0.505
280	5.283	-0.483
290	5.260	-0.460
300	5.238	-0.438
310	5.222	-0.422
320	5.203	-0.403
330	5.184	-0.384
340	5.168	-0.368
350	5.149	-0.349
360	5.136	-0.336
370	5.124	-0.324
380	5.111	-0.311

SLUG WITHDRAWL TEST DATA FORM 34791 - MW13

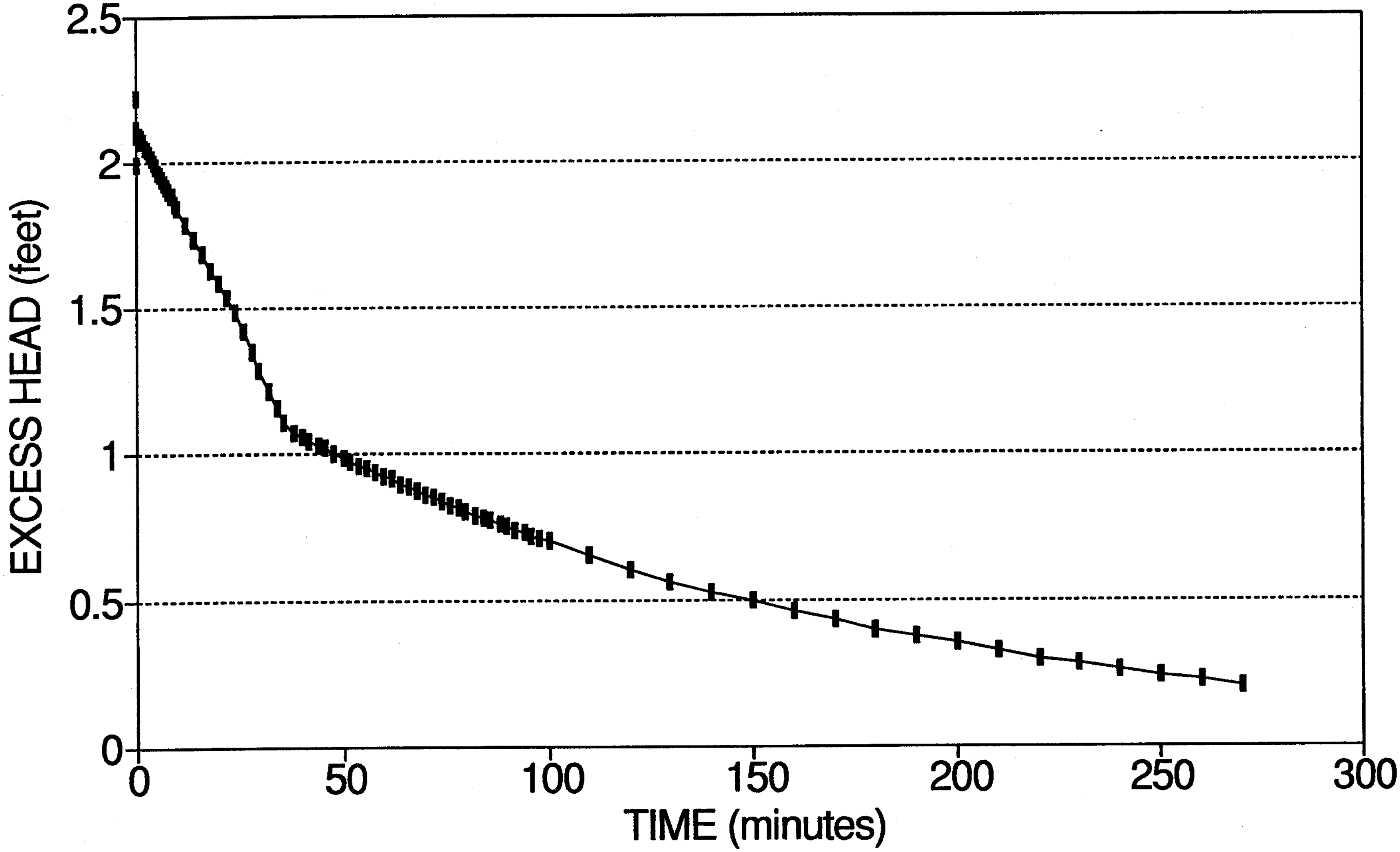
ELAPSED TIME (min)	DEPTH TO H20 FROM TOC (ft)	EXCESS HEAD (ft)
390	5.098	-0.298
400	5.086	-0.286
410	5.076	-0.276
420	5.067	-0.267
430	5.057	-0.257
440	5.051	-0.251
450	5.038	-0.238
460	5.032	-0.232
470	5.022	-0.222
480	5.019	-0.219
490	5.012	-0.212
500	5.006	-0.206
510	5.000	-0.200
520	4.993	-0.193
530	4.984	-0.184
540	4.981	-0.181
550	4.978	-0.178
560	4.974	-0.174
570	4.971	-0.171
580	4.968	-0.168
590	4.962	-0.162
600	4.958	-0.158
610	4.955	-0.155
620	4.952	-0.152
630	4.946	-0.146
640	4.939	-0.139
650	4.936	-0.136
660	4.930	-0.130
670	4.927	-0.127
680	4.920	-0.120
690	4.917	-0.117
700	4.914	-0.114
710	4.911	-0.111
720	4.904	-0.104
730	4.898	-0.098
740	4.901	-0.101
750	4.895	-0.095
760	4.895	-0.095
770	4.895	-0.095
780	4.889	-0.089
790	4.889	-0.089
800	4.889	-0.089
810	4.889	-0.089
820	4.889	-0.089
830	4.885	-0.085

SLUG WITHDRAWL TEST DATA FORM 34791 - MW13

ELAPSED TIME (min)	DEPTH TO H20 FROM TOC (ft)	EXCESS HEAD (ft)
840	4.882	-0.082
850	4.879	-0.079
860	4.879	-0.079
870	4.879	-0.079
880	4.873	-0.073
890	4.876	-0.076
900	4.873	-0.073
910	4.869	-0.069
920	4.866	-0.066
930	4.863	-0.063
940	4.863	-0.063
950	4.863	-0.063
960	4.860	-0.060
970	4.857	-0.057
980	4.857	-0.057
990	4.857	-0.057
1000	4.854	-0.054
1010	4.847	-0.047
1020	4.850	-0.050
1030	4.847	-0.047
1040	4.850	-0.050
1050	4.847	-0.047
1060	4.844	-0.044
1070	4.841	-0.041
1080	4.841	-0.041
1090	4.841	-0.041
1100	4.841	-0.041
1110	4.841	-0.041
1120	4.838	-0.038
1130	4.838	-0.038
1140	4.841	-0.041
1150	4.841	-0.041
1160	4.838	-0.038
1170	4.838	-0.038

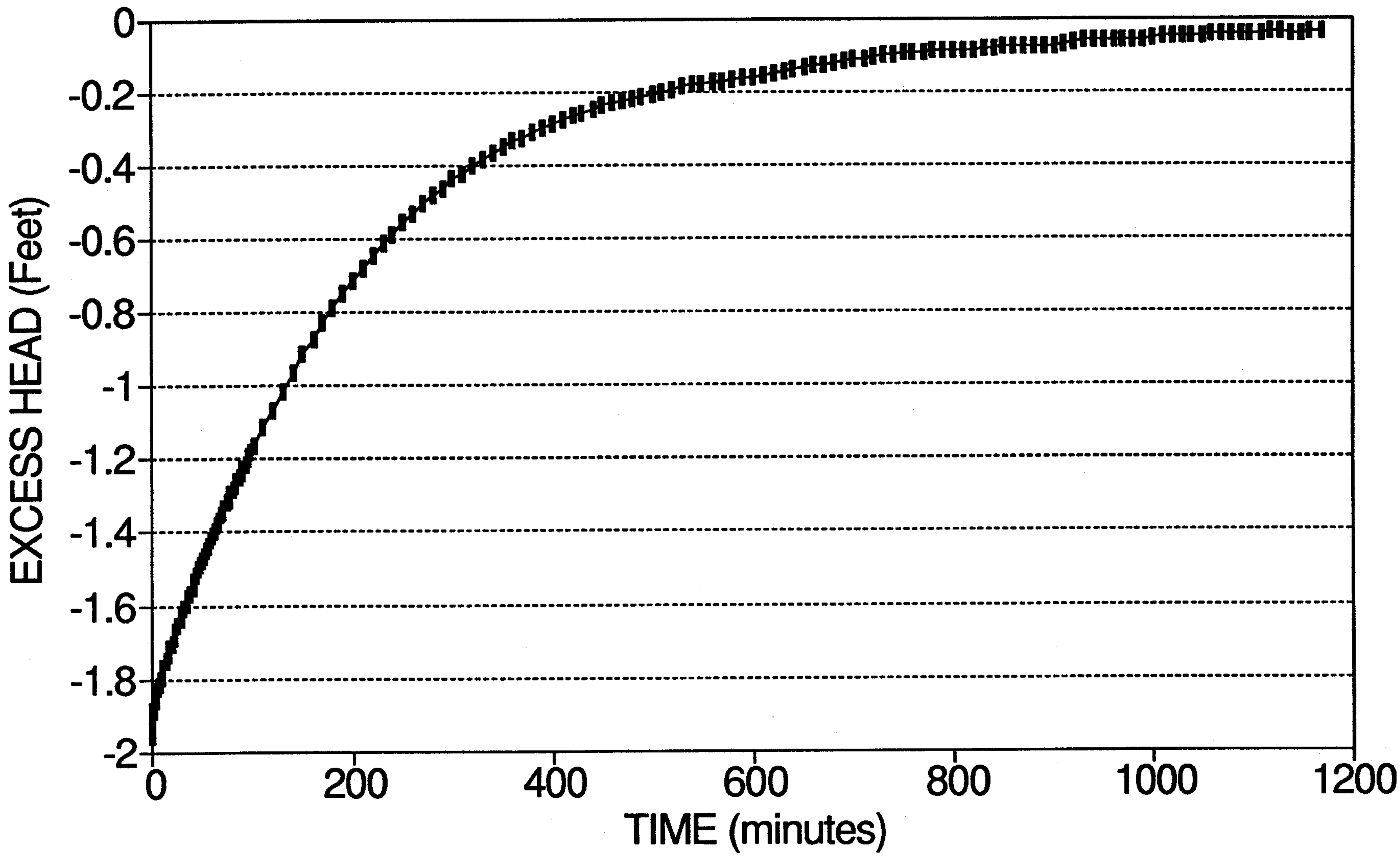
SLUG INJECTION TEST

34791 - MW13



SLUG WITHDRAWAL TEST

34791 - MW13



A Q T E S O L V   R E S U L T S
Version 1.10

06/05/92 09:58:55

==

TEST DESCRIPTION

Data set........... MW13INJ.DAT
Data set title..... SLUG INJECTION TEST 34791 - MW13
Project............ OPERABLE UNIT 1
Client............. EG&G ROCKY FLATS
Location........... 881 HILLSIDE
Test date.......... 12/20/91

Knowns and Constants:

No. of data points.................. 123
Radius of well casing............... 0.0863
Radius of well...................... 0.458
Aquifer saturated thickness......... 5.56
Well screen length.................. 1.54
Static height of water in well...... 5.28
Log(Re/Rw).......................... 1.102
A, B, C............................. 1.663, 0.253, 0.000

==

ANALYTICAL METHOD

Bouwer-Rice (Unconfined Aquifer Slug Test)

==

RESULTS FROM VISUAL CURVE MATCHING

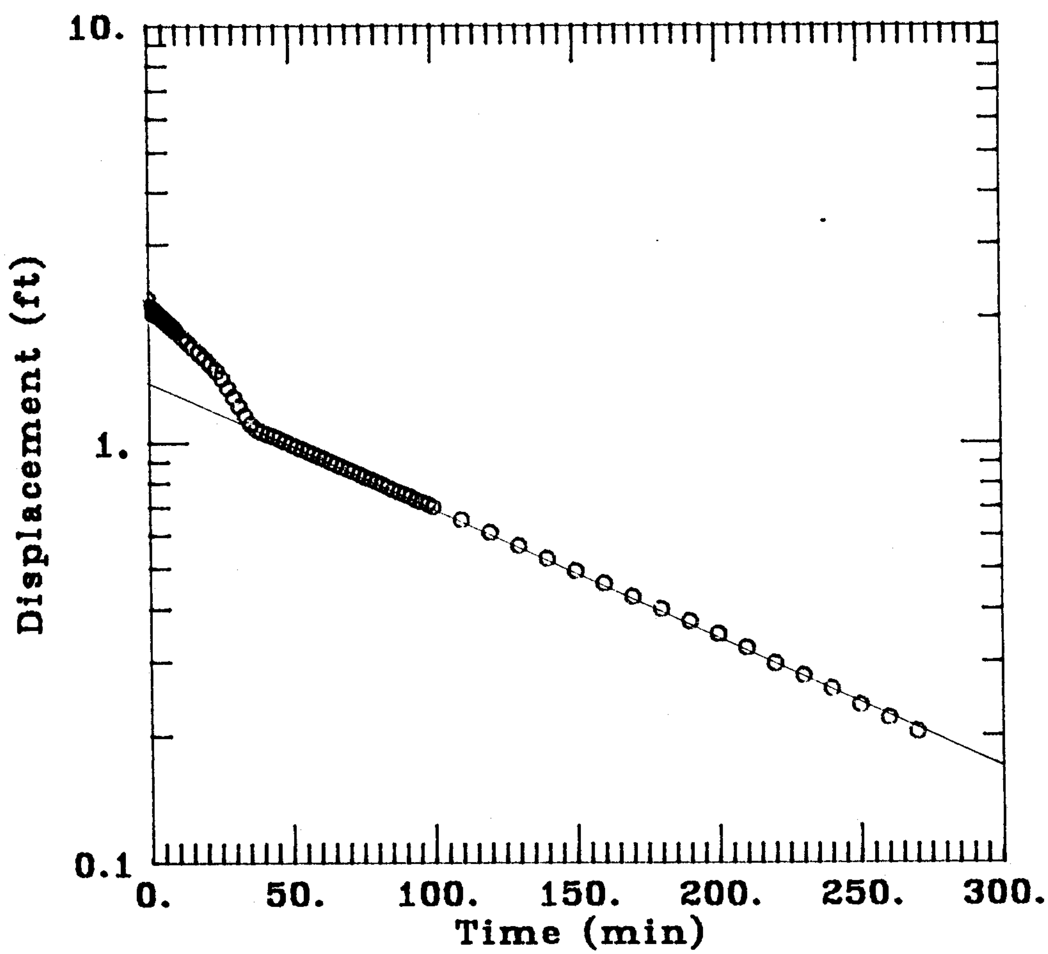
VISUAL MATCH PARAMETER ESTIMATES

	Estimate
K =	1.8752E-005
y0 =	1.4044E+000

<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>

Project No.: OPERABLE UNIT 1	Client: EG&G ROCKY FLATS Location: 881 HILLSIDE

SLUG INJECTION TEST 34791 - MW13



DATA SET:
MW13INJ.DAT
06/05/92

AQUIFER TYPE:
Unconfined
SOLUTION METHOD:
Bouwer-Rice
TEST DATE:
12/20/91

ESTIMATED PARAMETERS:
K = 1.8752E-05 ft/min
y0 = 1.404 ft

TEST DATA:

rc = 0.0863 ft
rw = 0.458 ft
L = 1.54 ft
b = 5.56 ft
H = 5.28 ft

A Q T E S O L V   R E S U L T S
Version 1.10

03/12/92 12:57:59

==

TEST DESCRIPTION

Data set........... mw13wd.dat
Data set title..... SLUG WITHDRAWAL TEST 34791 - MW13
Project............ OPERABLE UNIT 1
Client............. EG&G ROCKY FLATS
Location........... 881 HILLSIDE
Test date.......... 12/20/91

Knowns and Constants:
No. of data points.................. 213
Radius of well casing............... 0.0863
Radius of well...................... 0.458
Aquifer saturated thickness......... 5.56
Well screen length.................. 1.54
Static height of water in well...... 5.28
Log(Re/Rw).......................... 1.102
A, B, C............................. 1.663, 0.253, 0.000

==

ANALYTICAL METHOD

Bouwer-Rice (Unconfined Aquifer Slug Test)

==

RESULTS FROM VISUAL CURVE MATCHING

VISUAL MATCH PARAMETER ESTIMATES

	Estimate
K =	1.2726E-005
y0 =	1.9061E+000

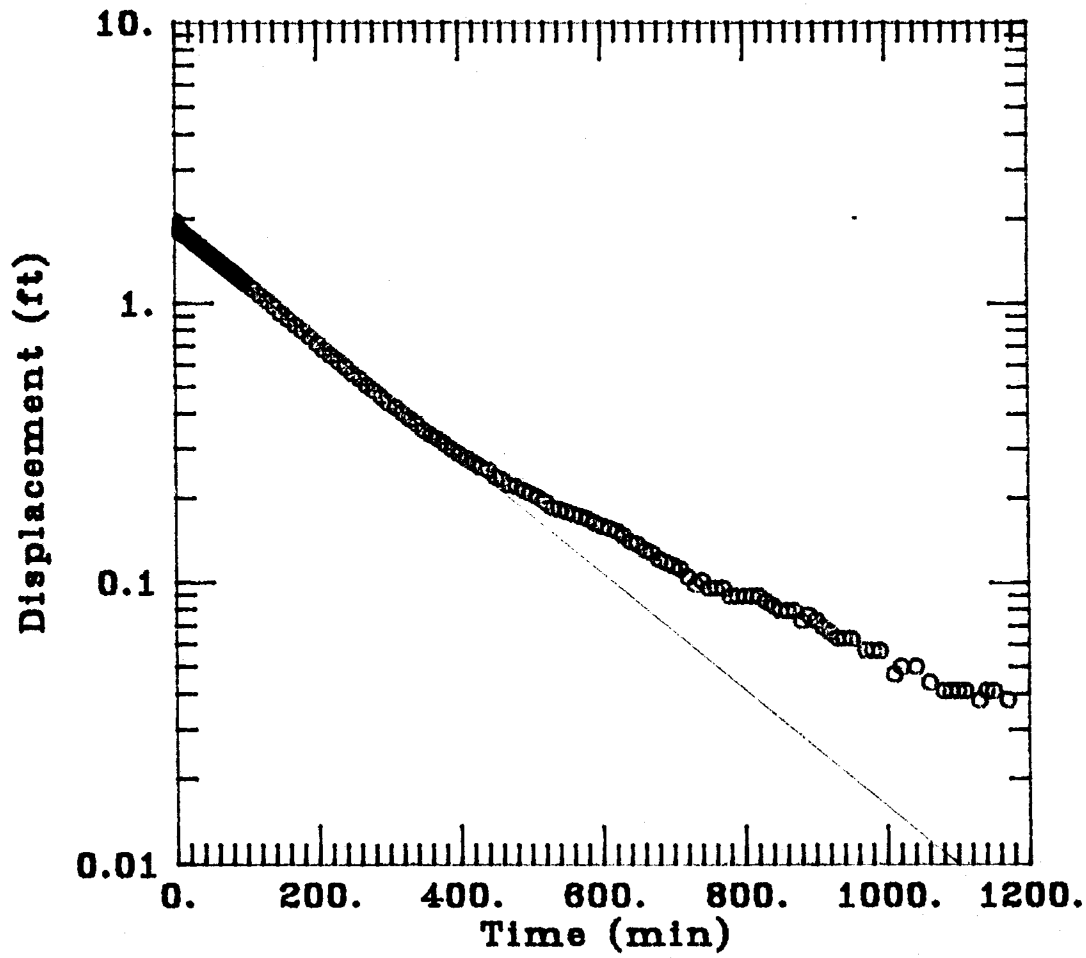
<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<>>

Project No.: **OPERABLE UNIT 1**

Client: **EG&G ROCKY FLATS**

Location: **881 HILLSIDE**

SLUG WITHDRAWAL TEST 34791 – MW13



DATA SET:
MW13WD.DAT
03/06/92

AQUIFER TYPE:
Unconfined

SOLUTION METHOD:
Bouwer-Rice

TEST DATE:
12/20/91

ESTIMATED PARAMETERS:
K = 1.2726E-05 ft/min
y0 = 1.906 ft

TEST DATA:

rc = 0.0863 ft
rw = 0.458 ft
L = 1.54 ft
b = 5.56 ft
H = 5.28 ft

INDEX OF BOREHOLE AND SINGLE WELL TEST DATA AND RESULTS

Borehole, well, or piezometer number: **35691 (MW17)**
(Work plan designation)

Data Available:

__ Packer Test – Set-up

__ Packer Test – Data Sheet (Flow vs. Time Data)

__ Packer Test – Data Logger Output (Head vs. Time Data)

__ Packer Test – Analysis and Results Calculation Sheet

✔ Single Well Test – Record of Initial Water Level Measurement

✔ Single Well Test – 10 Minute Calibration Plot

✔ Single Well Test – Head vs. Time Data Form

✔ Single Well Test – Head vs. Time Response Graph(s)

✔ Single Well Test —Bouwer and Rice Method Analytical Results

✔ S ingle Well Test – Hvorslev Method Analytical Results

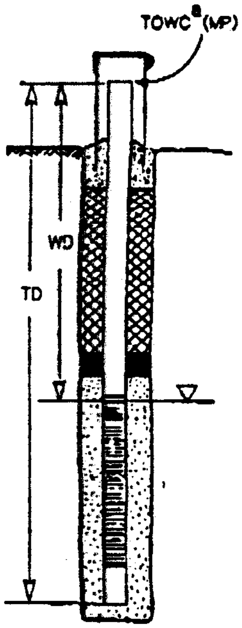
U.S. DEPARTMENT OF ENERGY ROCKY FLATS PLANT

FORM GW.1A

GROUNDWATER LEVELS MEASUREMENTS/CALCULATIONS

ROCKY FLATS PROJECT Revision 1.2
Project No. 881 Hillside OU1
Date 12/6/91
Personnel 1. J. Uhlinger
2. K. Maley

EQUIPMENT:	Manufacturer Solinst	Model		Serial No. ~~002~~ 10373 (SFU 12/6/91)	
CALIBRATION:	Date Passed		Date Due		
QC REVIEW:	Name		Date		



Well No. 35691	WD[b]	MTD[c]	Comments
Measurement 1	12.04'	~~12.~~ 30.46 (SFU 12/6/91)	K. Maley
Measurement 2	12.04'	30.46	J. Uhlinger
Measurement 3	12.04'	30.46'	K. Maley
	12.04' Average WD	30.46' Average MTD	+ 0 Probe End[d] = 30.46' TD[e] ____ Chk'd by

Well No.	WD[b]	MTD[c]	Comments
Measurement 1			
Measurement 2			
Measurement 3			
	Average WD	Average MTD	+ ____ Probe End[d] = ____ TD[e] ____ Chk'd by

Well No.	WD[b]	MTD[c]	Comments
Measurement 1			
Measurement 2			
Measurement 3			
	Average WD	Average MTD	+ ____ Probe End[d] = ____ TD[e] ____ Chk'd by

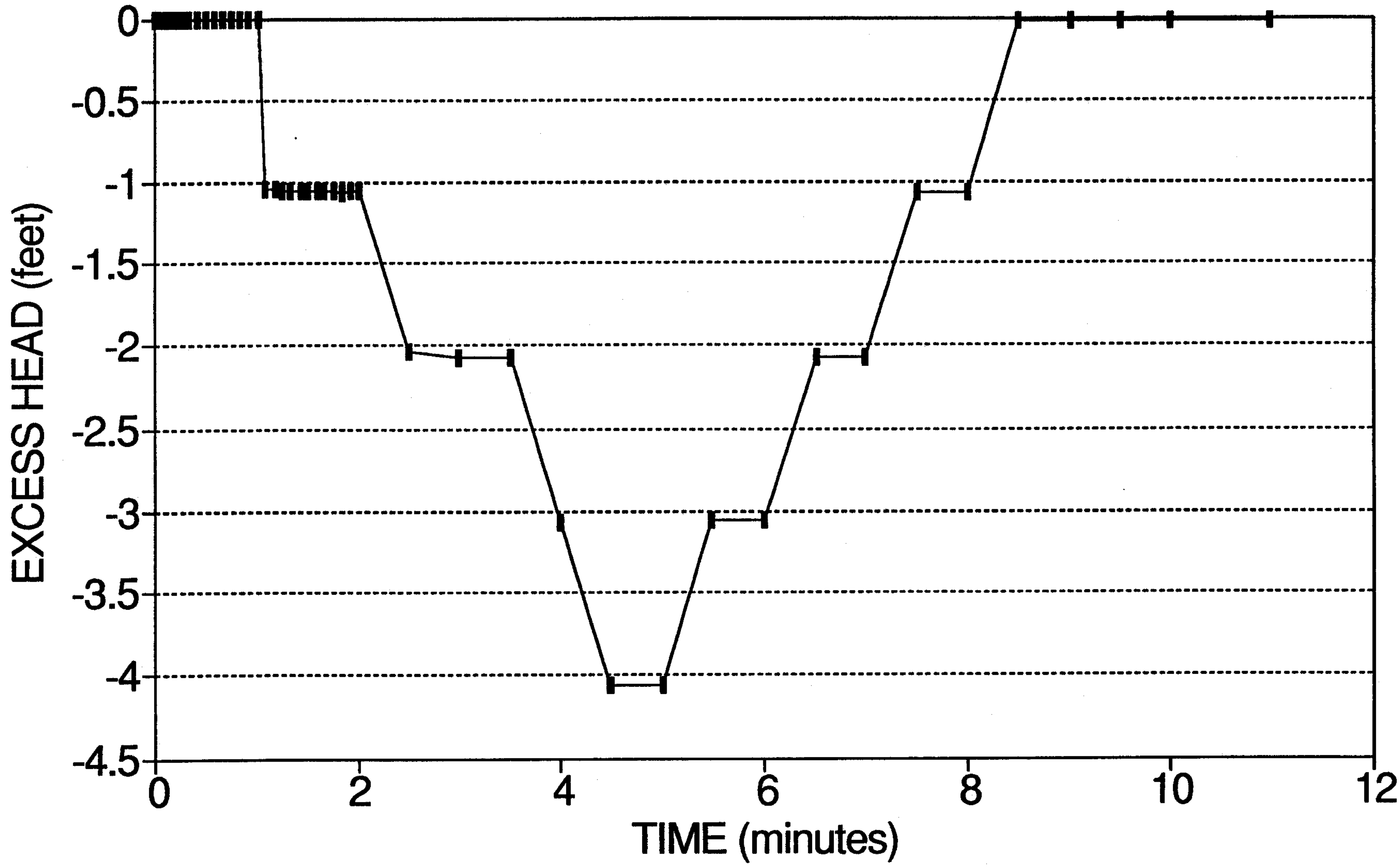
Footnotes:
A = TOWC = top of well casing
b = WD = depth to water from MP
c = MTD = measured total depth from MP
d = Probe End = length beyond measuring point on probe
e = TD = total depth of well from MP

Notes:
- All measurements are relative to Mark Point (MP) = north side of TOWC
- QC review by supervisor is a check of reasonableness
- Measurements 1 and 2 must be within .01 ft of a 3rd measurement must be taken

(4011-600-0022) (GW1-FORM.1A) (09-18-91) (4:18pm)

TEN MINUTE CALIBRATION TEST

35691 - MW17



SLUG TEST DATA FORM

Location 881 Hillside
Borehole No. 35691 ALMU MW17
Test Date 12/6/91 & 12/7/91
Measuring Point TOP PVC Casing
Type of Test Slug inj/withdrawal
Transductor Probe Serial No. 265825
Datalogger Test Run No.
(include time and date for identification purposes) MW17-1a.TST MW17-1b.TST MW17-1c.TST

Name J. Uhlinger, K. Maley
Groundwater Elevation Before Test 12.04' measured
Total Casing Depth 30.46' measured
Borehole Diameter 11" to 26'
Casing Diameter 2.07"
Screened Interval 18.28-29.26'
Sand Pack Interval 16.1'-31.66'
Lithology Tested silty clay, clayey gravel and sand

Actual Time	Elapsed Time	Depth to Water from Top of Casing (ft)	H Excess Head (ft)	H/HO

See FX Records

SLUG INJECTION TEST DATA FORM 35691 - MW17

FILE: MW17_1BE.WQ2
TEST DATE: 12/06/91
START TIME: 14:20:01 AM

H0: 1.5049 FT
REFERENCE: 20 FT

ELAPSED TIME (min)	DEPTH TO H20 FROM TOC (ft)	EXCESS HEAD (ft)	H/H0
0	21.449	1.449	0.96
0.0083	21.61	1.61	1.07
0.0166	21.721	1.721	1.14
0.025	21.667	1.667	1.11
0.0333	21.547	1.547	1.03
0.0416	21.49	1.49	0.99
0.05	21.519	1.519	1.01
0.0583	21.582	1.582	1.05
0.0666	21.61	1.61	1.07
0.075	21.585	1.585	1.05
0.0833	21.55	1.55	1.03
0.1	21.55	1.55	1.03
0.1166	21.573	1.573	1.05
0.1333	21.554	1.554	1.03
0.15	21.554	1.554	1.03
0.1666	21.557	1.557	1.03
0.1833	21.55	1.55	1.03
0.2	21.554	1.554	1.03
0.2166	21.554	1.554	1.03
0.2333	21.55	1.55	1.03
0.25	21.55	1.55	1.03
0.2666	21.55	1.55	1.03
0.2833	21.547	1.547	1.03
0.3	21.547	1.547	1.03
0.3166	21.547	1.547	1.03
0.3333	21.547	1.547	1.03
0.4166	21.544	1.544	1.03
0.5	21.544	1.544	1.03
0.5833	21.541	1.541	1.02
0.6666	21.541	1.541	1.02
0.75	21.538	1.538	1.02
0.8333	21.538	1.538	1.02
0.9166	21.535	1.535	1.02
1	21.535	1.535	1.02
1.0833	21.532	1.532	1.02
1.1666	21.532	1.532	1.02
1.25	21.532	1.532	1.02
1.3333	21.532	1.532	1.02
1.4166	21.528	1.528	1.02
1.5	21.528	1.528	1.02
1.5833	21.528	1.528	1.02
1.6666	21.525	1.525	1.01
1.75	21.525	1.525	1.01
1.8333	21.525	1.525	1.01
1.9166	21.522	1.522	1.01

SLUG INJECTION TEST DATA FORM 35691 - MW17

ELAPSED TIME (min)	DEPTH TO H20 FROM TOC (ft)	EXCESS HEAD (ft)	H/H0
2	21.522	1.522	1.01
2.5	21.513	1.513	1.01
3	21.509	1.509	1.00
3.5	21.503	1.503	1.00
4	21.5	1.5	1.00
4.5	21.497	1.497	0.99
5	21.494	1.494	0.99
5.5	21.487	1.487	0.99
6	21.487	1.487	0.99
6.5	21.487	1.487	0.99
7	21.481	1.481	0.98
7.5	21.478	1.478	0.98
8	21.475	1.475	0.98
8.5	21.475	1.475	0.98
9	21.471	1.471	0.98
9.5	21.468	1.468	0.98
10	21.468	1.468	0.98
12	21.462	1.462	0.97
14	21.456	1.456	0.97
16	21.446	1.446	0.96
18	21.44	1.44	0.96
20	21.43	1.43	0.95
22	21.427	1.427	0.95
24	21.415	1.415	0.94
26	21.411	1.411	0.94
28	21.405	1.405	0.93
30	21.402	1.402	0.93
32	21.396	1.396	0.93
34	21.389	1.389	0.92
36	21.383	1.383	0.92
38	21.377	1.377	0.92
40	21.37	1.37	0.91
42	21.364	1.364	0.91
44	21.361	1.361	0.90
46	21.348	1.348	0.90
48	21.345	1.345	0.89
50	21.342	1.342	0.89
52	21.336	1.336	0.89
54	21.333	1.333	0.89
56	21.326	1.326	0.88
58	21.323	1.323	0.88
60	21.317	1.317	0.88
62	21.31	1.31	0.87
64	21.304	1.304	0.87
66	21.298	1.298	0.86

SLUG INJECTION TEST DATA FORM 35691 - MW17

ELAPSED TIME (min)	DEPTH TO H20 FROM TOC (ft)	EXCESS HEAD (ft)	H/H0
68	21.295	1.295	0.86
70	21.288	1.288	0.86
72	21.282	1.282	0.85
74	21.276	1.276	0.85
76	21.272	1.272	0.85
78	21.266	1.266	0.84
80	21.266	1.266	0.84
82	21.257	1.257	0.84
84	21.25	1.25	0.83
86	21.247	1.247	0.83
88	21.238	1.238	0.82
90	21.241	1.241	0.82
92	21.235	1.235	0.82
94	21.228	1.228	0.82
96	21.225	1.225	0.81
98	21.222	1.222	0.81
100	21.212	1.212	0.81
110	21.194	1.194	0.79
120	21.168	1.168	0.78
130	21.146	1.146	0.76
140	21.124	1.124	0.75
150	21.105	1.105	0.73
160	21.083	1.083	0.72
170	21.064	1.064	0.71
180	21.045	1.045	0.69
190	21.023	1.023	0.68
200	21.004	1.004	0.67
210	20.985	0.985	0.65
220	20.969	0.969	0.64
230	20.95	0.95	0.63
240	20.935	0.935	0.62
250	20.919	0.919	0.61
260	20.903	0.903	0.60
270	20.89	0.89	0.59
280	20.874	0.874	0.58
290	20.862	0.862	0.57
300	20.846	0.846	0.56
310	20.83	0.83	0.55
320	20.818	0.818	0.54
330	20.805	0.805	0.53
340	20.789	0.789	0.52
350	20.777	0.777	0.52
360	20.761	0.761	0.51
370	20.751	0.751	0.50
380	20.739	0.739	0.49

SLUG INJECTION TEST DATA FORM 35691 - MW17

ELAPSED TIME (min)	DEPTH TO H20 FROM TOC (ft)	EXCESS HEAD (ft)	H/H0
390	20.726	0.726	0.48
400	20.717	0.717	0.48
410	20.701	0.701	0.47
420	20.691	0.691	0.46
430	20.682	0.682	0.45
440	20.672	0.672	0.45
450	20.657	0.657	0.44
460	20.647	0.647	0.43
470	20.634	0.634	0.42
480	20.628	0.628	0.42
490	20.615	0.615	0.41
500	20.606	0.606	0.40
510	20.593	0.593	0.39
520	20.587	0.587	0.39
530	20.578	0.578	0.38
540	20.568	0.568	0.38
550	20.562	0.562	0.37
560	20.552	0.552	0.37
570	20.546	0.546	0.36
580	20.536	0.536	0.36
590	20.53	0.53	0.35
600	20.524	0.524	0.35
610	20.518	0.518	0.34
620	20.511	0.511	0.34
630	20.505	0.505	0.34
640	20.499	0.499	0.33
650	20.492	0.492	0.33
660	20.489	0.489	0.32
670	20.483	0.483	0.32
680	20.473	0.473	0.31
690	20.464	0.464	0.31
700	20.461	0.461	0.31
710	20.454	0.454	0.30
720	20.448	0.448	0.30
730	20.442	0.442	0.29
740	20.435	0.435	0.29
750	20.432	0.432	0.29
760	20.426	0.426	0.28
770	20.42	0.42	0.28
780	20.413	0.413	0.27
790	20.407	0.407	0.27
800	20.401	0.401	0.27
810	20.401	0.401	0.27
820	20.398	0.398	0.26
830	20.391	0.391	0.26

SLUG INJECTION TEST DATA FORM 35691 - MW17

ELAPSED TIME (min)	DEPTH TO H20 FROM TOC (ft)	EXCESS HEAD (ft)	H/H0
840	20.388	0.388	0.26
850	20.388	0.388	0.26
860	20.382	0.382	0.25
870	20.379	0.379	0.25
880	20.375	0.375	0.25
890	20.369	0.369	0.25
900	20.366	0.366	0.24
910	20.36	0.36	0.24
920	20.356	0.356	0.24
930	20.35	0.35	0.23
940	20.347	0.347	0.23
950	20.344	0.344	0.23
960	20.341	0.341	0.23
970	20.334	0.334	0.22
980	20.331	0.331	0.22
990	20.328	0.328	0.22
1000	20.325	0.325	0.22
1010	20.319	0.319	0.21
1020	20.315	0.315	0.21
1030	20.312	0.312	0.21
1040	20.309	0.309	0.21
1050	20.303	0.303	0.20
1060	20.3	0.3	0.20
1070	20.293	0.293	0.19

SLUG WITHDRAWAL TEST DATA FORM 35691 - MW17

FILE: MW17_1CE.WQ2
TEST DATE: 12/07/91
START TIME: 08:23:16 AM

H0: -1.245 FT
REFERENCE: 20 FT

ELAPSED TIME (min)	DEPTH TO H20 FROM TOC (ft)	EXCESS HEAD (ft)	H/H0
0	18.796	-1.204	0.97
0.0083	18.711	-1.289	1.04
0.0166	18.543	-1.457	1.17
0.025	18.648	-1.352	1.09
0.0333	18.723	-1.277	1.03
0.0416	18.673	-1.327	1.07
0.05	18.644	-1.356	1.09
0.0583	18.701	-1.299	1.04
0.0666	18.717	-1.283	1.03
0.075	18.682	-1.318	1.06
0.0833	18.663	-1.337	1.07
0.1	18.701	-1.299	1.04
0.1166	18.685	-1.315	1.06
0.1333	18.711	-1.289	1.04
0.15	18.708	-1.292	1.04
0.1666	18.717	-1.283	1.03
0.1833	18.717	-1.283	1.03
0.2	18.72	-1.28	1.03
0.2166	18.72	-1.28	1.03
0.2333	18.723	-1.277	1.03
0.25	18.723	-1.277	1.03
0.2666	18.723	-1.277	1.03
0.2833	18.727	-1.273	1.02
0.3	18.727	-1.273	1.02
0.3166	18.73	-1.27	1.02
0.3333	18.73	-1.27	1.02
0.4166	18.733	-1.267	1.02
0.5	18.736	-1.264	1.02
0.5833	18.736	-1.264	1.02
0.6666	18.739	-1.261	1.01
0.75	18.739	-1.261	1.01
0.8333	18.742	-1.258	1.01
0.9166	18.742	-1.258	1.01
1	18.742	-1.258	1.01
1.0833	18.745	-1.255	1.01
1.1666	18.745	-1.255	1.01
1.25	18.749	-1.251	1.00
1.3333	18.749	-1.251	1.00
1.4166	18.749	-1.251	1.00
1.5	18.749	-1.251	1.00
1.5833	18.752	-1.248	1.00
1.6666	18.752	-1.248	1.00
1.75	18.752	-1.248	1.00
1.8333	18.752	-1.248	1.00
1.9166	18.755	-1.245	1.00

SLUG WITHDRAWAL TEST DATA FORM 35691 - MW17

ELAPSED TIME (min)	DEPTH TO H20 FROM TOC (ft)	EXCESS HEAD (ft)	H/H0
2	18.755	-1.245	1.00
2.5	18.761	-1.239	1.00
3	18.764	-1.236	0.99
3.5	18.764	-1.236	0.99
4	18.768	-1.232	0.99
4.5	18.771	-1.229	0.99
5	18.777	-1.223	0.98
5.5	18.777	-1.223	0.98
6	18.78	-1.22	0.98
6.5	18.787	-1.213	0.97
7	18.79	-1.21	0.97
7.5	18.793	-1.207	0.97
8	18.809	-1.191	0.96
8.5	18.799	-1.201	0.96
9	18.799	-1.201	0.96
9.5	18.802	-1.198	0.96
10	18.802	-1.198	0.96
12	18.809	-1.191	0.96
14	18.815	-1.185	0.95
16	18.821	-1.179	0.95
18	18.824	-1.176	0.94
20	18.831	-1.169	0.94
22	18.834	-1.166	0.94
24	18.837	-1.163	0.93
26	18.843	-1.157	0.93
28	18.847	-1.153	0.93
30	18.85	-1.15	0.92
32	18.853	-1.147	0.92
34	18.856	-1.144	0.92
36	18.859	-1.141	0.92
38	18.862	-1.138	0.91
40	18.869	-1.131	0.91
42	18.872	-1.128	0.91
44	18.878	-1.122	0.90
46	18.881	-1.119	0.90
48	18.884	-1.116	0.90
50	18.894	-1.106	0.89
52	18.897	-1.103	0.89
54	18.897	-1.103	0.89
56	18.894	-1.106	0.89
58	18.897	-1.103	0.89
60	18.9	-1.1	0.88
62	18.903	-1.097	0.88
64	18.907	-1.093	0.88
66	18.91	-1.09	0.88

SLUG WITHDRAWAL TEST DATA FORM 35691 - MW17

ELAPSED TIME (min)	DEPTH TO H20 FROM TOC (ft)	EXCESS HEAD (ft)	H/H0
68	18.916	-1.084	0.87
70	18.919	-1.081	0.87
72	18.922	-1.078	0.87
74	18.929	-1.071	0.86
76	18.935	-1.065	0.86
78	18.935	-1.065	0.86
80	18.938	-1.062	0.85
82	18.941	-1.059	0.85
84	18.944	-1.056	0.85
86	18.944	-1.056	0.85
88	18.948	-1.052	0.84
90	18.951	-1.049	0.84
92	18.954	-1.046	0.84
94	18.957	-1.043	0.84
96	18.96	-1.04	0.84
98	18.963	-1.037	0.83
100	18.967	-1.033	0.83
110	18.982	-1.018	0.82
120	19.011	-0.989	0.79
130	19.02	-0.98	0.79
140	19.039	-0.961	0.77
150	19.052	-0.948	0.76
160	19.071	-0.929	0.75
170	19.093	-0.907	0.73
180	19.106	-0.894	0.72
190	19.125	-0.875	0.70
200	19.143	-0.857	0.69
210	19.159	-0.841	0.68
220	19.172	-0.828	0.67
230	19.185	-0.815	0.65
240	19.2	-0.8	0.64
250	19.213	-0.787	0.63
260	19.226	-0.774	0.62
270	19.241	-0.759	0.61
280	19.248	-0.752	0.60
290	19.257	-0.743	0.60
300	19.27	-0.73	0.59
310	19.279	-0.721	0.58
320	19.289	-0.711	0.57
330	19.298	-0.702	0.56
340	19.308	-0.692	0.56
350	19.32	-0.68	0.55
360	19.327	-0.673	0.54
370	19.336	-0.664	0.53
380	19.342	-0.658	0.53

SLUG WITHDRAWAL TEST DATA FORM 35691 - MW17

ELAPSED TIME (min)	DEPTH TO H20 FROM TOC (ft)	EXCESS HEAD (ft)	H/H0
390	19.352	-0.648	0.52
400	19.361	-0.639	0.51
410	19.368	-0.632	0.51
420	19.374	-0.626	0.50
430	19.38	-0.62	0.50
440	19.387	-0.613	0.49
450	19.396	-0.604	0.49
460	19.402	-0.598	0.48
470	19.412	-0.588	0.47
480	19.418	-0.582	0.47
490	19.425	-0.575	0.46
500	19.431	-0.569	0.46
510	19.437	-0.563	0.45
520	19.444	-0.556	0.45
530	19.45	-0.55	0.44
540	19.453	-0.547	0.44
550	19.459	-0.541	0.43
560	19.466	-0.534	0.43
570	19.472	-0.528	0.42
580	19.475	-0.525	0.42
590	19.478	-0.522	0.42
600	19.485	-0.515	0.41
610	19.488	-0.512	0.41
620	19.497	-0.503	0.40
630	19.5	-0.5	0.40
640	19.504	-0.496	0.40
650	19.51	-0.49	0.39
660	19.516	-0.484	0.39
670	19.523	-0.477	0.38
680	19.526	-0.474	0.38
690	19.532	-0.468	0.38
700	19.535	-0.465	0.37
710	19.541	-0.459	0.37
720	19.545	-0.455	0.37
730	19.551	-0.449	0.36
740	19.554	-0.446	0.36
750	19.56	-0.44	0.35
760	19.567	-0.433	0.35
770	19.57	-0.43	0.35
780	19.576	-0.424	0.34
790	19.579	-0.421	0.34
800	19.583	-0.417	0.33
810	19.586	-0.414	0.33
820	19.592	-0.408	0.33
830	19.595	-0.405	0.33

SLUG WITHDRAWAL TEST DATA FORM 35691 - MW17

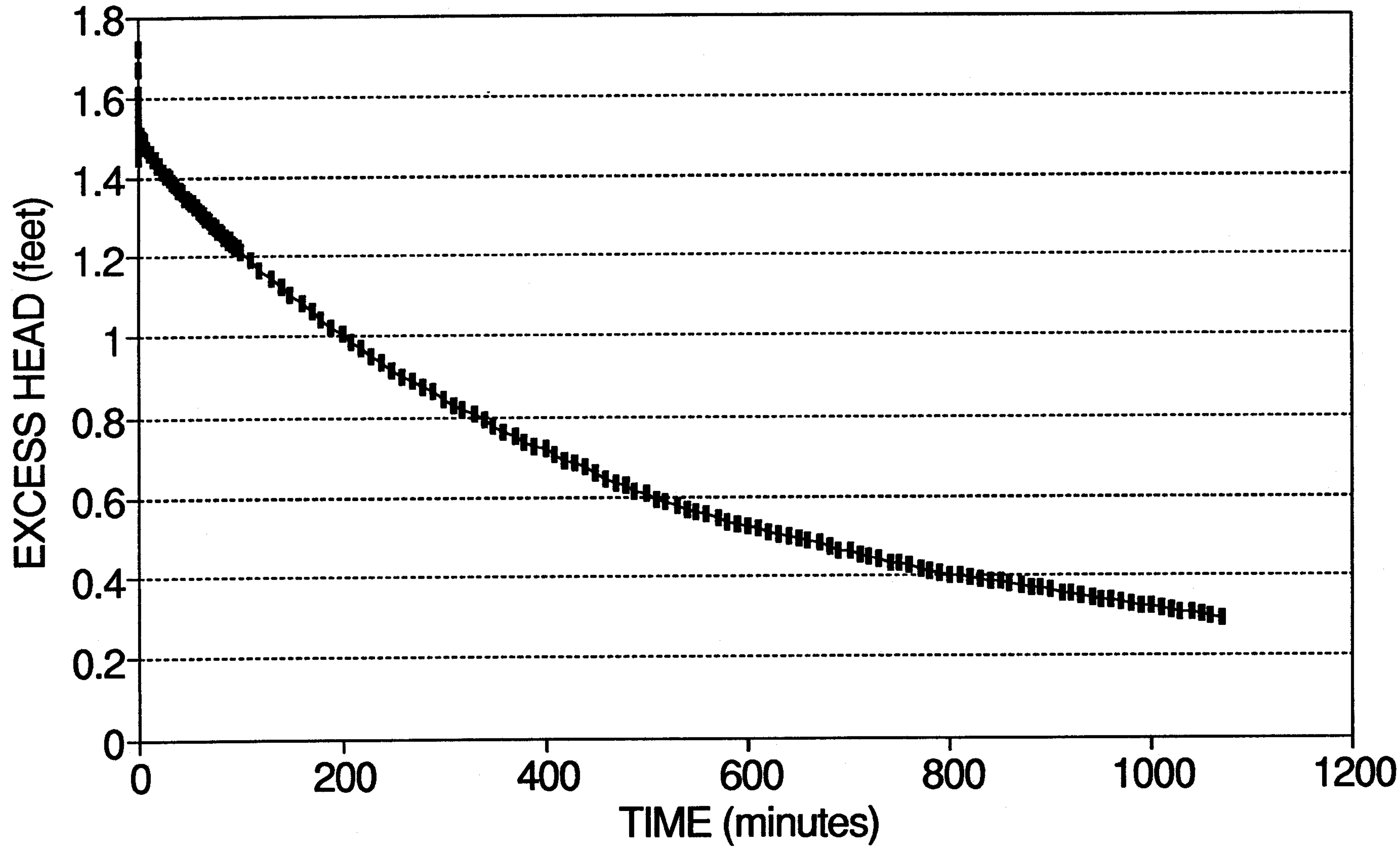
ELAPSED TIME (min)	DEPTH TO H20 FROM TOC (ft)	EXCESS HEAD (ft)	H/H0
840	19.598	-0.402	0.32
850	19.601	-0.399	0.32
860	19.605	-0.395	0.32
870	19.608	-0.392	0.31
880	19.611	-0.389	0.31
890	19.611	-0.389	0.31
900	19.614	-0.386	0.31
910	19.617	-0.383	0.31
920	19.62	-0.38	0.31
930	19.627	-0.373	0.30
940	19.627	-0.373	0.30
950	19.63	-0.37	0.30
960	19.633	-0.367	0.29
970	19.639	-0.361	0.29
980	19.643	-0.357	0.29
990	19.643	-0.357	0.29
1000	19.646	-0.354	0.28
1010	19.652	-0.348	0.28
1020	19.655	-0.345	0.28
1030	19.658	-0.342	0.27
1040	19.658	-0.342	0.27
1050	19.665	-0.335	0.27
1060	19.665	-0.335	0.27
1070	19.671	-0.329	0.26
1080	19.674	-0.326	0.26
1090	19.674	-0.326	0.26
1100	19.68	-0.32	0.26
1110	19.684	-0.316	0.25
1120	19.687	-0.313	0.25
1130	19.69	-0.31	0.25
1140	19.69	-0.31	0.25
1150	19.696	-0.304	0.24
1160	19.699	-0.301	0.24
1170	19.706	-0.294	0.24
1180	19.706	-0.294	0.24
1190	19.709	-0.291	0.23
1200	19.709	-0.291	0.23
1210	19.715	-0.285	0.23
1220	19.718	-0.282	0.23
1230	19.722	-0.278	0.22
1240	19.722	-0.278	0.22
1250	19.725	-0.275	0.22
1260	19.722	-0.278	0.22
1270	19.725	-0.275	0.22
1280	19.725	-0.275	0.22

SLUG WITHDRAWAL TEST DATA FORM 35691 - MW17

ELAPSED TIME (min)	DEPTH TO H20 FROM TOC (ft)	EXCESS HEAD (ft)	H/H0
1290	19.728	-0.272	0.22
1300	19.725	-0.275	0.22
1310	19.728	-0.272	0.22
1320	19.731	-0.269	0.22
1330	19.731	-0.269	0.22
1340	19.731	-0.269	0.22
1350	19.734	-0.266	0.21
1360	19.734	-0.266	0.21
1370	19.734	-0.266	0.21

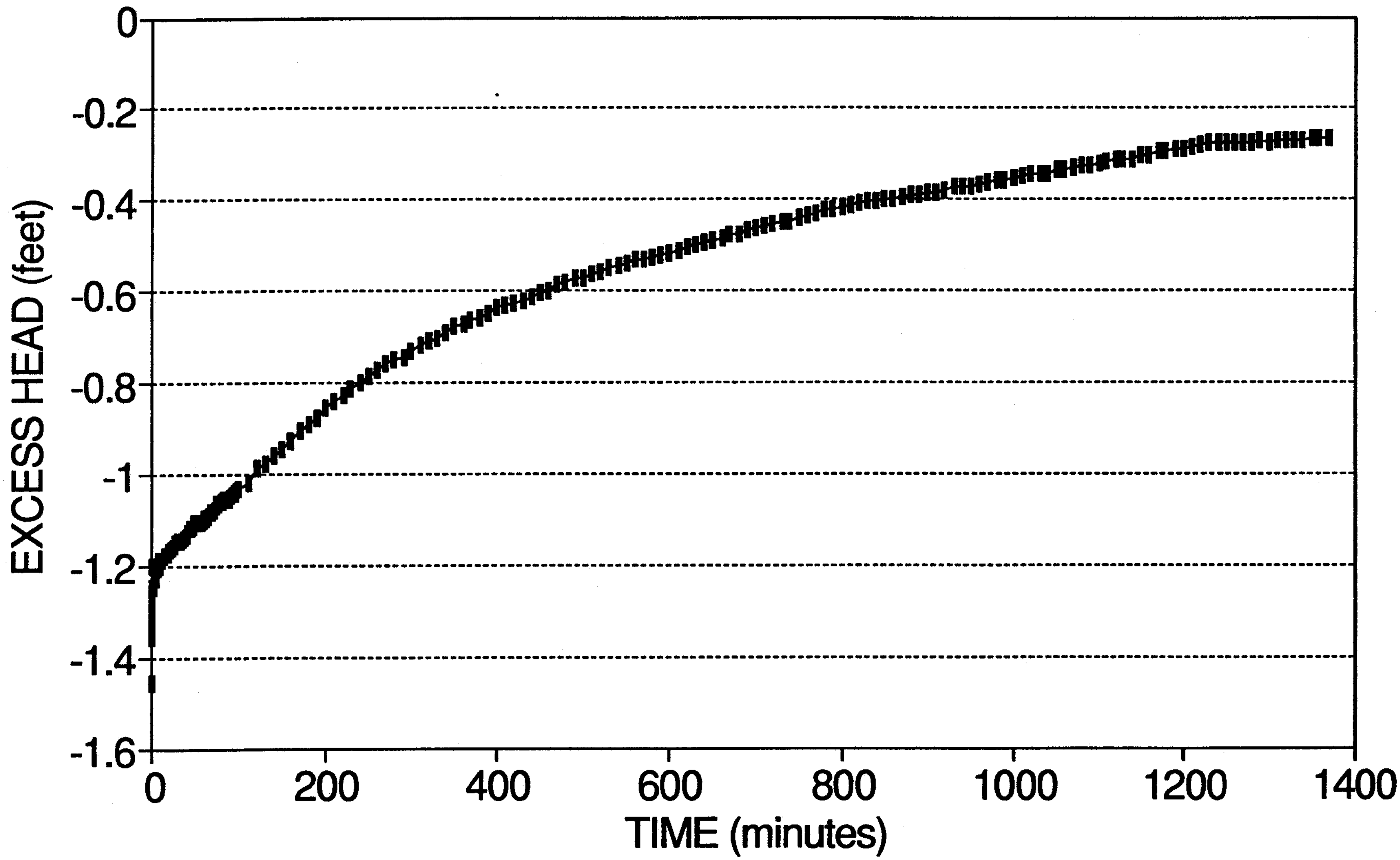
SLUG INJECTION TEST

35691 - MW17



SLUG WITHDRAWAL TEST

35691 - MW17



A Q T E S O L V   R E S U L T S
Version 1.10

03/01/92 15:20:11

TEST DESCRIPTION

Data set........... MW17INJ.DAT
Data set title..... SLUG INJECTION TEST 35691 - MW17
Project............ OPERABLE UNIT 1
Client............. EG&G ROCKY FLATS
Location........... 881 HILLSIDE
Test date.......... 12/06/91

Knowns and Constants:
   No. of data points................. 203
   Radius of well casing.............. 0.0863
   Radius of well..................... 0.458
   Aquifer saturated thickness......... 17.02
   Well screen length................. 10.52
   Static height of water in well...... 17.02
   Log(Re/Rw)......................... 2.628
   A, B, C............................ 0.000, 0.000, 1.751

ANALYTICAL METHOD

Bouwer-Rice (Unconfined Aquifer Slug Test)

RESULTS FROM VISUAL CURVE MATCHING

VISUAL MATCH PARAMETER ESTIMATES

	Estimate
K =	1.8853E-006
y0 =	1.5049E+000

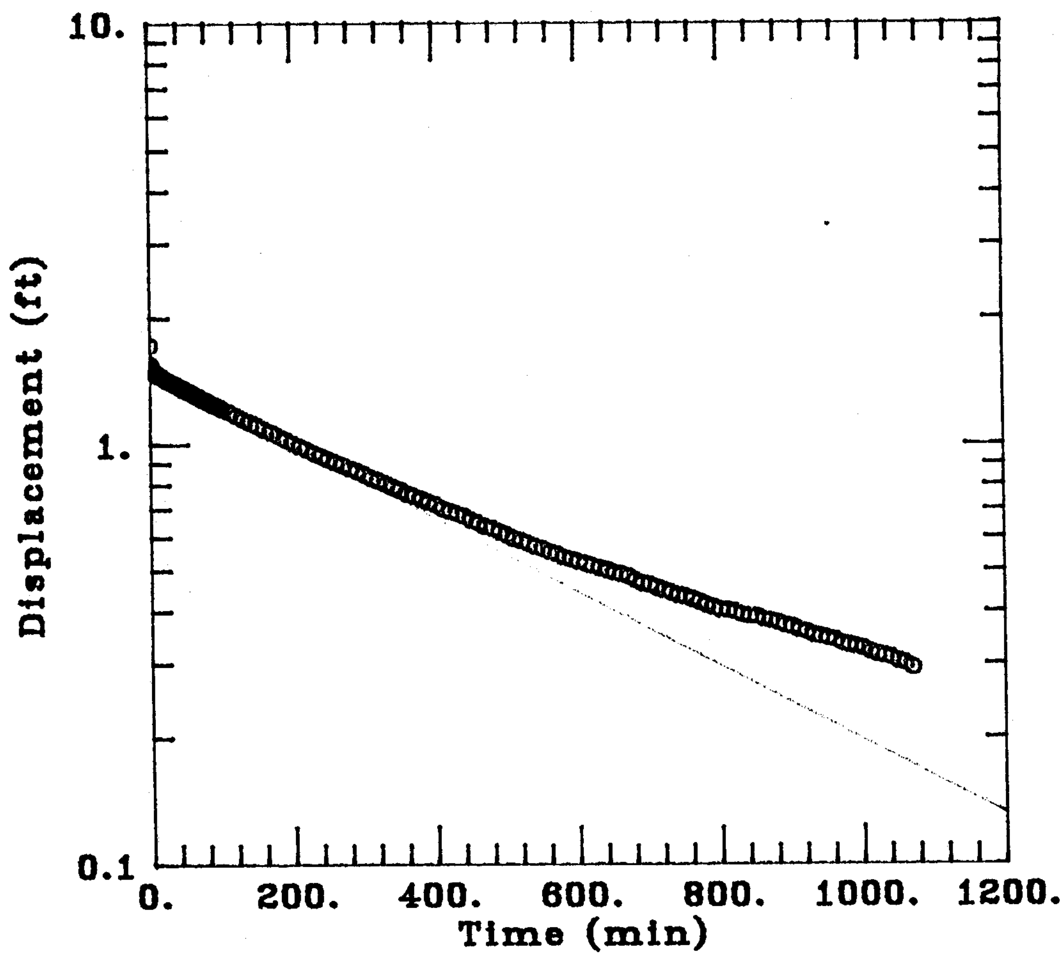
<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<>>

Project No.: **OPERABLE UNIT 1**

Client: **EG&G ROCKY FLATS**

Location: **881 HILLSIDE**

SLUG INJECTION TEST 35691 – MW17



DATA SET:
MW17INJ1.DAT
03/06/92

AQUIFER TYPE:
Unconfined

SOLUTION METHOD:
Bouwer-Rice

TEST DATE:
12/06/91

ESTIMATED PARAMETERS:
K = 1.8853E-06 ft/min
y0 = 1.505 ft

TEST DATA:

rc = 0.0863 ft
rw = 0.458 ft
L = 10.52 ft
b = 17.02 ft
H = 17.02 ft

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                    A Q T E S O L V   R E S U L T S
                              Version  1.10

03/01/92                                                       15:28:58

========================================================================
                           TEST DESCRIPTION

Data set........... MW17WD.DAT
Data set title..... SLUG WITHDRAWAL TEST 25691 - MW17
Project............ OPERABLE UNIT 1
Client............. EG&G ROCKY FLATS
Location........... 881 HILLSIDE
Test date.......... 12/07/91

Knowns and Constants:
   No. of data points.................. 233
   Radius of well casing............... 0.0863
   Radius of well...................... 0.458
   Aquifer saturated thickness......... 17.02
   Well screen length.................. 10.52
   Static height of water in well...... 17.02
   Log(Re/Rw).......................... 2.628
   A, B, C.............................  0.000,   0.000,   1.751

========================================================================
                          ANALYTICAL METHOD

Bouwer-Rice (Unconfined Aquifer Slug Test)

========================================================================
                                RESULTS FROM VISUAL CURVE MATCHING

VISUAL MATCH PARAMETER ESTIMATES

            Estimate
   K  =   1.7489E-006
   y0 =   1.2450E+000

<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>
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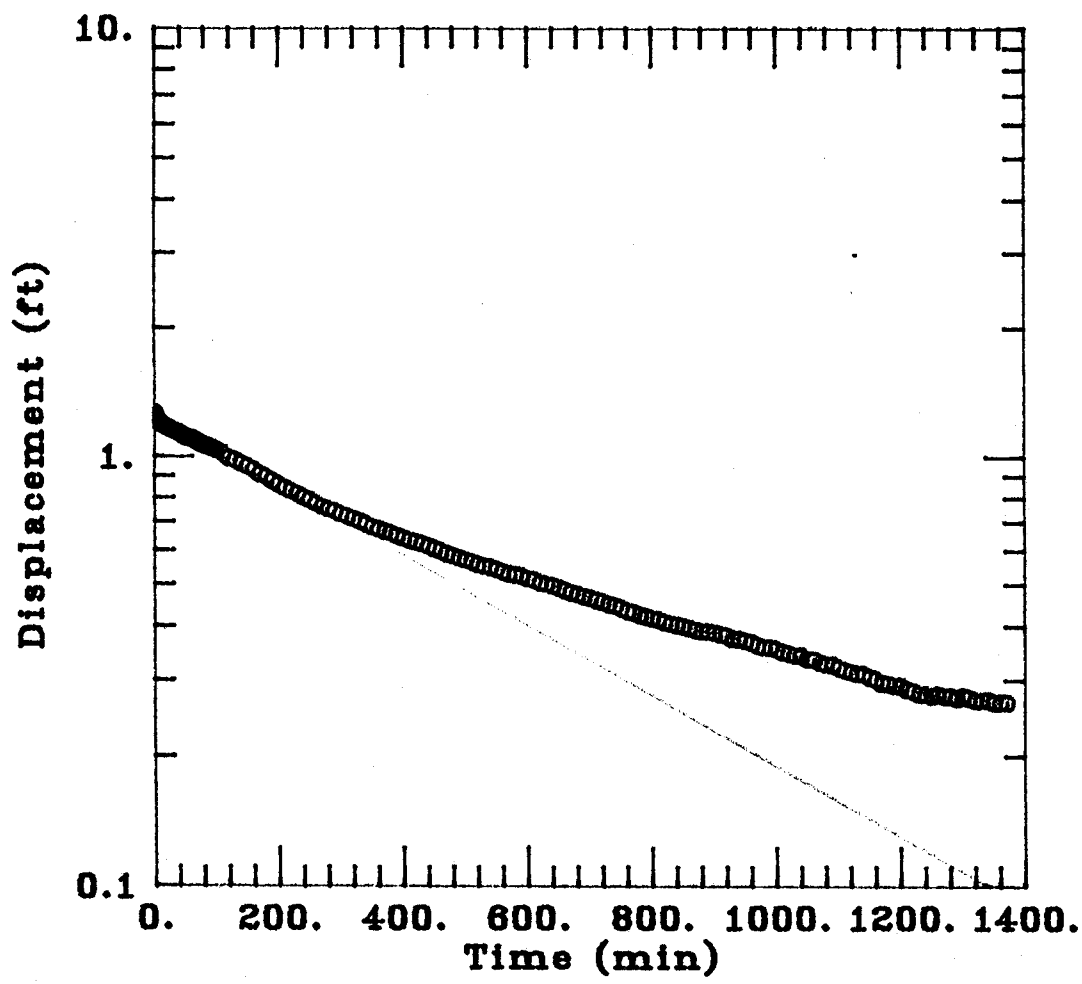
Project No.: **OPERABLE UNIT 1**

Client: **EG&G ROCKY FLATS**

Location: **881 HILLSIDE**

SLUG WITHDRAWAL TEST 35691 – MW17



DATA SET:
MW17WD1.DAT
03/06/92

AQUIFER TYPE:
Unconfined
SOLUTION METHOD:
Bouwer–Rice
TEST DATE:
12/07/91

ESTIMATED PARAMETERS:
K = 1.7489E-06 ft/min
y0 = 1.245 ft

TEST DATA:

rc = 0.0863 ft
rw = 0.458 ft
L = 10.52 ft
b = 17.02 ft
H = 17.02 ft

Single Well Test Analysis

Date of Test:	12/06/91	Project:	OU1 PHASE III RI
Well:	35691	Client:	EG&G ROCKY FLATS
Screen Interval:	15.8-26.4	Location:	881 Hillside
Filter Interval:	13.4-29.0	Type of Test:	Slug Injection
Water Level:	9.34		

Hvorslev Analysis Method:
(after Fetter, 1988)

$$K = \frac{(r\ squared)}{2\ (L)\ (To)} \ln (L/R)$$

For L/R>8

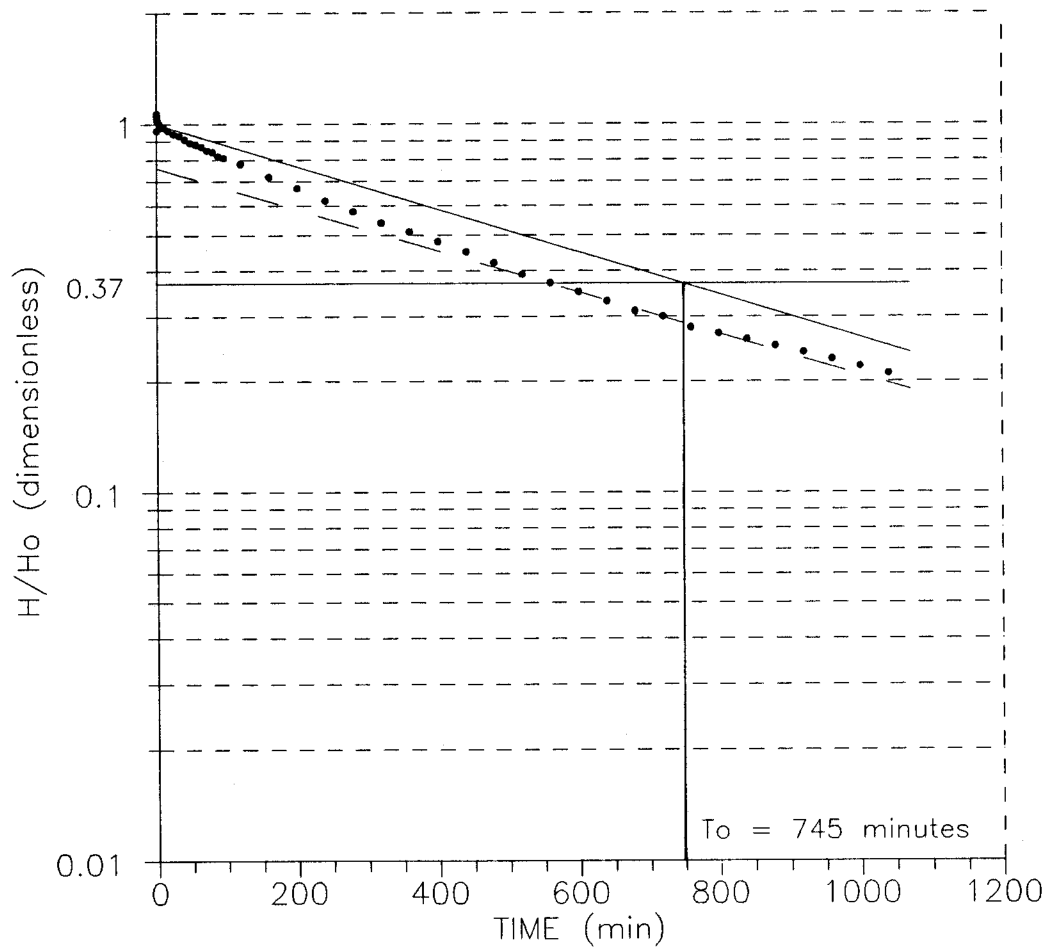
L = length of the well screen:	10.52	feet
r = radius of the well casing:	0.0863	feet
R = radius of the well screen	0.458	feet
To = time to recover 37%	745	minutes
L/R = Validity Check	22.97	

K = 1.5E-06 ft/min x 0.508 cm-min/sec-ft

K = 7.6E-07 cm/sec

HVORSLEV ANALYSIS

35691 – MW17
SLUG INJECTION TEST
To = 745 minutes



Single Well Test Analysis

Date of Test:	12/07/91	Project:	OU1 PHASE III RI
Well:	35691	Client:	EG&G ROCKY FLATS
Screen Interval:	15.8-26.4	Location:	881 Hillside
Filter Interval:	13.4-29.0	Type of Test:	Slug Withdrawal
Water Level:	9.34		

Hvorslev Analysis Method
(after Fetter, 1988)

$$K = \frac{(r\ \text{squared})}{2\,(L)\,(To)} \ln (L/R)$$

For L/R>8

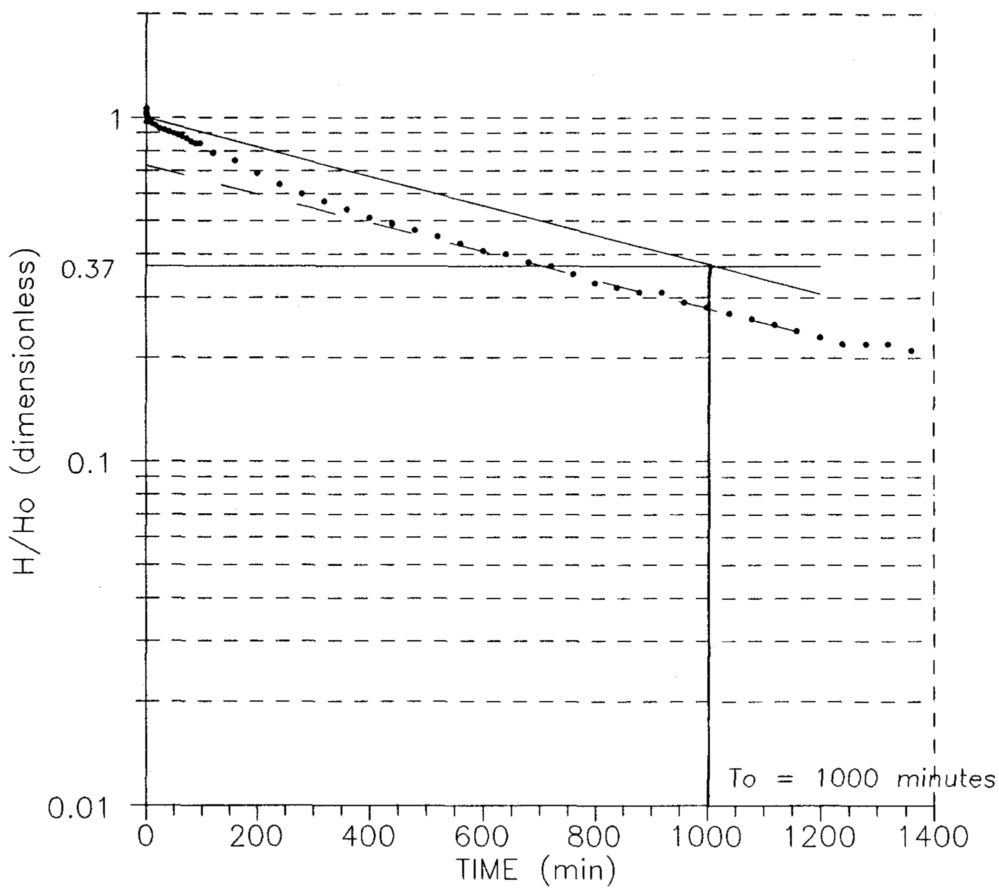
L = length of the well screen:	10.52	feet
r = radius of the well casing:	0.0863	feet
R = radius of the well screen	0.458	feet
To = time to recover 37%	1000	minutes
L/R = Validity Check	22.97	

K = 1.1E-06 ft/min x 0.508 cm-min/sec-ft

K = 5.6E-07 cm/sec

HVORSLEV ANALYSIS

35691 - MW17
SLUG WITHDRAWAL TEST
To = 1000 minutes



INDEX OF BOREHOLE AND SINGLE WELL TEST DATA AND RESULTS

Borehole, well, or piezometer number: **36191 (MW05)**
(Work plan designation)

Data Available:

__ Packer Test – Set-up

__ Packer Test – Data Sheet (Flow vs. Time Data)

__ Packer Test – Data Logger Output (Head vs. Time Data)

__ Packer Test – Analysis and Results Calculation Sheet

✔ Single Well Test – Record of Initial Water Level Measurement

✔ Single Well Test – 10 Minute Calibration Plot

✔ Single Well Test – Head vs. Time Data Form

✔ Single Well Test – Head vs. Time Response Graph(s)

✔ Single Well Test – Bouwer and Rice Method Analytical Results

__ Single Well Test – Hvorslev Method Analytical Results

U.S. DEPARTMENT OF ENERGY ROCKY FLATS PLANT

FORM GW.1A

GROUNDWATER LEVELS MEASUREMENTS/CALCULATIONS

ROCKY FLATS PROJECT — Revision 1.2

Project No. OU1 - 881 Hillside

Date 12/9/91

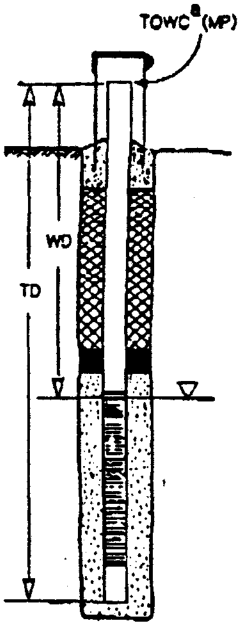
Personnel 1. J. Uhlinger

2. K. Maly

EQUIPMENT: Manufacturer Solinst Model ______ Serial No. 10373

CALIBRATION: Date Passed ______ Date Due ______

QC REVIEW: Name ______ Date ______



Well No. 36191	WD[b]	MTD[c]	Comments
Measurement 1	14.34		K. Maly
Measurement 2	14.34	Sol 12/7/91	J. Uhlinger
Measurement 3	14.34	(19.41')	K. Maly
	14.34 Average WD	Average MTD	+ 0 Probe End[d] = ______ TD[e] ______ Chk'd by

Well No.	WD[b]	MTD[c]	Comments
Measurement 1			
Measurement 2			
Measurement 3			
	Average WD	Average MTD	+ ______ Probe End[d] = ______ TD[e] ______ Chk'd by

Well No.	WD[b]	MTD[c]	Comments
Measurement 1			
Measurement 2			
Measurement 3			
	Average WD	Average MTD	+ ______ Probe End[d] = ______ TD[e] ______ Chk'd by

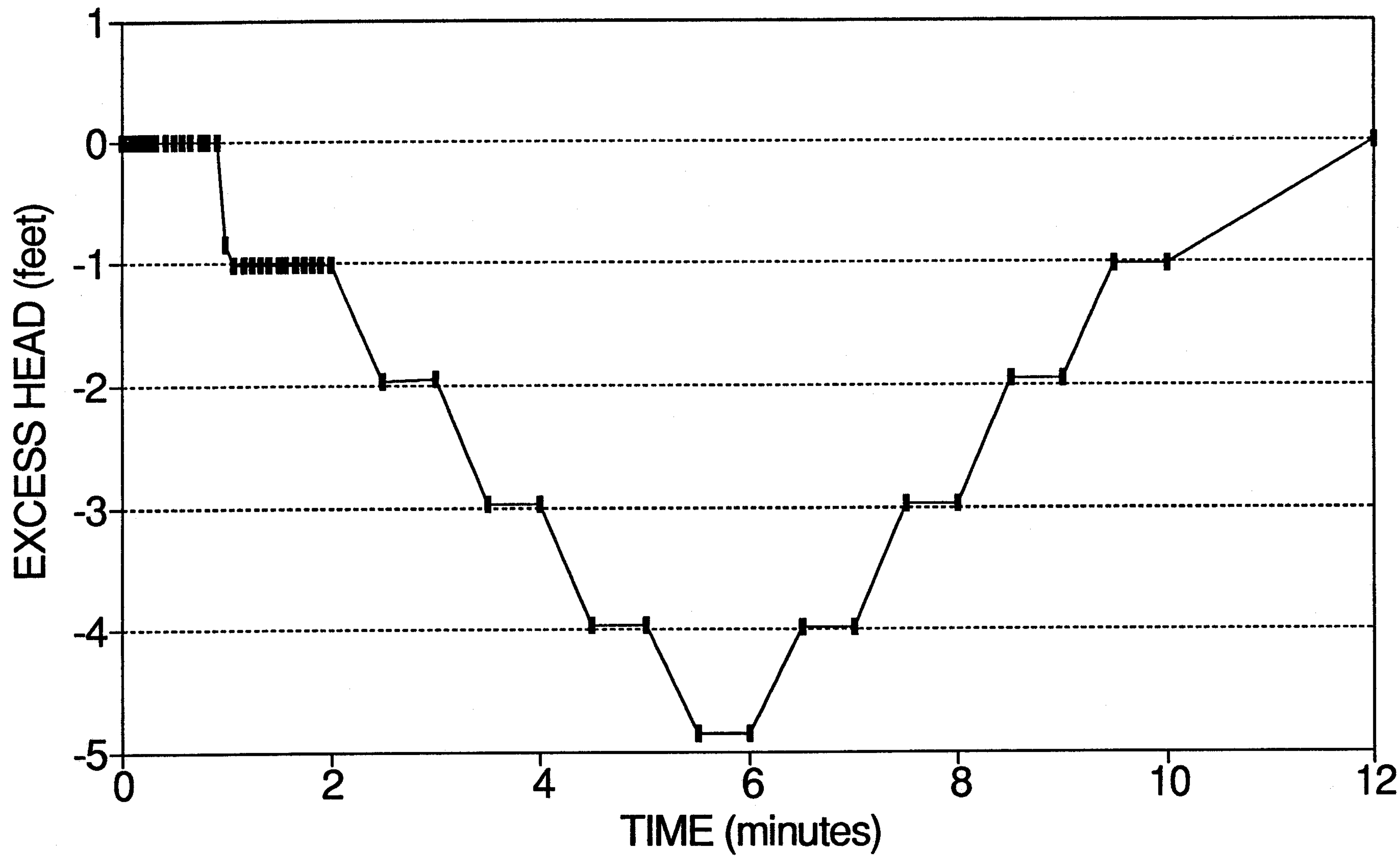
Footnotes:
- A = TOWC = top of well casing
- b = WD = depth to water from MP
- c = MTD = measured total depth from MP
- d = Probe End = length beyond measuring point on probe
- e = TD = total depth of well from MP

Notes:
- All measurements are relative to Mark Point (MP) = north side of TOWC
- QC review by supervisor is a check of reasonableness
- Measurements 1 and 2 must be within .01 ft of a 3rd measurement must be taken

(4011-600-0022) (GW1-FORM.1A) (09-18-91) (4:18pm)

TEN MINUTE CALIBRATION TEST

36191 - MW05



U.S. DEPARTMENT OF ENERGY ROCKY FLATS PLANT

FORM GW.4A

BAILDOWN RECOVERY ~~SLUG~~ TEST DATA FORM

Location OU 1 881 Hillside
Borehole No. 36191 (MW5)
Test Date 12/9/91
Measuring Point Top PVC Casing
Type of Test Baildown Recovery
Transductor Probe Serial No. 1257 DD
Datalogger Test Run No. ____
(include time and date for identification purposes)
MW05_1E.TST
(No field Printout Problems w/printer)

Name J. Uhlinger, K. MALEY
Groundwater Elevation Before Test 14.34 (measured)
Total Casing Depth 19.91' (measured)
Borehole Diameter 11" to ~~...~~ 17.7'
Casing Diameter 2.07" (nom)
Screened Interval 17.01 - 11.93
Sand Pack Interval 17.7 - 10.2'
Lithology Tested Well graded Gravelly sand

Actual Time	Elapsed Time	Depth to Water from Top of Casing (ft)	H Excess Head (ft)	H/HO

See ID Records

(4011-600-0024)(GW4REV.1)(09-11-91)

BAIL DOWN/RECOVERY TEST DATA FORM 36191 - MW05

FILE: MW05_1B.WQ2
TEST DATE: 12/24/91
START TIME: 08:30:02 AM

REFERENCE: 14.34 FT

ELAPSED TIME (min)	DEPTH TO H20 FROM TOC (ft)	EXCESS HEAD (ft)
0	17.412	-3.072
0.0083	17.526	-3.186
0.0166	17.358	-3.018
0.025	17.292	-2.952
0.0333	17.282	-2.942
0.0416	17.241	-2.901
0.05	17.210	-2.870
0.0583	17.140	-2.800
0.0666	17.134	-2.794
0.075	17.102	-2.762
0.0833	17.067	-2.727
0.1	17.001	-2.661
0.1166	16.934	-2.594
0.1333	16.874	-2.534
0.15	16.814	-2.474
0.1666	16.757	-2.417
0.1833	16.700	-2.360
0.2	16.653	-2.313
0.2166	16.605	-2.265
0.2333	16.561	-2.221
0.25	16.523	-2.183
0.2666	16.495	-2.155
0.2833	16.453	-2.113
0.3	16.425	-2.085
0.3166	16.403	-2.063
0.3333	16.384	-2.044
0.4166	16.305	-1.965
0.5	16.257	-1.917
0.5833	16.226	-1.886
0.6666	16.203	-1.863
0.75	16.188	-1.848
0.8333	16.172	-1.832
0.9166	16.159	-1.819
1	16.150	-1.810
1.0833	16.146	-1.806
1.1666	16.134	-1.794
1.25	16.124	-1.784
1.3333	16.127	-1.787
1.4166	16.112	-1.772
1.5	16.105	-1.765
1.5833	16.099	-1.759
1.6666	16.096	-1.756
1.75	16.089	-1.749
1.8333	16.089	-1.749
1.9166	16.086	-1.746

BAIL DOWN/RECOVERY TEST DATA FORM 36191 - MW05

ELAPSED TIME (min)	DEPTH TO H20 FROM TOC (ft)	EXCESS HEAD (ft)
2	16.086	-1.746
2.5	16.061	-1.721
3	16.045	-1.705
3.5	16.039	-1.699
4	16.023	-1.683
4.5	16.014	-1.674
5	16.004	-1.664
5.5	15.998	-1.658
6	15.988	-1.648
6.5	15.988	-1.648
7	15.982	-1.642
7.5	15.972	-1.632
8	15.963	-1.623
8.5	15.960	-1.620
9	15.953	-1.613
9.5	15.950	-1.610
10	15.957	-1.617
12	15.931	-1.591
14	15.922	-1.582
16	15.912	-1.572
18	15.906	-1.566
20	15.893	-1.553
22	15.881	-1.541
24	15.884	-1.544
26	15.877	-1.537
28	15.874	-1.534
30	15.846	-1.506
32	15.843	-1.503
34	15.839	-1.499
36	15.836	-1.496
38	15.830	-1.490
40	15.827	-1.487
42	15.827	-1.487
44	15.820	-1.480
46	15.817	-1.477
48	15.814	-1.474
50	15.814	-1.474
52	15.814	-1.474
54	15.811	-1.471
56	15.811	-1.471
58	15.808	-1.468
60	15.805	-1.465
62	15.805	-1.465
64	15.801	-1.461
66	15.801	-1.461

BAIL DOWN/RECOVERY TEST DATA FORM 36191 - MW05

ELAPSED TIME (min)	DEPTH TO H20 FROM TOC (ft)	EXCESS HEAD (ft)
68	15.798	-1.458
70	15.798	-1.458
72	15.795	-1.455
74	15.792	-1.452
76	15.792	-1.452
78	15.789	-1.449
80	15.792	-1.452
82	15.789	-1.449
84	15.789	-1.449
86	15.789	-1.449
88	15.786	-1.446
90	15.783	-1.443
92	15.783	-1.443
94	15.779	-1.439
96	15.779	-1.439
98	15.786	-1.446
100	15.779	-1.439
110	15.776	-1.436
120	15.773	-1.433
130	15.776	-1.436
140	15.773	-1.433
150	15.770	-1.430
160	15.770	-1.430
170	15.767	-1.427
180	15.764	-1.424
190	15.764	-1.424
200	15.764	-1.424
210	15.760	-1.420
220	15.760	-1.420
230	15.760	-1.420
240	15.760	-1.420
250	15.757	-1.417
260	15.754	-1.414
270	15.751	-1.411
280	15.748	-1.408
290	15.726	-1.386
300	15.726	-1.386
310	15.726	-1.386
320	15.722	-1.382
330	15.719	-1.379
340	15.719	-1.379
350	15.710	-1.370
360	15.710	-1.370
370	15.710	-1.370
380	15.707	-1.367

BAIL DOWN/RECOVERY TEST DATA FORM 36191 - MW05

ELAPSED TIME (min)	DEPTH TO H20 FROM TOC (ft)	EXCESS HEAD (ft)
390	15.707	-1.367
400	15.700	-1.360
410	15.703	-1.363
420	15.703	-1.363
430	15.700	-1.360
440	15.703	-1.363
450	15.700	-1.360
460	15.697	-1.357
470	15.697	-1.357
480	15.694	-1.354
490	15.694	-1.354
500	15.694	-1.354
510	15.691	-1.351
520	15.691	-1.351
530	15.688	-1.348
540	15.691	-1.351
550	15.688	-1.348
560	15.684	-1.344
570	15.681	-1.341
580	15.678	-1.338
590	15.675	-1.335
600	15.681	-1.341
610	15.678	-1.338
620	15.678	-1.338
630	15.678	-1.338
640	15.678	-1.338
650	15.675	-1.335
660	15.672	-1.332
670	15.678	-1.338
680	15.672	-1.332
690	15.672	-1.332
700	15.672	-1.332
710	15.672	-1.332
720	15.669	-1.329
730	15.665	-1.325
740	15.665	-1.325
750	15.665	-1.325
760	15.665	-1.325
770	15.662	-1.322
780	15.662	-1.322
790	15.662	-1.322
800	15.656	-1.316
810	15.662	-1.322
820	15.656	-1.316
830	15.659	-1.319

BAIL DOWN/RECOVERY TEST DATA FORM 36191 - MW05

ELAPSED TIME (min)	DEPTH TO H20 FROM TOC (ft)	EXCESS HEAD (ft)
840	15.656	-1.316
850	15.656	-1.316
860	15.653	-1.313
870	15.653	-1.313
880	15.653	-1.313
890	15.653	-1.313
900	15.653	-1.313
910	15.650	-1.310
920	15.650	-1.310
930	15.650	-1.310
940	15.650	-1.310
950	15.643	-1.303
960	15.643	-1.303
970	15.643	-1.303
980	15.646	-1.306
990	15.643	-1.303
1000	15.640	-1.300
1010	15.640	-1.300
1020	15.637	-1.297
1030	15.640	-1.300
1040	15.637	-1.297
1050	15.637	-1.297
1060	15.634	-1.294
1070	15.637	-1.297
1080	15.631	-1.291
1090	15.631	-1.291
1100	15.631	-1.291
1110	15.627	-1.287
1120	15.621	-1.281
1130	15.627	-1.287
1140	15.624	-1.284
1150	15.624	-1.284
1160	15.621	-1.281
1170	15.621	-1.281
1180	15.618	-1.278
1190	15.621	-1.281
1200	15.618	-1.278
1210	15.615	-1.275
1220	15.615	-1.275
1230	15.612	-1.272
1240	15.612	-1.272
1250	15.612	-1.272
1260	15.608	-1.268
1270	15.599	-1.259
1280	15.599	-1.259

BAIL DOWN/RECOVERY TEST DATA FORM 36191 - MW05

ELAPSED TIME (min)	DEPTH TO H20 FROM TOC (ft)	EXCESS HEAD (ft)
1290	15.599	-1.259
1300	15.599	-1.259
1310	15.599	-1.259
1320	15.602	-1.262
1330	15.602	-1.262
1340	15.599	-1.259
1350	15.602	-1.262
1360	15.602	-1.262
1370	15.602	-1.262
1380	15.599	-1.259
1390	15.596	-1.256
1400	15.602	-1.262
1410	15.599	-1.259
1420	15.599	-1.259
1430	15.596	-1.256
1440	15.596	-1.256
1450	15.596	-1.256
1460	15.593	-1.253
1470	15.593	-1.253
1480	15.593	-1.253
1490	15.589	-1.249
1500	15.586	-1.246
1510	15.586	-1.246
1520	15.586	-1.246
1530	15.586	-1.246
1540	15.583	-1.243
1550	15.580	-1.240
1560	15.580	-1.240
1570	15.577	-1.237
1580	15.574	-1.234
1590	15.564	-1.224
1600	15.580	-1.240
1610	15.580	-1.240
1620	15.580	-1.240
1630	15.580	-1.240
1640	15.580	-1.240
1650	15.580	-1.240
1660	15.577	-1.237
1670	15.577	-1.237
1680	15.574	-1.234
1690	15.570	-1.230
1700	15.567	-1.227
1710	15.567	-1.227
1720	15.564	-1.224
1730	15.564	-1.224

BAIL DOWN/RECOVERY TEST DATA FORM 36191 - MW05

ELAPSED TIME (min)	DEPTH TO H20 FROM TOC (ft)	EXCESS HEAD (ft)
1740	15.561	-1.221
1750	15.561	-1.221
1760	15.558	-1.218
1770	15.555	-1.215
1780	15.551	-1.211
1790	15.545	-1.205
1800	15.542	-1.202
1810	15.536	-1.196
1820	15.533	-1.193
1830	15.533	-1.193
1840	15.529	-1.189
1850	15.529	-1.189
1860	15.529	-1.189
1870	15.529	-1.189
1880	15.526	-1.186
1890	15.526	-1.186
1900	15.526	-1.186
1910	15.523	-1.183
1920	15.523	-1.183
1930	15.523	-1.183
1940	15.520	-1.180
1950	15.523	-1.183
1960	15.520	-1.180
1970	15.520	-1.180
1980	15.520	-1.180
1990	15.517	-1.177
2000	15.517	-1.177
2010	15.517	-1.177
2020	15.514	-1.174
2030	15.514	-1.174
2040	15.510	-1.170
2050	15.510	-1.170
2060	15.510	-1.170
2070	15.507	-1.167
2080	15.507	-1.167
2090	15.507	-1.167
2100	15.504	-1.164
2110	15.504	-1.164
2120	15.504	-1.164
2130	15.501	-1.161
2140	15.501	-1.161
2150	15.501	-1.161
2160	15.498	-1.158
2170	15.498	-1.158
2180	15.498	-1.158

BAIL DOWN/RECOVERY TEST DATA FORM 36191 - MW05

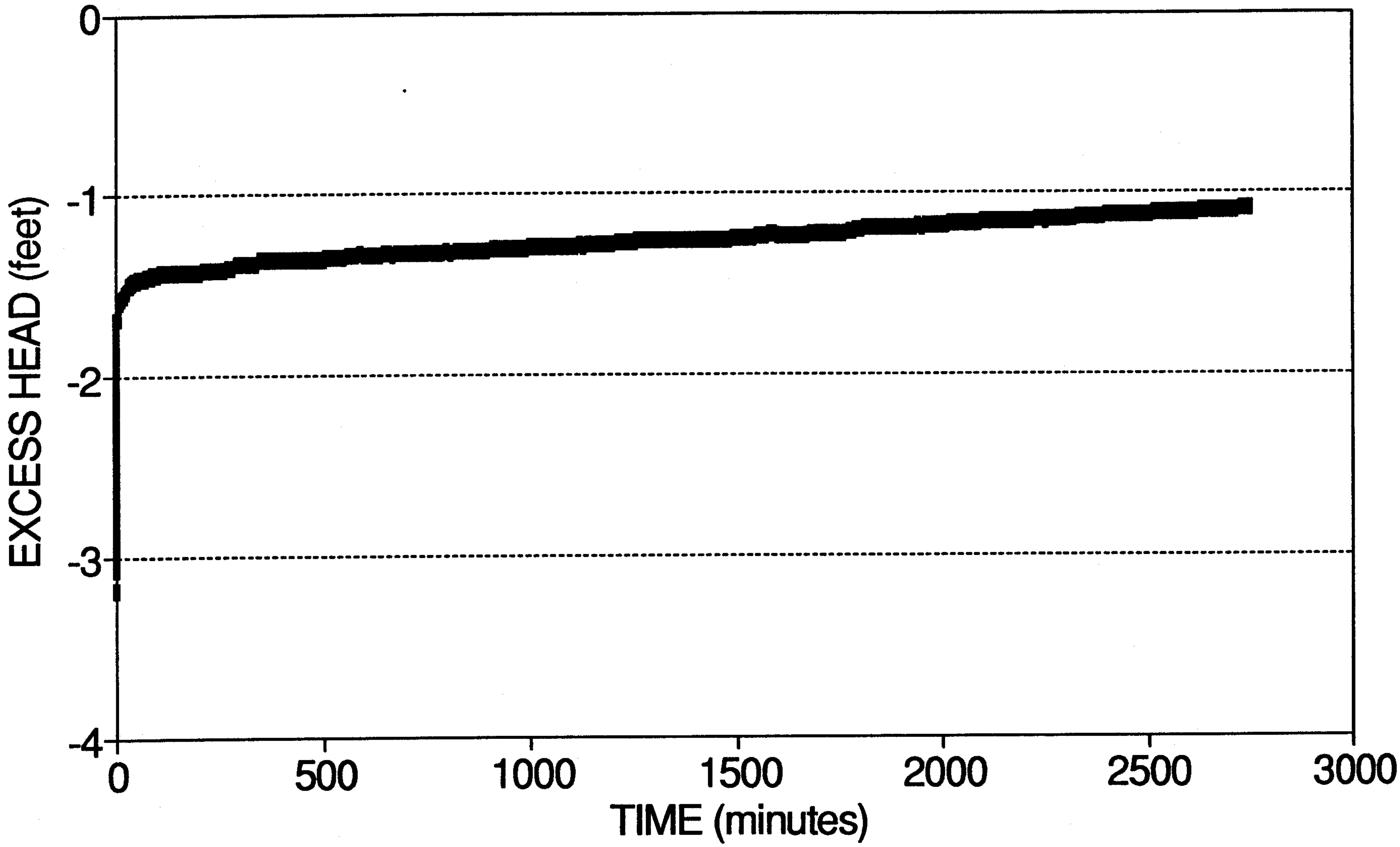
ELAPSED TIME (min)	DEPTH TO H20 FROM TOC (ft)	EXCESS HEAD (ft)
2190	15.498	-1.158
2200	15.495	-1.155
2210	15.495	-1.155
2220	15.491	-1.151
2230	15.488	-1.148
2240	15.488	-1.148
2250	15.491	-1.151
2260	15.488	-1.148
2270	15.485	-1.145
2280	15.485	-1.145
2290	15.485	-1.145
2300	15.482	-1.142
2310	15.482	-1.142
2320	15.482	-1.142
2330	15.479	-1.139
2340	15.479	-1.139
2350	15.476	-1.136
2360	15.476	-1.136
2370	15.476	-1.136
2380	15.472	-1.132
2390	15.472	-1.132
2400	15.469	-1.129
2410	15.469	-1.129
2420	15.466	-1.126
2430	15.466	-1.126
2440	15.463	-1.123
2450	15.463	-1.123
2460	15.463	-1.123
2470	15.463	-1.123
2480	15.460	-1.120
2490	15.460	-1.120
2500	15.460	-1.120
2510	15.457	-1.117
2520	15.453	-1.113
2530	15.453	-1.113
2540	15.453	-1.113
2550	15.453	-1.113
2560	15.453	-1.113
2570	15.450	-1.110
2580	15.450	-1.110
2590	15.450	-1.110
2600	15.447	-1.107
2610	15.447	-1.107
2620	15.447	-1.107
2630	15.444	-1.104

BAIL DOWN/RECOVERY TEST DATA FORM 36191 - MW05

ELAPSED TIME (min)	DEPTH TO H20 FROM TOC (ft)	EXCESS HEAD (ft)
2640	15.444	-1.104
2650	15.444	-1.104
2660	15.441	-1.101
2670	15.441	-1.101
2680	15.441	-1.101
2690	15.441	-1.101
2700	15.438	-1.098
2710	15.438	-1.098
2720	15.438	-1.098
2730	15.431	-1.091
2740	15.434	-1.094
2750	15.434	-1.094

BAIL DOWN/RECOVERY TEST

36191 - MW05



A Q T E S O L V   R E S U L T S
Version 1.10

03/06/92 12:19:32

TEST DESCRIPTION

```
Data set........... MW05BDR.DAT
Data set title..... BAIL DOWN/RECOVERY TEST 36191 - MW05
Project............ OPERABLE UNIT 1
Client............. EG&G ROCKY FLATS
Location........... 881 HILLSIDE
Test date.......... 12/09/91

Knowns and Constants:
   No. of data points.................. 371
   Radius of well casing............... 0.26
   Radius of well...................... 0.458
   Aquifer saturated thickness......... 2.46
   Well screen length.................. 2.46
   Static height of water in well...... 2.46
   Log(Re/Rw).......................... 1.212
   A, B, C.............................  0.000,  0.000,  0.916
```

ANALYTICAL METHOD

Bouwer-Rice (Unconfined Aquifer Slug Test)

RESULTS FROM VISUAL CURVE MATCHING

VISUAL MATCH PARAMETER ESTIMATES

```
          Estimate
   K  =   2.1920E-006
   y0 =   1.4540E+000
```

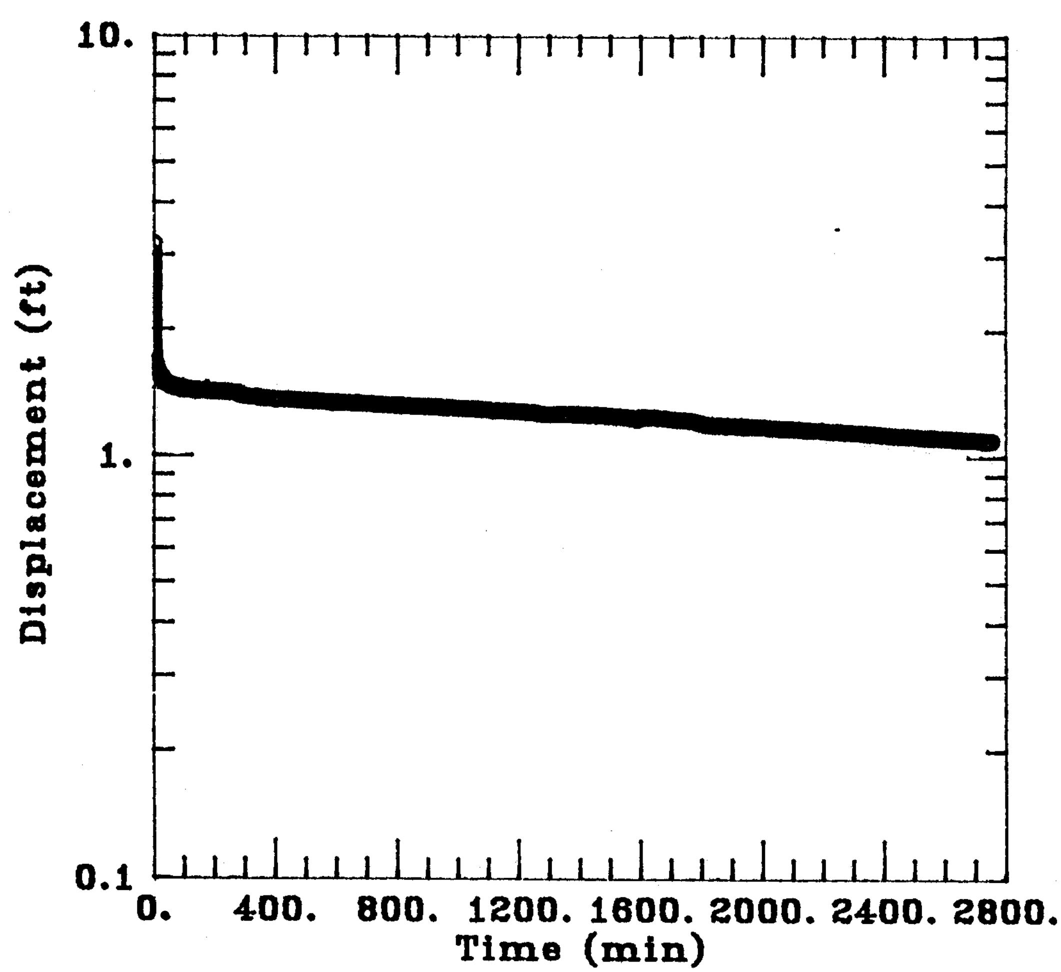
```
<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>
```

Project No.: OPERABLE UNIT 1

Client: EG&G ROCKY FLATS

Location: 881 HILLSIDE

BAILDOWN/RECOVERY TEST 36191 - MW05



DATA SET:
MW05BDR.DAT
03/06/92

AQUIFER TYPE:
Unconfined

SOLUTION METHOD:
Bouwer-Rice

TEST DATE:
12/09/91

ESTIMATED PARAMETERS:
K = 2.192E-06 ft/min
y0 = 1.454 ft

TEST DATA:

rc = 0.26 ft
rw = 0.458 ft
L = 2.46 ft
b = 2.46 ft
H = 2.46 ft

INDEX OF BOREHOLE AND SINGLE WELL TEST DATA AND RESULTS

Borehole, well, or piezometer number: **37191 (MW16)**
(Work plan designation)

Data Available:

__ Packer Test – Set-up

__ Packer Test – Data Sheet (Flow vs. Time Data)

__ Packer Test – Data Logger Output (Head vs. Time Data)

__ Packer Test – Analysis and Results Calculation Sheet

✔ Single Well Test – Record of Initial Water Level Measurement

✔ Single Well Test – 10 Minute Calibration Plot

✔ Single Well Test – Head vs. Time Data Form

✔ Single Well Test – Head vs. Time Response Graph(s)

✔ Single Well Test – Bouwer and Rice Method Analytical Results

✔ Single Well Test – Hvorslev Method Analytical Results

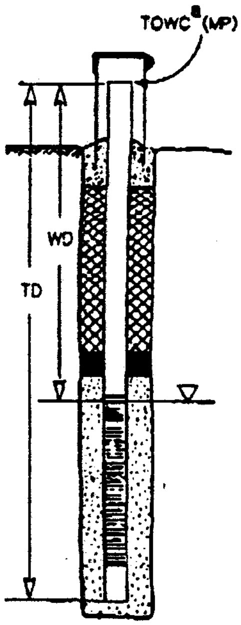
U.S. DEPARTMENT OF ENERGY ROCKY FLATS PLANT | FORM GW.1A

GROUNDWATER LEVELS MEASUREMENTS/CALCULATIONS

ROCKY FLATS PROJECT | Revision 1.2

Project No. OU1 - 881 Hillside
Date 12/7/91
Personnel 1. J. Uhlinger
2. K. Maley

EQUIPMENT: Manufacturer Solinst Model ______ Serial No. 10373
CALIBRATION: Date Passed ______ Date Due ______
QC REVIEW: Name ______ Date ______



Well No. 37191	WD[b]	MTD[c]	Comments
Measurement 1	9.88'	25.85	J. Uhlinger
Measurement 2	9.88'	25.85	K. Maley
Measurement 3	9.88'	25.85	J. Uhlinger
	9.88' Average WD	25.85' Average MTD	+ 0 Probe End[d] = ______ TD[e] ______ Chk'd by

Well No.	WD[b]	MTD[c]	Comments
Measurement 1			
Measurement 2			
Measurement 3			
	Average WD	Average MTD	+ ______ Probe End[d] = ______ TD[e] ______ Chk'd by

Well No.	WD[b]	MTD[c]	Comments
Measurement 1			
Measurement 2			
Measurement 3			
	Average WD	Average MTD	+ ______ Probe End[d] = ______ TD[e] ______ Chk'd by

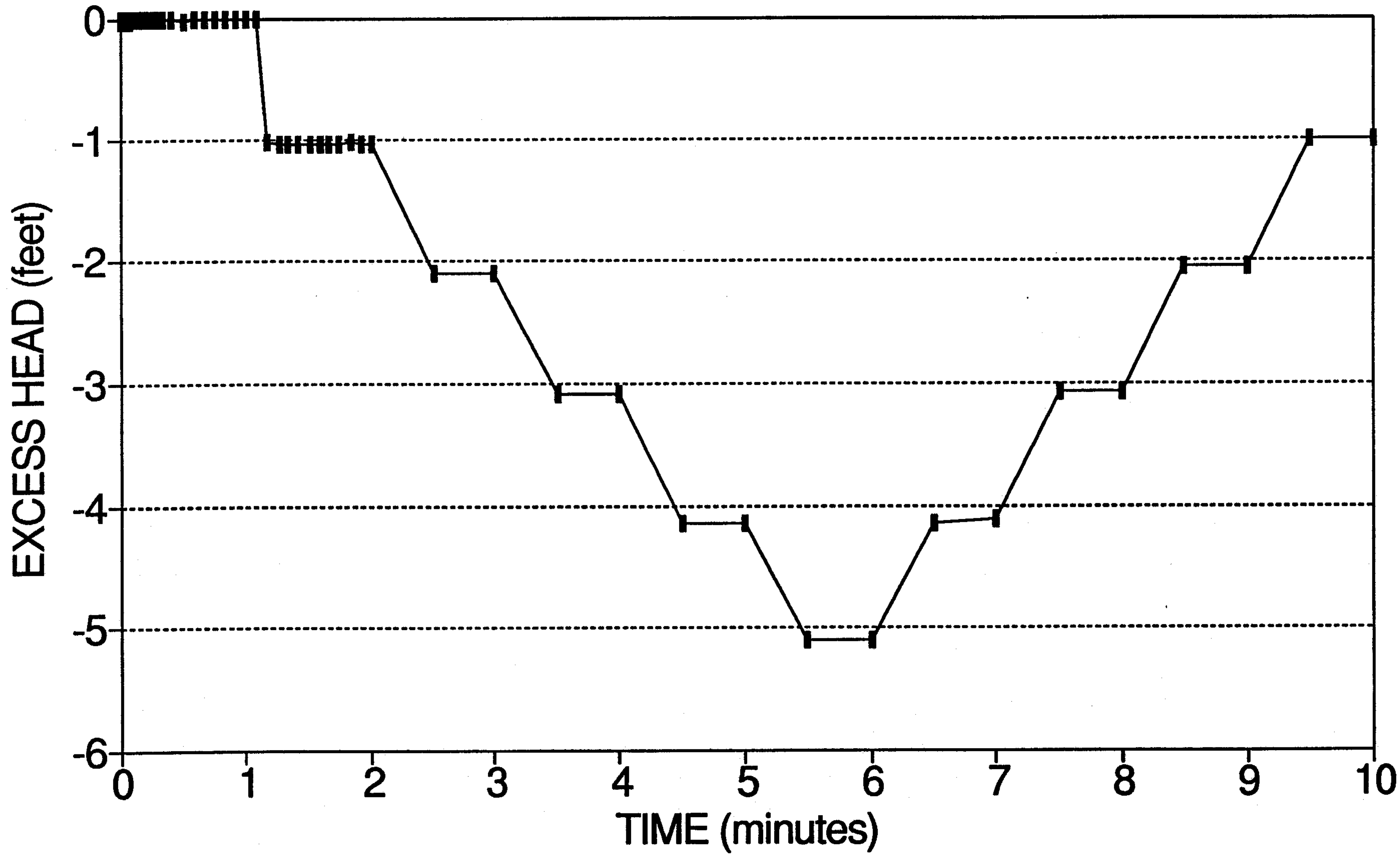
Footnotes:
A = TOWC = top of well casing
b = WD = depth to water from MP
c = MTD = measured total depth from MP
d = Probe End = length beyond measuring point on probe
e = TD = total depth of well from MP

Notes:
- All measurements are relative to Mark Point (MP) = north side of TOWC
- QC review by supervisor is a check of reasonableness
- Measurements 1 and 2 must be within .01 ft of a 3rd measurement must be taken

(4011-600-0022) (GW1-FORM.1A) (09-18-91) (4:18pm)

TEN MINUTE CALIBRATION TEST

37191 - MW16



SLUG TEST DATA FORM

Location 881 Hillside
Borehole No. 37191 MW16
Test Date 12/7/91
Measuring Point TOP PVC Casing
Type of Test Slug inj/withdrawl
Transductor Probe Serial No. 1759DD
Datalogger Test Run No.
(include time and date for identification purposes)
MW16_1a. TST
MW16-1b. TST
MW16_1c. TST

Name J. Ohlinger, K. Maley
Groundwater Elevation Before Test 9.88 TOC (measured)
Total Casing Depth 25.85' measured TOC
Borehole Diameter 11"
Casing Diameter 2.07"
Screened Interval 13.9'-23.8'
Sand Pack Interval 12.0 - 24.8
Lithology Tested gravelly sandy clay

Actual Time	Elapsed Time	Depth to Water from Top of Casing (ft)	H Excess Head (ft)	H/HO

See XD Records

SLUG INJECTION TEST DATA FORM 37191 - MW16

FILE: MW16_1B.WQ2
TEST DATE: 12/07/91
START TIME: 11:49:38 AM

H0: 1.645 FT
REFERENCE: 9.88 FT

ELAPSED TIME (min)	DEPTH TO H20 FROM TOC (ft)	EXCESS HEAD (ft)	H/H0
0	8.01	1.87	1.14
0.0083	7.938	1.942	1.18
0.0166	7.985	1.895	1.15
0.025	7.95	1.93	1.17
0.0333	7.966	1.914	1.16
0.0416	7.988	1.892	1.15
0.05	7.985	1.895	1.15
0.0583	7.988	1.892	1.15
0.0666	8.001	1.879	1.14
0.075	8.004	1.876	1.14
0.0833	8.004	1.876	1.14
0.1	8.02	1.86	1.13
0.1166	8.023	1.857	1.13
0.1333	8.039	1.841	1.12
0.15	8.042	1.838	1.12
0.1666	8.076	1.804	1.10
0.1833	8.054	1.826	1.11
0.2	8.08	1.8	1.09
0.2166	8.083	1.797	1.09
0.2333	8.099	1.781	1.08
0.25	8.105	1.775	1.08
0.2666	8.118	1.762	1.07
0.2833	8.124	1.756	1.07
0.3	8.143	1.737	1.06
0.3166	8.143	1.737	1.06
0.3333	8.162	1.718	1.04
0.4166	8.209	1.671	1.02
0.5	8.247	1.633	0.99
0.5833	8.285	1.595	0.97
0.6666	8.323	1.557	0.95
0.75	8.364	1.516	0.92
0.8333	8.399	1.481	0.90
0.9166	8.433	1.447	0.88
1	8.468	1.412	0.86
1.0833	8.503	1.377	0.84
1.1666	8.537	1.343	0.82
1.25	8.569	1.311	0.80
1.3333	8.597	1.283	0.78
1.4166	8.626	1.254	0.76
1.5	8.654	1.226	0.75
1.5833	8.683	1.197	0.73
1.6666	8.711	1.169	0.71
1.75	8.736	1.144	0.70
1.8333	8.759	1.121	0.68
1.9166	8.787	1.093	0.66

SLUG INJECTION TEST DATA FORM 37191 - MW16

ELAPSED TIME (min)	DEPTH TO H20 FROM TOC (ft)	EXCESS HEAD (ft)	H/H0
2	8.809	1.071	0.65
2.5	8.951	0.929	0.56
3	9.065	0.815	0.50
3.5	9.163	0.717	0.44
4	9.245	0.635	0.39
4.5	9.311	0.569	0.35
5	9.377	0.503	0.31
5.5	9.425	0.455	0.28
6	9.466	0.414	0.25
6.5	9.51	0.37	0.22
7	9.545	0.335	0.20
7.5	9.58	0.3	0.18
8	9.608	0.272	0.17
8.5	9.633	0.247	0.15
9	9.655	0.225	0.14
9.5	9.681	0.199	0.12
10	9.7	0.18	0.11
12	9.75	0.13	0.08
14	9.794	0.086	0.05
16	9.826	0.054	0.03
18	9.842	0.038	0.02
20	9.854	0.026	0.02
22	9.864	0.016	0.01
24	9.87	0.01	0.01
26	9.876	0.004	0.002

SLUG WITHDRAWAL TEST DATA FORM 37191 - MW16

FILE: MW16_1C.WQ2
TEST DATE: 12/07/91
START TIME: 12:16:35 PM

H0: -1.9223 FT
REFERENCE: 9.88 FT

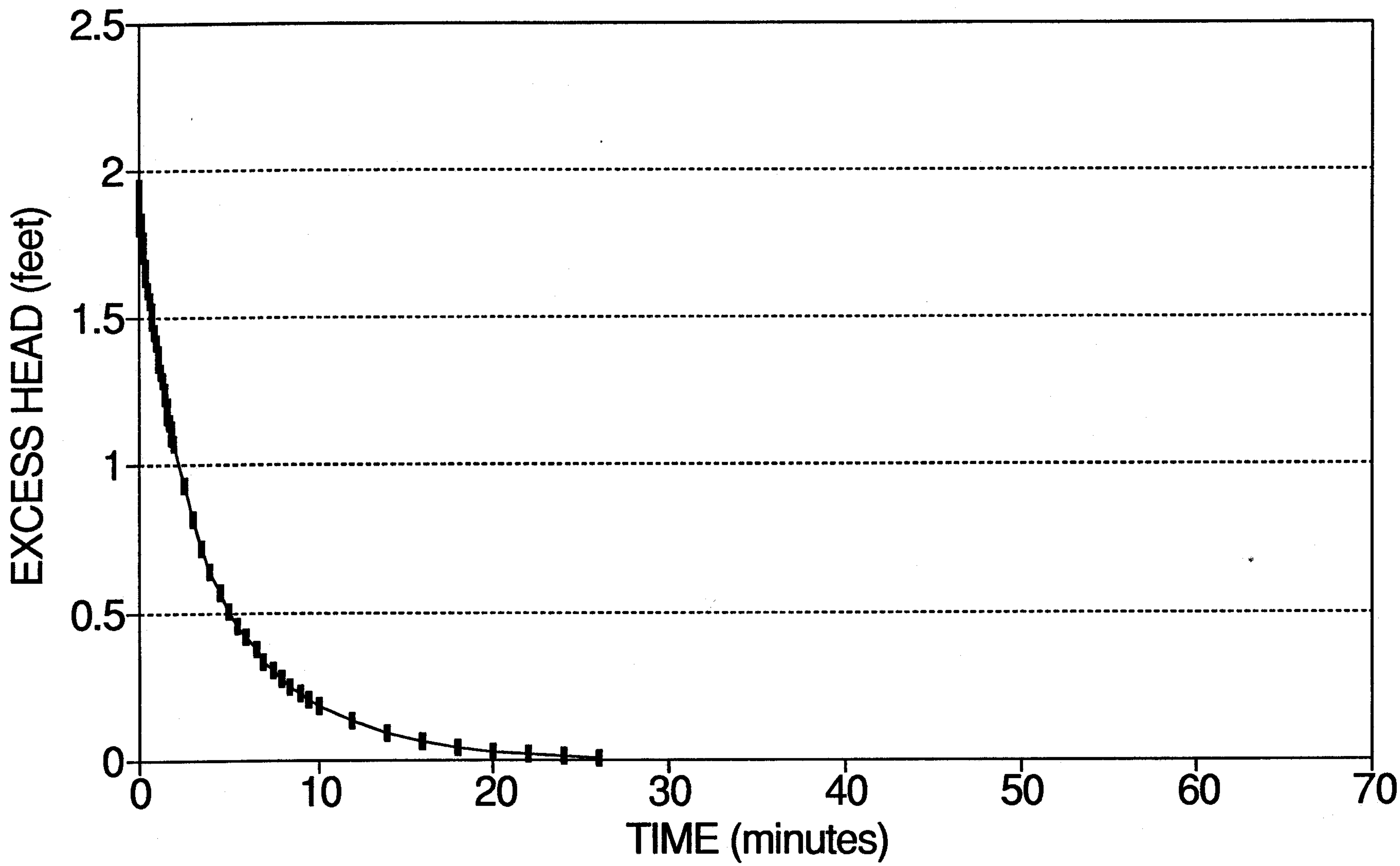
ELAPSED TIME (min)	DEPTH TO H20 FROM TOC (ft)	EXCESS HEAD (ft)	H/H0
0	11.878	-1.998	1.04
0.0083	11.9	-2.02	1.05
0.0166	11.878	-1.998	1.04
0.025	11.885	-2.005	1.04
0.0333	11.875	-1.995	1.04
0.0416	11.872	-1.992	1.04
0.05	11.866	-1.986	1.03
0.0583	11.964	-2.084	1.08
0.0666	11.863	-1.983	1.03
0.075	11.866	-1.986	1.03
0.0833	11.863	-1.983	1.03
0.1	11.856	-1.976	1.03
0.1166	11.866	-1.986	1.03
0.1333	11.837	-1.957	1.02
0.15	11.834	-1.954	1.02
0.1666	11.834	-1.954	1.02
0.1833	11.828	-1.948	1.01
0.2	11.818	-1.938	1.01
0.2166	11.818	-1.938	1.01
0.2333	11.809	-1.929	1.00
0.25	11.806	-1.926	1.00
0.2666	11.803	-1.923	1.00
0.2833	11.799	-1.919	1.00
0.3	11.796	-1.916	1.00
0.3166	11.799	-1.919	1.00
0.3333	11.787	-1.907	0.99
0.4166	11.771	-1.891	0.98
0.5	11.758	-1.878	0.98
0.5833	11.749	-1.869	0.97
0.6666	11.73	-1.85	0.96
0.75	11.717	-1.837	0.96
0.8333	11.705	-1.825	0.95
0.9166	11.692	-1.812	0.94
1	11.676	-1.796	0.93
1.0833	11.67	-1.79	0.93
1.1666	11.651	-1.771	0.92
1.25	11.638	-1.758	0.91
1.3333	11.626	-1.746	0.91
1.4166	11.616	-1.736	0.90
1.5	11.604	-1.724	0.90
1.5833	11.597	-1.717	0.89
1.6666	11.581	-1.701	0.88
1.75	11.569	-1.689	0.88
1.8333	11.556	-1.676	0.87
1.9166	11.547	-1.667	0.87

SLUG WITHDRAWAL TEST DATA FORM 37191 - MW16

ELAPSED TIME (min)	DEPTH TO H20 FROM TOC (ft)	EXCESS HEAD (ft)	H/H0
2	11.537	-1.657	0.86
2.5	11.462	-1.582	0.82
3	11.395	-1.515	0.79
3.5	11.335	-1.455	0.76
4	11.272	-1.392	0.72
4.5	11.215	-1.335	0.69
5	11.155	-1.275	0.66
5.5	11.105	-1.225	0.64
6	11.057	-1.177	0.61
6.5	11.004	-1.124	0.58
7	10.959	-1.079	0.56
7.5	10.918	-1.038	0.54
8	10.874	-0.994	0.52
8.5	10.846	-0.966	0.50
9	10.802	-0.922	0.48
9.5	10.764	-0.884	0.46
10	10.726	-0.846	0.44
12	10.599	-0.719	0.37
14	10.489	-0.609	0.32
16	10.401	-0.521	0.27
18	10.322	-0.442	0.23
20	10.258	-0.378	0.20
22	10.202	-0.322	0.17
24	10.151	-0.271	0.14
26	10.11	-0.230	0.12
28	10.078	-0.198	0.10
30	10.047	-0.167	0.09
32	10.028	-0.148	0.08
34	9.999	-0.119	0.06
36	9.984	-0.104	0.05
38	9.971	-0.091	0.05
40	9.962	-0.082	0.04
42	9.952	-0.072	0.04
44	9.939	-0.059	0.03
46	9.933	-0.053	0.03
48	9.924	-0.044	0.02
50	9.917	-0.037	0.02
52	9.914	-0.034	0.02
54	9.911	-0.031	0.02
56	9.911	-0.031	0.02
58	9.911	-0.031	0.02
60	9.908	-0.028	0.01
62	9.905	-0.025	0.01
64	9.905	-0.025	0.01

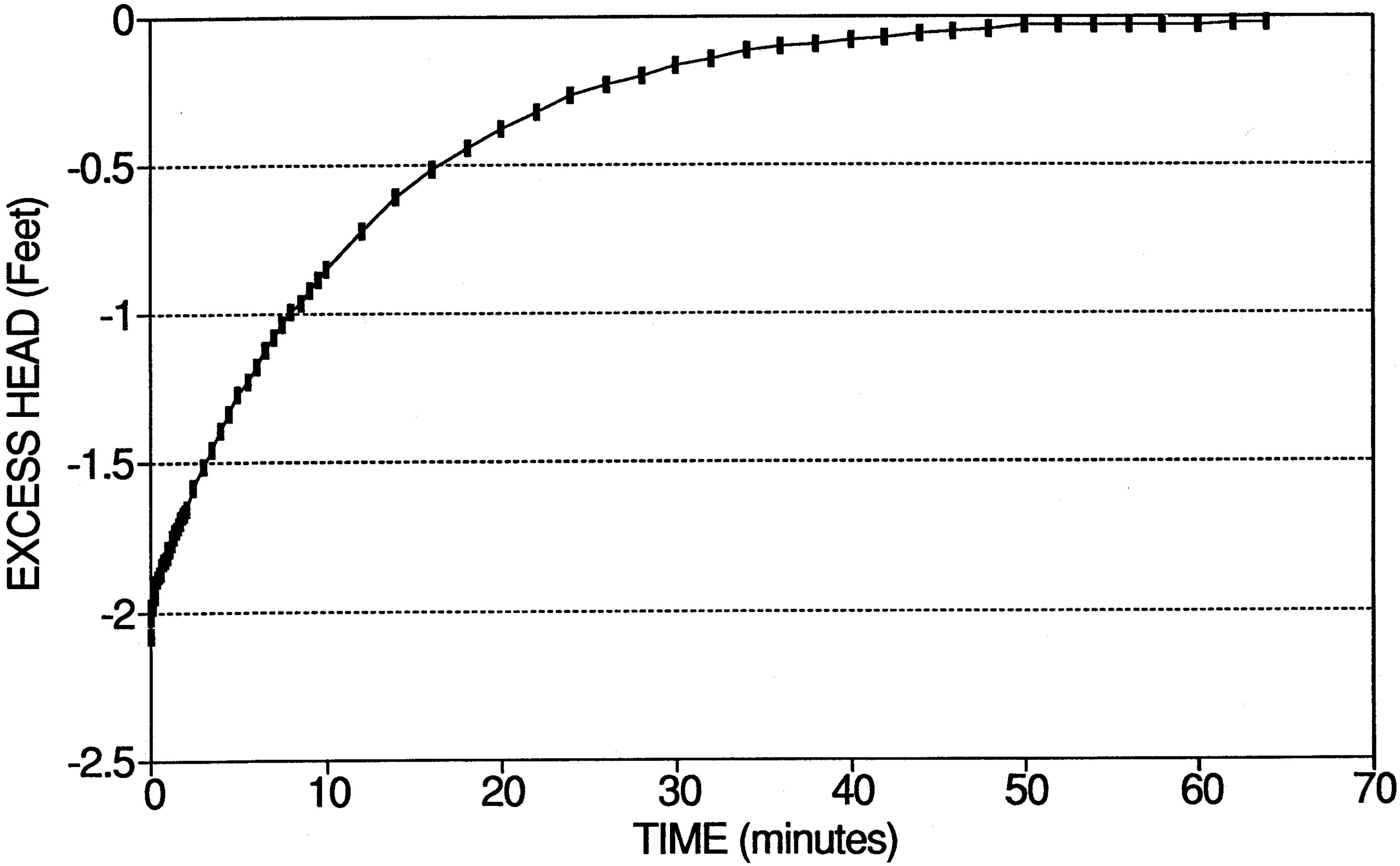
SLUG INJECTION TEST

37191 - MW16



SLUG WITHDRAWAL TEST

37191 - MW16



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                    A Q T E S O L V   R E S U L T S
                            Version  1.10

03/12/92                                                           13:01:57

================================================================================
                               TEST DESCRIPTION

Data set........... mw16inj.dat
Data set title..... SLUG INJECTION TEST 37191 - MW16
Project............ OPERABLE UNIT 1
Client............. EG&G ROCKY FLATS
Location........... 881 HILLSIDE
Test date.......... 12/07/91

Knowns and Constants:
   No. of data points.................. 69
   Radius of well casing............... 0.0863
   Radius of well...................... 0.458
   Aquifer saturated thickness......... 13.74
   Well screen length.................. 9.55
   Static height of water in well...... 13.74
   Log(Re/Rw).......................... 2.473
   A, B, C.............................  0.000,  0.000,  1.687

================================================================================
                              ANALYTICAL METHOD

Bouwer-Rice (Unconfined Aquifer Slug Test)


================================================================================
                      RESULTS FROM VISUAL CURVE MATCHING

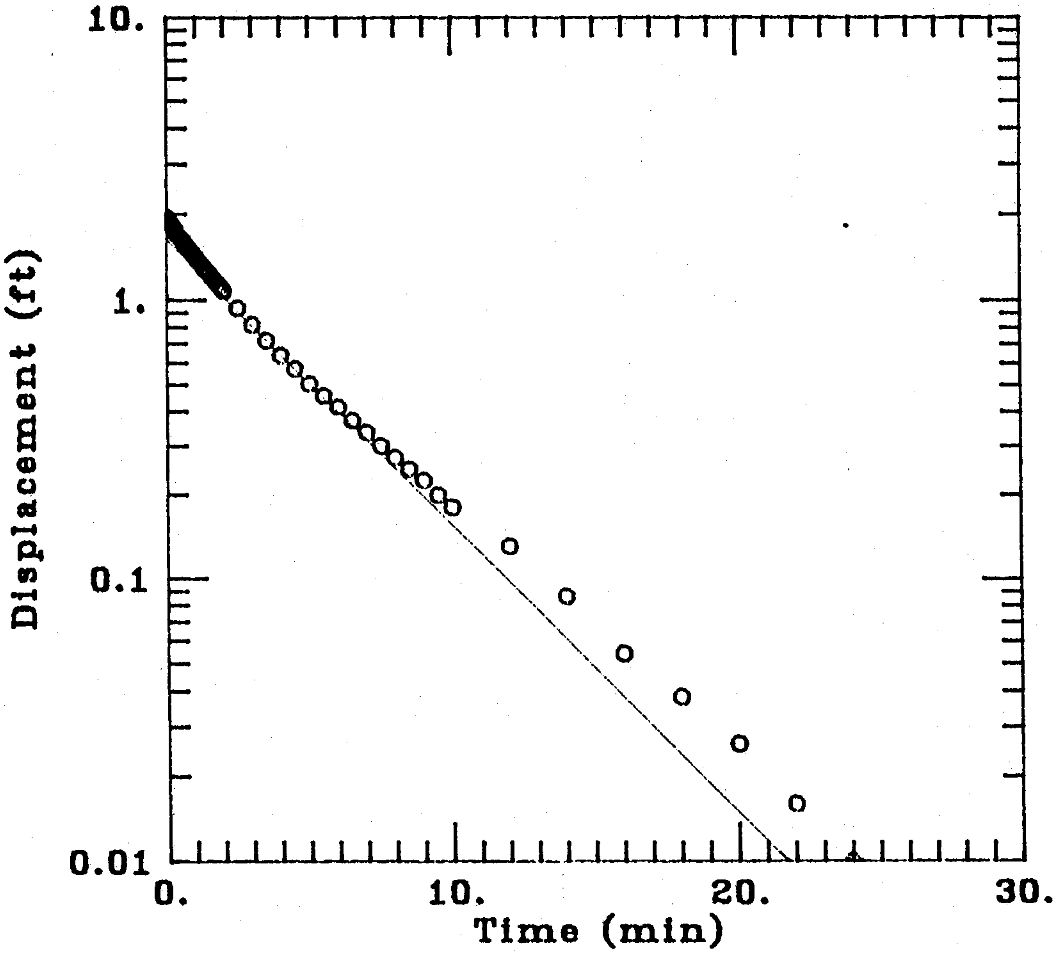
VISUAL MATCH PARAMETER ESTIMATES

           Estimate
   K  =   2.2660E-004
   y0 =   1.6450E+000

<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>
```

	Client: EG&G ROCKY FLATS
Project No.: OPERABLE UNIT 1	Location: 881 HILLSIDE

SLUG INJECTION TEST 37191 – MW16



DATA SET:
MW16INJ.DAT
02/27/92

AQUIFER TYPE:
Unconfined

SOLUTION METHOD:
Bouwer-Rice

TEST DATE:
12/07/91

ESTIMATED PARAMETERS:
K = 0.0002266 ft/min
y0 = 1.645 ft

TEST DATA:

rc = 0.0863 ft
rw = 0.458 ft
L = 9.55 ft
b = 13.74 ft
H = 13.74 ft

A Q T E S O L V   R E S U L T S

Version 1.10

03/12/92 13:03:23

==

TEST DESCRIPTION

Data set........... mw16wd.dat
Data set title..... SLUG WITHDRAWAL TEST 37191 - MW16
Project............ OPERABLE UNIT 1
Client............. EG&G ROCKY FLATS
Location........... 881 HILLSIDE
Test date.......... 12/07/91

Knowns and Constants:
No. of data points.................. 88
Radius of well casing............... 0.0863
Radius of well...................... 0.458
Aquifer saturated thickness......... 13.74
Well screen length.................. 9.55
Static height of water in well...... 13.74
Log(Re/Rw).......................... 2.473
A, B, C............................. 0.000, 0.000, 1.687

==

ANALYTICAL METHOD

Bouwer-Rice (Unconfined Aquifer Slug Test)

==

RESULTS FROM VISUAL CURVE MATCHING

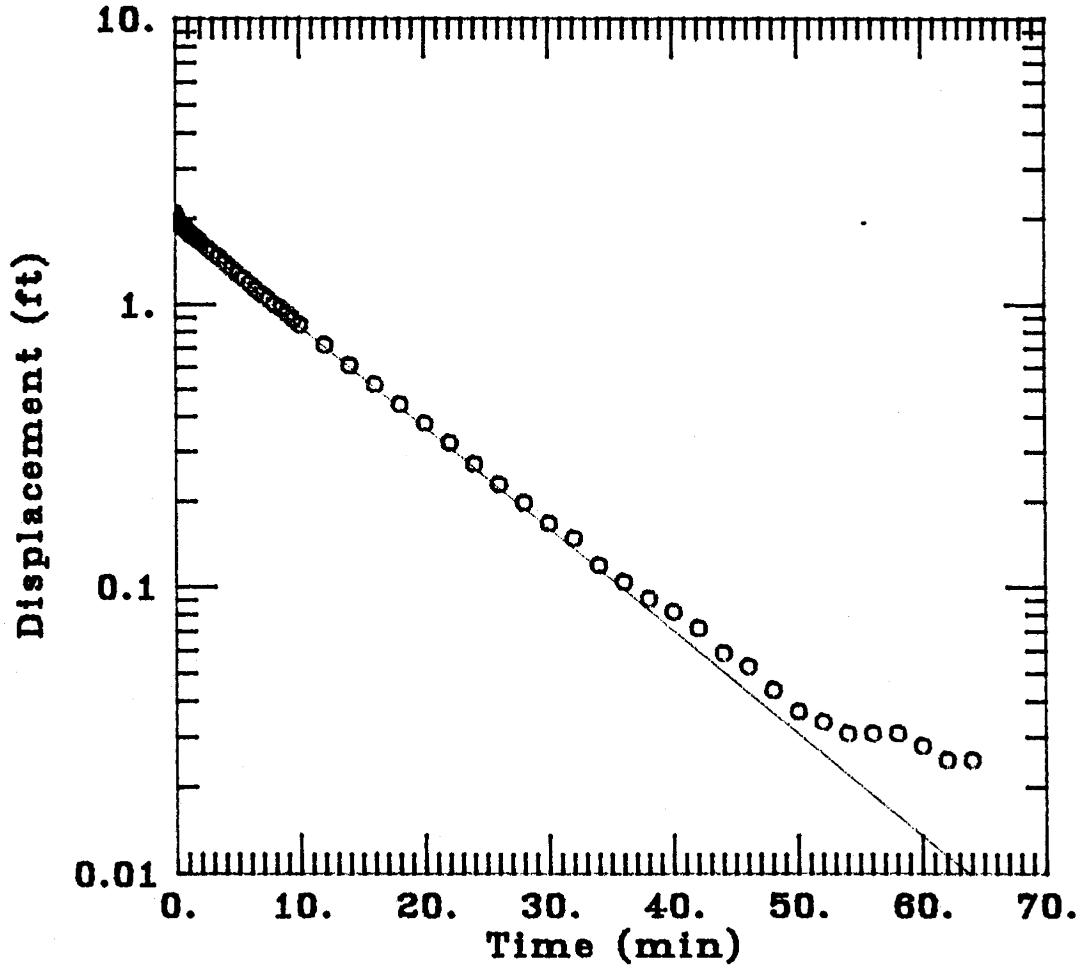
VISUAL MATCH PARAMETER ESTIMATES

	Estimate
K =	7.9463E-005
y0 =	1.9223E+000

<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<>>>

Project No.: **OPERABLE UNIT 1**	Client: **EG&G ROCKY FLATS**
	Location: **881 HILLSIDE**

SLUG WITHDRAWAL TEST 37191 – MW16



DATA SET:
MW16WD.DAT
02/27/92

AQUIFER TYPE:
Unconfined
SOLUTION METHOD:
Bouwer-Rice
TEST DATE:
12/07/91

ESTIMATED PARAMETERS:
K = 7.9463E-05 ft/min
y0 = 1.922 ft

TEST DATA:

rc = 0.0863 ft
rw = 0.458 ft
L = 9.55 ft
b = 13.74 ft
H = 13.74 ft

Single Well Test Analysis

Date of Test:	12/07/91	Project:	OU1 PHASE III RI
Well:	37191	Client:	EG&G ROCKY FLATS
Screen Interval:	11.3-20.9	Location:	881 Hillside
Filter Interval:	9.2-22.0	Type of Test:	Slug Injection
Water Level:	7.13		

Hvorslev Analysis Method:
(after Fetter, 1988)

$$K = \frac{(r\ squared)}{2\,(L)\,(To)}\ \ln\,(L/R)$$

For L/R>8

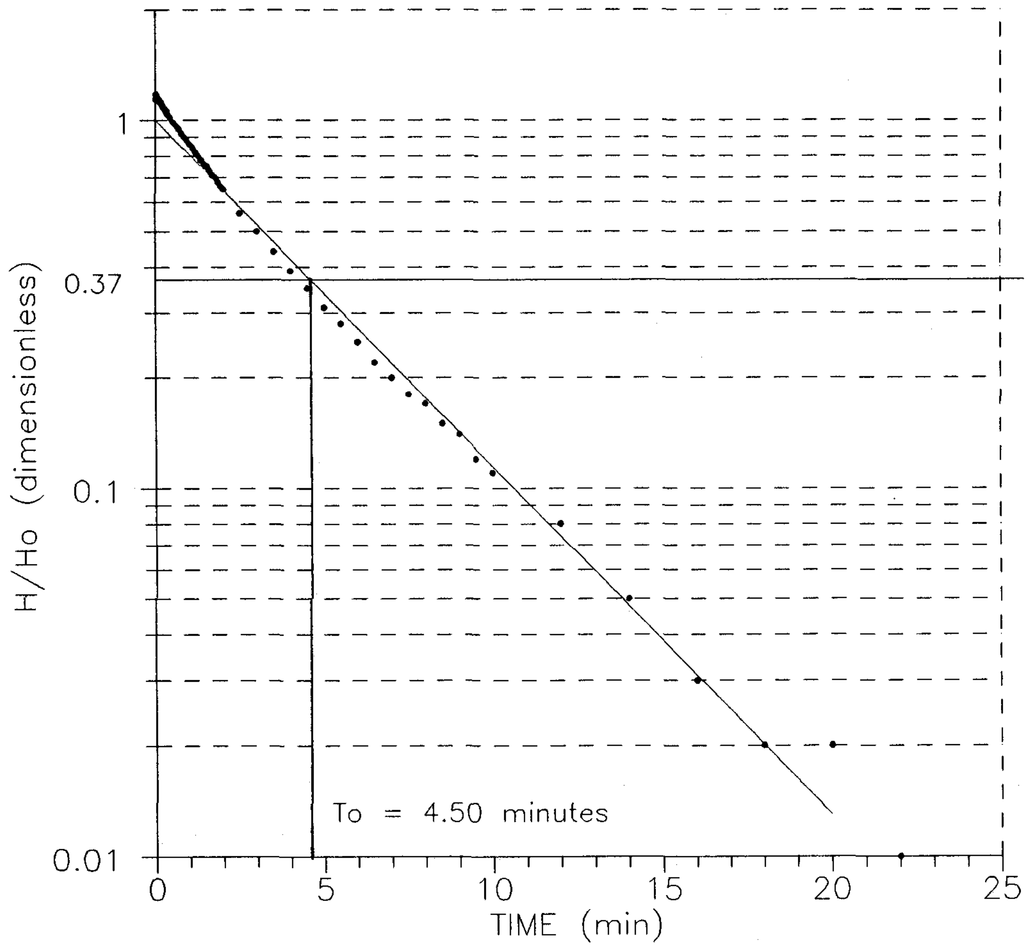
L = length of the well screen:	9.55	feet
r = radius of the well casing:	0.0863	feet
R = radius of the well screen	0.458	feet
To = time to recover 37%	4.5	minutes
L/R = Validity Check	20.85	

K = 2.6E-04 ft/min x 0.508 cm-min/sec-ft

K = 1.3E-04 cm/sec

HVORSLEV ANALYSIS

37191 – MW16
SLUG INJECTION TEST
To = 4.50 minutes



Single Well Test Analysis

Date of Test:	12/07/91	Project:	OU1 PHASE III RI
Well:	37191	Client:	EG&G ROCKY FLATS
Screen Interval:	11.3-20.9	Location:	881 Hillside
Filter Interval:	9.2-22.0	Type of Test:	Slug Withdrawal
Water Level:	7.13		

Hvorslev Analysis Method:
(after Fetter, 1988)

$$K = \frac{(r\ squared)}{2\ (L)\ (To)}\ \ln (L/R)$$

For L/R>8

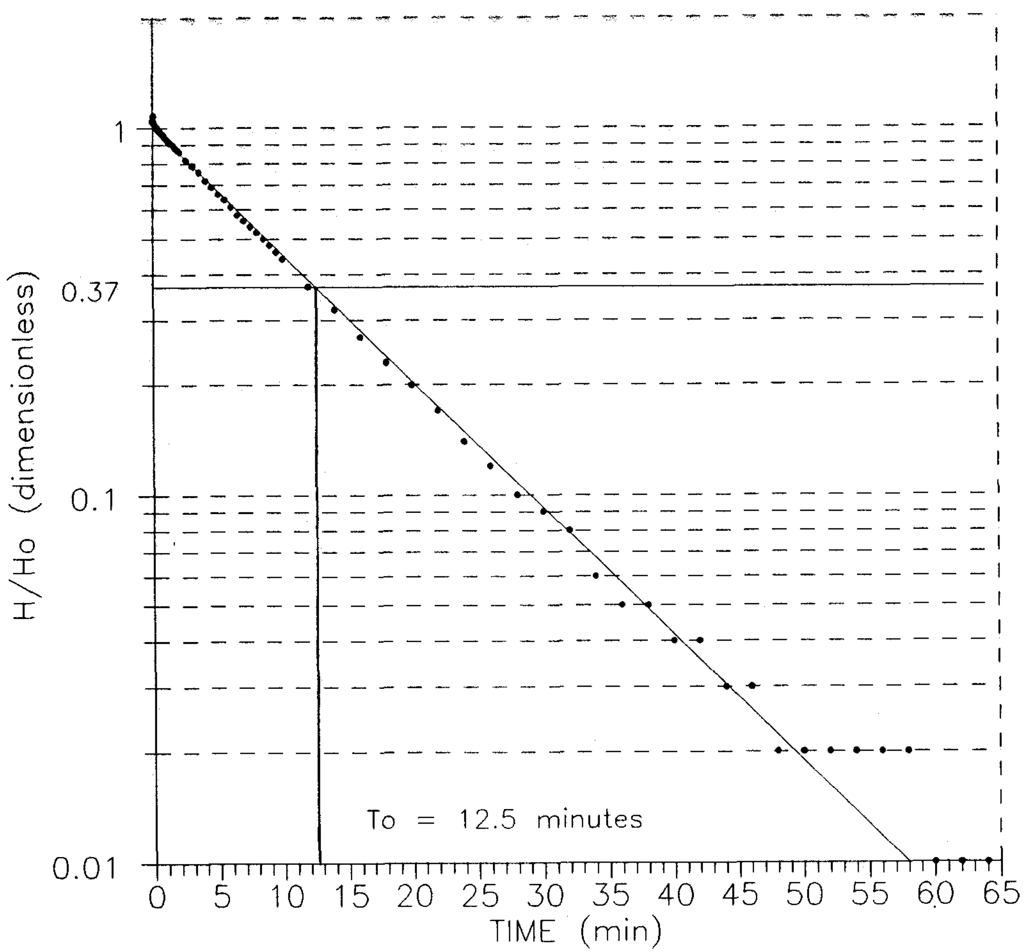
L = length of the well screen:	9.55	feet
r = radius of the well casing:	0.0863	feet
R = radius of the well screen	0.458	feet
To = time to recover 37%	12.5	minutes
L/R = Validity Check	20.85	

K = 9.5E-05 ft/min x 0.508 cm-min/sec-ft

K = 4.8E-05 cm/sec

HVORSLEV ANALYSIS

37191 – MW16
SLUG WITHDRAWAL TEST
To = 12.5 minutes



INDEX OF BOREHOLE AND SINGLE WELL TEST DATA AND RESULTS

Borehole, well, or piezometer number: **37591 (MW22)**
(Work plan designation)

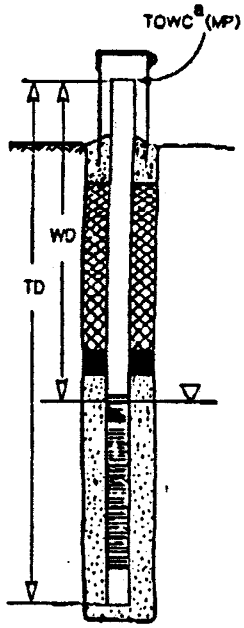
Data Available:

- __ Packer Test – Set-up
- __ Packer Test – Data Sheet (Flow vs. Time Data)
- __ Packer Test – Data Logger Output (Head vs. Time Data)
- __ Packer Test – Analysis and Results Calculation Sheet
- ✔ Single Well Test – Record of Initial Water Level Measurement
- ✔ Single Well Test – 10 Minute Calibration Plot
- ✔ Single Well Test – Head vs. Time Data Form
- ✔ Single Well Test —Head vs. Time Response Graph(s)
- ✔ Single Well Test – Bouwer and Rice Method Analytical Results
- __ Single Well Test – Hvorslev Method Analytical Results

GROUNDWATER LEVELS MEASUREMENTS/CALCULATIONS

ROCKY FLATS PROJECT Revision 1.2
Project No. OU 1
Date 12/21/91
Personnel 1. J. Uhlinger
2. J. Coen

EQUIPMENT: Manufacturer Solinst Model ______ Serial No. 10373
CALIBRATION: Date Passed ______ Date Due ______
QC REVIEW: Name ______ Date ______



Well No. 37591 JFU	WD[b]	MTD[c]	Comments		
Measurement 1	13.29	17.00	JC		
Measurement 2	13.29	17.00	JF		
Measurement 3	13.29	17.00	JC		
	Average WD	Average MTD	+ Probe End[d]	= TD[e]	Chk'd by

Well No.	WD[b]	MTD[c]	Comments		
Measurement 1					
Measurement 2					
Measurement 3					
	Average WD	Average MTD	+ Probe End[d]	= TD[e]	Chk'd by

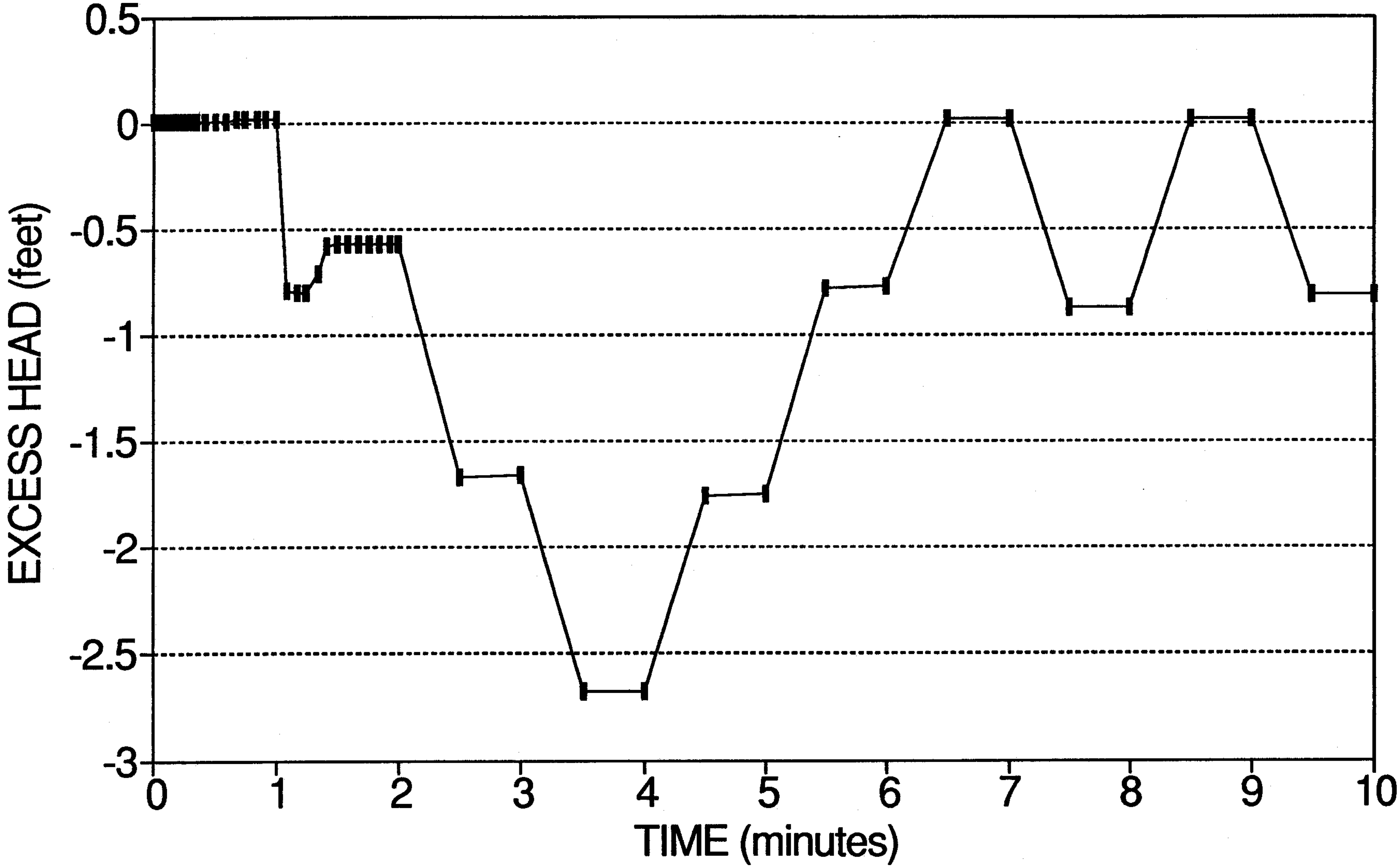
Well No.	WD[b]	MTD[c]	Comments		
Measurement 1					
Measurement 2					
Measurement 3					
	Average WD	Average MTD	+ Probe End[d]	= TD[e]	Chk'd by

Footnotes:
A = TOWC = top of well casing
b = WD = depth to water from MP
c = MTD = measured total depth from MP
d = Probe End = length beyond measuring point on probe
e = TD = total depth of well from MP

Notes:
- All measurements are relative to Mark Point (MP) = north side of TOWC
- QC review by supervisor is a check of reasonableness
- Measurements 1 and 2 must be within .01 ft of a 3rd measurement must be taken

TEN MINUTE CALIBRATION TEST

37591 - MW22



MW 22

U.S. DEPARTMENT OF ENERGY ROCKY FLATS PLANT

FORM GW.4A
Page 1 of 2

BAILDOWN/RECOVERY TEST ~~SLUG TEST~~ DATA FORM

Location 881 Hillside
Borehole No. 37591 MW22
Test Date 12/21/91
Measuring Point Top PVC Casing
Type of Test Baildown/Recovery
Transductor Probe Serial No. 350975
Datalogger Test Run No.
(include time and date for identification purposes)
MW22-1a.TST
MW22-1b.TST

Name J. Uhlinger
Groundwater Elevation Before Test 13.29
Total Casing Depth 17.00'
Borehole Diameter 11"
Casing Diameter 2.07"
Screened Interval 14.70-9.70 (5ft)
Sand Pack Interval 16.80' - 7.70
Lithology Tested gravelly sandy clay

Actual Time	Elapsed Time	Depth to Water from Top of Casing (ft)	H Excess Head (ft)	H/HO

See XD Records

(4011-600-0024)(GW4REV.1)(09-11-91)

BAIL DOWN/RECOVERY TEST DATA FORM 37591 - MW22

FILE: MW22_1B.WQ2
TEST DATE: 12/21/91
START TIME: 10:32:48 AM

REFERENCE: 13.27 FT

ELAPSED TIME (min)	DEPTH TO H20 FROM TOC (ft)	EXCESS HEAD (ft)
0	14.697	-1.427
0.0083	14.694	-1.424
0.0166	14.690	-1.420
0.025	14.687	-1.417
0.0333	14.684	-1.414
0.0416	14.678	-1.408
0.05	14.675	-1.405
0.0583	14.675	-1.405
0.0666	14.668	-1.398
0.075	14.665	-1.395
0.0833	14.665	-1.395
0.1	14.675	-1.405
0.1166	14.665	-1.395
0.1333	14.659	-1.389
0.15	14.652	-1.382
0.1666	14.646	-1.376
0.1833	14.640	-1.370
0.2	14.630	-1.360
0.2166	14.627	-1.357
0.2333	14.621	-1.351
0.25	14.615	-1.345
0.2666	14.608	-1.338
0.2833	14.602	-1.332
0.3	14.596	-1.326
0.3166	14.589	-1.319
0.3333	14.583	-1.313
0.4166	14.558	-1.288
0.5	14.532	-1.262
0.5833	14.510	-1.240
0.6666	14.488	-1.218
0.75	14.466	-1.196
0.8333	14.447	-1.177
0.9166	14.431	-1.161
1	14.412	-1.142
1.0833	14.396	-1.126
1.1666	14.384	-1.114
1.25	14.368	-1.098
1.3333	14.355	-1.085
1.4166	14.342	-1.072
1.5	14.330	-1.060
1.5833	14.317	-1.047
1.6666	14.308	-1.038
1.75	14.304	-1.034
1.8333	14.289	-1.019
1.9166	14.279	-1.009

ELAPSED TIME (min)	DEPTH TO H20 FROM TOC (ft)	EXCESS HEAD (ft)
2	14.270	-1.000
2.5	14.225	-0.955
3	14.194	-0.924
3.5	14.165	-0.895
4	14.140	-0.870
4.5	14.115	-0.845
5	14.102	-0.832
5.5	14.089	-0.819
6	14.073	-0.803
6.5	14.064	-0.794
7	14.054	-0.784
7.5	14.051	-0.781
8	14.045	-0.775
8.5	14.035	-0.765
9	14.029	-0.759
9.5	14.023	-0.753
10	14.020	-0.750
12	14.007	-0.737
14	13.994	-0.724
16	13.982	-0.712
18	13.972	-0.702
20	13.966	-0.696
22	13.956	-0.686
24	13.950	-0.680
26	13.947	-0.677
28	13.937	-0.667
30	13.934	-0.664
32	13.928	-0.658
34	13.925	-0.655
36	13.921	-0.651
38	13.918	-0.648
40	13.912	-0.642
42	13.912	-0.642
44	13.909	-0.639
46	13.902	-0.632
48	13.899	-0.629
50	13.896	-0.626
52	13.893	-0.623
54	13.893	-0.623
56	13.887	-0.617
58	13.883	-0.613
60	13.883	-0.613
62	13.877	-0.607
64	13.877	-0.607
66	13.874	-0.604

ELAPSED TIME (min)	DEPTH TO H20 FROM TOC (ft)	EXCESS HEAD (ft)
68	13.874	-0.604
70	13.871	-0.601
72	13.868	-0.598
74	13.864	-0.594
76	13.864	-0.594
78	13.861	-0.591
80	13.858	-0.588
82	13.855	-0.585
84	13.855	-0.585
86	13.855	-0.585
88	13.849	-0.579
90	13.849	-0.579
92	13.845	-0.575
94	13.842	-0.572
96	13.842	-0.572
98	13.839	-0.569
100	13.839	-0.569
110	13.830	-0.560
120	13.820	-0.550
130	13.814	-0.544
140	13.804	-0.534
150	13.795	-0.525
160	13.789	-0.519
170	13.782	-0.512
180	13.773	-0.503
190	13.766	-0.496
200	13.757	-0.487
210	13.754	-0.484
220	13.744	-0.474
230	13.738	-0.468
240	13.732	-0.462
250	13.725	-0.455
260	13.716	-0.446
270	13.709	-0.439
280	13.703	-0.433
290	13.697	-0.427
300	13.694	-0.424
310	13.687	-0.417
320	13.678	-0.408
330	13.668	-0.398
340	13.665	-0.395
350	13.659	-0.389
360	13.656	-0.386
370	13.649	-0.379
380	13.646	-0.376

BAIL DOWN/RECOVERY TEST DATA FORM 37591 - MW22

ELAPSED TIME (min)	DEPTH TO H20 FROM TOC (ft)	EXCESS HEAD (ft)
390	13.643	-0.373
400	13.637	-0.367
410	13.630	-0.360
420	13.627	-0.357
430	13.624	-0.354
440	13.618	-0.348
450	13.614	-0.344
460	13.608	-0.338
470	13.605	-0.335
480	13.602	-0.332
490	13.595	-0.325
500	13.592	-0.322
510	13.589	-0.319
520	13.583	-0.313
530	13.576	-0.306
540	13.573	-0.303
550	13.567	-0.297
560	13.564	-0.294
570	13.561	-0.291
580	13.558	-0.288
590	13.551	-0.281
600	13.548	-0.278
610	13.542	-0.272
620	13.535	-0.265
630	13.532	-0.262
640	13.529	-0.259
650	13.526	-0.256
660	13.523	-0.253
670	13.516	-0.246
680	13.513	-0.243
690	13.510	-0.240
700	13.504	-0.234
710	13.501	-0.231
720	13.497	-0.227
730	13.494	-0.224
740	13.488	-0.218
750	13.488	-0.218
760	13.482	-0.212
770	13.478	-0.208
780	13.475	-0.205
790	13.469	-0.199
800	13.466	-0.196
810	13.463	-0.193
820	13.459	-0.189
830	13.453	-0.183

BAIL DOWN/RECOVERY TEST DATA FORM 37591 - MW22

ELAPSED TIME (min)	DEPTH TO H20 FROM TOC (ft)	EXCESS HEAD (ft)
840	13.453	-0.183
850	13.447	-0.177
860	13.444	-0.174
870	13.437	-0.167
880	13.434	-0.164
890	13.431	-0.161
900	13.428	-0.158
910	13.425	-0.155
920	13.418	-0.148
930	13.415	-0.145
940	13.412	-0.142
950	13.409	-0.139
960	13.406	-0.136
970	13.402	-0.132
980	13.396	-0.126
990	13.396	-0.126
1000	13.393	-0.123
1010	13.390	-0.120
1020	13.383	-0.113
1030	13.380	-0.110
1040	13.377	-0.107
1050	13.374	-0.104
1060	13.371	-0.101
1070	13.368	-0.098
1080	13.364	-0.094
1090	13.358	-0.088
1100	13.358	-0.088
1110	13.358	-0.088
1120	13.355	-0.085
1130	13.352	-0.082
1140	13.345	-0.075
1150	13.342	-0.072
1160	13.339	-0.069
1170	13.336	-0.066
1180	13.333	-0.063
1190	13.330	-0.060
1200	13.326	-0.056
1210	13.323	-0.053
1220	13.317	-0.047
1230	13.314	-0.044
1240	13.311	-0.041
1250	13.311	-0.041
1260	13.304	-0.034
1270	13.304	-0.034
1280	13.301	-0.031

BAIL DOWN/RECOVERY TEST DATA FORM 37591 - MW22

ELAPSED TIME (min)	DEPTH TO H20 FROM TOC (ft)	EXCESS HEAD (ft)
1290	13.298	-0.028
1300	13.295	-0.025
1310	13.288	-0.018
1320	13.285	-0.015
1330	13.282	-0.012
1340	13.279	-0.009
1350	13.279	-0.009
1360	13.273	-0.003
1370	13.270	0.000
1380	13.266	0.004
1390	13.263	0.007
1400	13.26	0.010
1410	13.257	0.013
1420	13.254	0.016
1430	13.251	0.019
1440	13.247	0.023
1450	13.244	0.026
1460	13.241	0.029
1470	13.238	0.032
1480	13.235	0.035
1490	13.232	0.038
1500	13.228	0.042
1510	13.225	0.045
1520	13.222	0.048
1530	13.219	0.051
1540	13.213	0.057
1550	13.213	0.057
1560	13.209	0.061
1570	13.206	0.064
1580	13.203	0.067
1590	13.197	0.073
1600	13.197	0.073
1610	13.19	0.080
1620	13.187	0.083
1630	13.184	0.086
1640	13.181	0.089
1650	13.178	0.092
1660	13.175	0.095
1670	13.175	0.095
1680	13.171	0.099
1690	13.168	0.102
1700	13.165	0.105
1710	13.162	0.108
1720	13.159	0.111
1730	13.156	0.114

BAIL DOWN/RECOVERY TEST DATA FORM 37591 - MW22

ELAPSED TIME (min)	DEPTH TO H20 FROM TOC (ft)	EXCESS HEAD (ft)
1740	13.156	0.114
1750	13.152	0.118
1760	13.149	0.121
1770	13.146	0.124
1780	13.143	0.127
1790	13.14	0.130
1800	13.137	0.133
1810	13.133	0.137
1820	13.13	0.140
1830	13.13	0.140
1840	13.127	0.143
1850	13.124	0.146
1860	13.121	0.149
1870	13.118	0.152
1880	13.114	0.156
1890	13.111	0.159
1900	13.108	0.162
1910	13.105	0.165
1920	13.105	0.165
1930	13.102	0.168
1940	13.099	0.171
1950	13.095	0.175
1960	13.092	0.178
1970	13.092	0.178
1980	13.089	0.181
1990	13.086	0.184
2000	13.086	0.184
2010	13.08	0.190
2020	13.076	0.194
2030	13.076	0.194
2040	13.073	0.197
2050	13.07	0.200
2060	13.067	0.203
2070	13.064	0.206
2080	13.061	0.209
2090	13.057	0.213
2100	13.057	0.213
2110	13.054	0.216
2120	13.051	0.219
2130	13.048	0.222
2140	13.045	0.225
2150	13.045	0.225
2160	13.042	0.228
2170	13.038	0.232
2180	13.035	0.235

BAIL DOWN/RECOVERY TEST DATA FORM 37591 - MW22

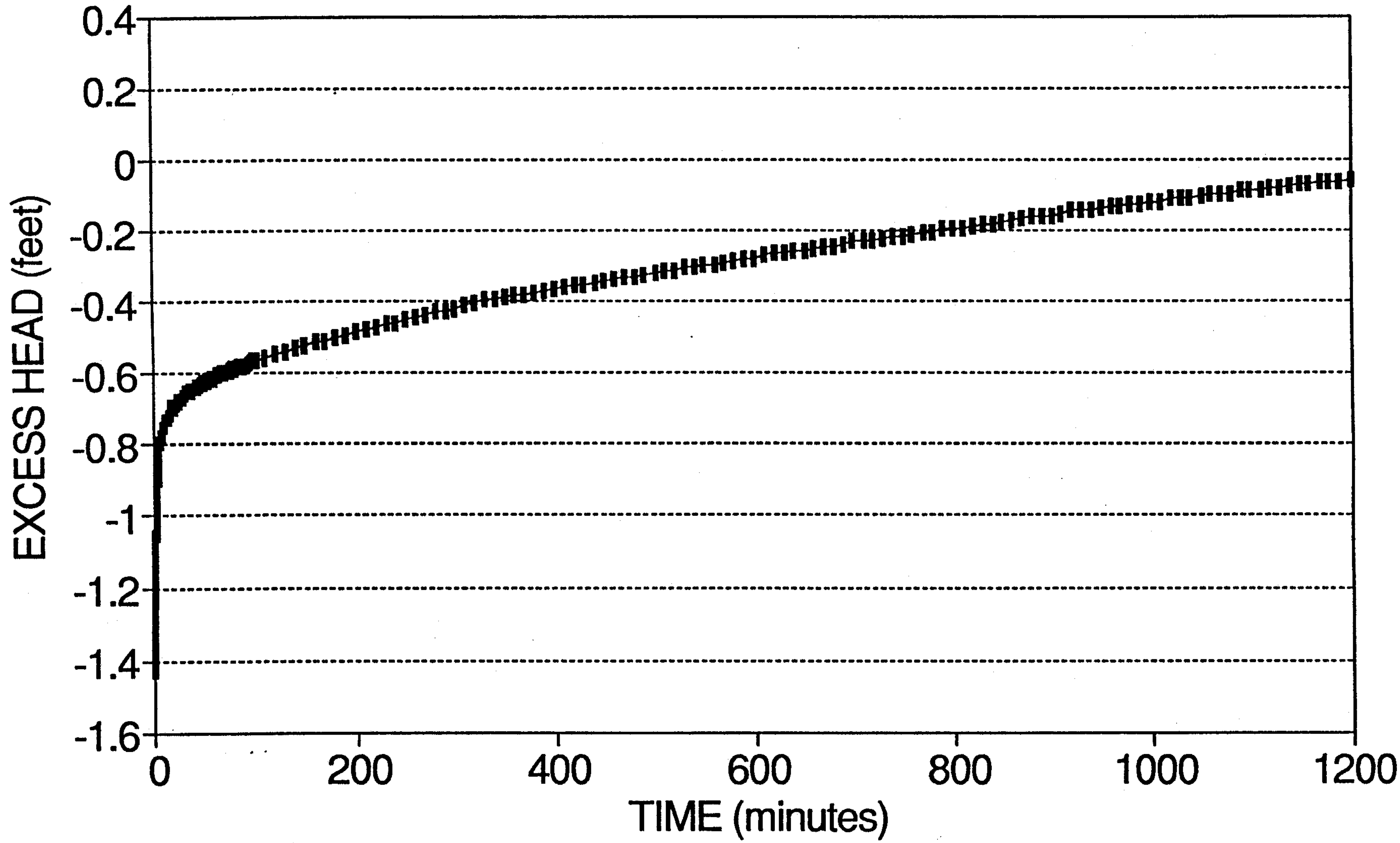
ELAPSED TIME (min)	DEPTH TO H20 FROM TOC (ft)	EXCESS HEAD (ft)
2190	13.032	0.238
2200	13.032	0.238
2210	13.026	0.244
2220	13.026	0.244
2230	13.023	0.247
2240	13.019	0.251
2250	13.016	0.254
2260	13.016	0.254
2270	13.013	0.257
2280	13.01	0.260
2290	13.01	0.260
2300	13.007	0.263
2310	13.004	0.266
2320	13	0.270
2330	12.997	0.273
2340	12.997	0.273
2350	12.994	0.276
2360	12.991	0.279
2370	12.988	0.282
2380	12.988	0.282
2390	12.985	0.285
2400	12.981	0.289
2410	12.978	0.292
2420	12.978	0.292
2430	12.975	0.295
2440	12.972	0.298
2450	12.969	0.301
2460	12.969	0.301
2470	12.963	0.307
2480	12.963	0.307
2490	12.959	0.311
2500	12.956	0.314
2510	12.953	0.317
2520	12.95	0.320
2530	12.95	0.320
2540	12.944	0.326
2550	12.94	0.330
2560	12.94	0.330
2570	12.937	0.333
2580	12.934	0.336
2590	12.934	0.336
2600	12.931	0.339
2610	12.928	0.342
2620	12.925	0.345
2630	12.925	0.345

BAIL DOWN/RECOVERY TEST DATA FORM 37591 - MW22

ELAPSED TIME (min)	DEPTH TO H20 FROM TOC (ft)	EXCESS HEAD (ft)
2640	12.921	0.349
2650	12.918	0.352

BAIL DOWN/RECOVERY TEST

37591 - MW22



A Q T E S O L V   R E S U L T S
Version 1.10

06/05/92 11:41:08

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TEST DESCRIPTION

Data set........... mw22bdr.dat
Data set title..... BAIL DOWN RECOVERY TEST 37591 - MW22
Project............ OPERABLE UNIT 1
Client............. EG&G ROCKY FLATS
Location........... 881 HILLSIDE
Test date.......... 12/21/91

Knowns and Constants:

No. of data points.................. 360
Radius of well casing............... 0.261
Radius of well...................... 0.458
Aquifer saturated thickness......... 1.21
Well screen length.................. 1.21
Static height of water in well...... 1.21
Log(Re/Rw).......................... 0.7309
A, B, C............................. 0.000, 0.000, 0.623

==

ANALYTICAL METHOD

Bouwer-Rice (Unconfined Aquifer Slug Test)

==

RESULTS FROM VISUAL CURVE MATCHING

VISUAL MATCH PARAMETER ESTIMATES

	Estimate
K =	1.4723E-005
y0 =	9.6610E-001

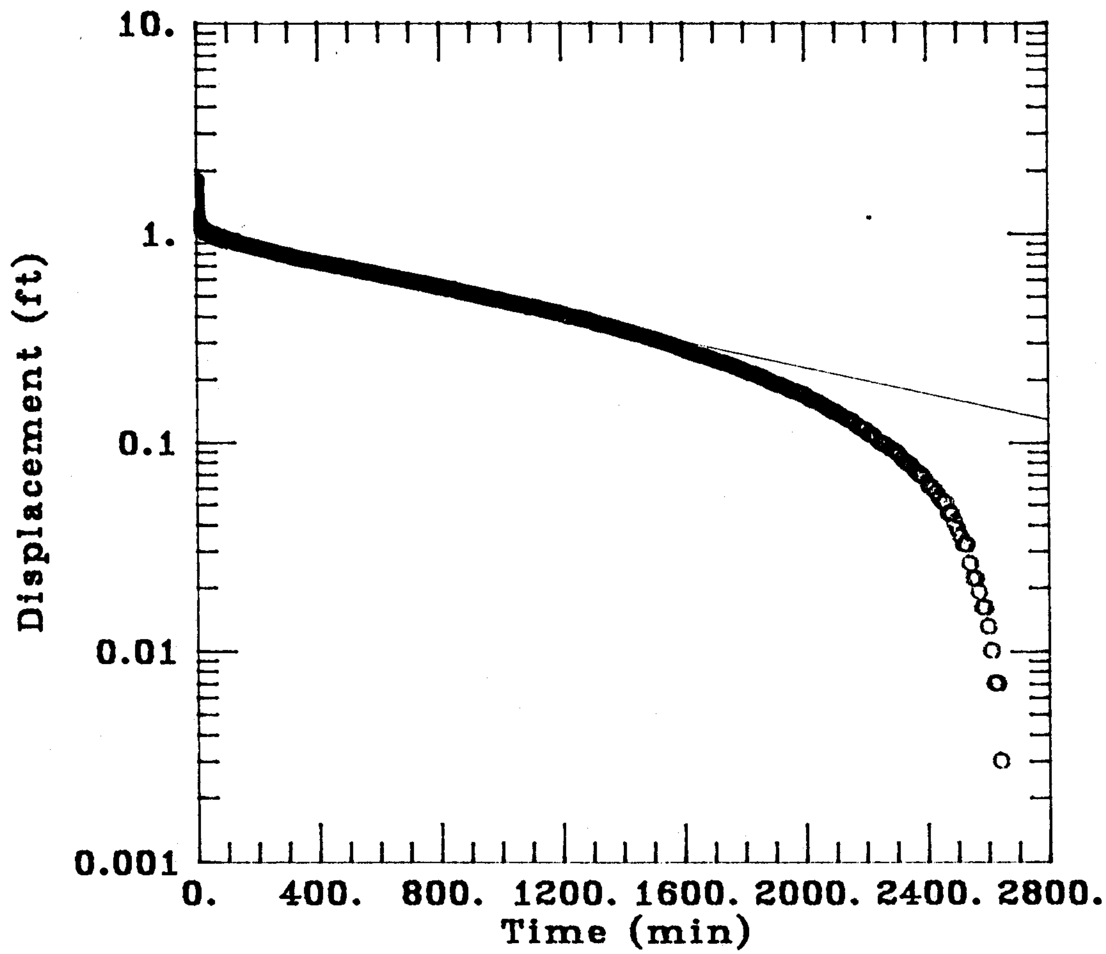
<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>

Project No.: OPERABLE UNIT 1

Client: EG&G ROCKY FLATS

Location: 881 HILLSIDE

BAIL DOWN RECOVERY TEST 37591 – MW22



DATA SET:
mw22bdr.dat
06/05/92

AQUIFER TYPE:
Unconfined

SOLUTION METHOD:
Bouwer-Rice

TEST DATE:
12/21/91

ESTIMATED PARAMETERS:
K = 1.4723E-05 ft/min
y0 = 0.9661 ft

TEST DATA:
H0 = 1.427 ft
rc = 0.261 ft
rw = 0.458 ft
L = 1.21 ft
b = 1.21 ft
H = 1.21 ft

INDEX OF BOREHOLE AND SINGLE WELL TEST DATA AND RESULTS

Borehole, well, or piezometer number: **37791 (MW21)**
(Work plan designation)

Data Available:

__ Packer Test – Set-up

__ Packer Test – Data Sheet (Flow vs. Time Data)

__ Packer Test – Data Logger Output (Head vs. Time Data)

__ Packer Test – Analysis and Results Calculation Sheet

✔ Single Well Test – Record of Initial Water Level Measurement

__ Single Well Test – 10 Minute Calibration Plot

✔ Single Well Test – Head vs. Time Data Form

✔ Single Well Test – Head vs. Time Response Graph(s)

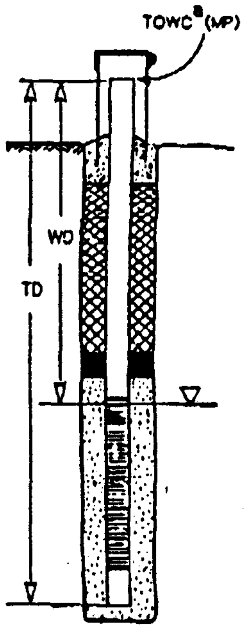
__ Single Well Test – Bouwer and Rice Method Analytical Results

__ Single Well Test – Hvorslev Method Analytical Results

GROUNDWATER LEVELS MEASUREMENTS/CALCULATIONS

ROCKY FLATS PROJECT Revision 1.2
Project No. OU1 881 Hillside
Date 12/23/91
Personnel 1. J. Uhlinger
2. B. Brenner

EQUIPMENT: Manufacturer Solinst Model ______ Serial No. ______
CALIBRATION: Date Passed ______ Date Due ______
QC REVIEW: Name ______ Date ______



Well No.	WD[b]	MTD[c]	Comments		
37791					
Measurement 1	22.50	25.00			
Measurement 2					
Measurement 3					
	Average WD	Average MTD	+ 0 Probe End[d]	= TD[e]	Chk'd by

Well No.	WD[b]	MTD[c]	Comments		
Measurement 1					
Measurement 2					
Measurement 3					
	Average WD	Average MTD	+ Probe End[d]	= TD[e]	Chk'd by

Well No.	WD[b]	MTD[c]	Comments		
Measurement 1					
Measurement 2					
Measurement 3					
	Average WD	Average MTD	+ Probe End[d]	= TD[e]	Chk'd by

Footnotes:
A = TOWC = top of well casing
b = WD = depth to water from MP
c = MTD = measured total depth from MP
d = Probe End = length beyond measuring point on probe
e = TD = total depth of well from MP

Notes:
- All measurements are relative to Mark Point (MP) = north side of TOWC
- QC review by supervisor is a check of reasonableness
- Measurements 1 and 2 must be within .01 ft of a 3rd measurement must be taken

U.S. DEPARTMENT OF ENERGY ROCKY FLATS PLANT

FORM GW.4A

BAILDOWN/RECOVERY
~~SLUG TEST~~ DATA FORM

Location OU1 881 Hillside
Borehole No. 37791 MW21
Test Date 12/23/91
Measuring Point Top PVC Casing
Type of Test Bail/Down - Recovery
Transductor Probe Serial No. 265825
Datalogger Test Run No.
(include time and date for identification purposes)
~~MW21-1a.TST~~
MW21-1b.TST

Name J. Uhling, B. Brennan, C. Benulis
Groundwater Elevation Before Test 22.48 Top MP
Total Casing Depth 24' 11 7/8"
Borehole Diameter 11"
Casing Diameter 2.07"
Screened Interval 23.10 - 13.10'
Sand Pack Interval 11.30 - 25.10'
Lithology Tested Clay, gravel, cobbles, silt.

Actual Time	Elapsed Time	Depth to Water from Top of Casing (ft)	H Excess Head (ft)	H/HO

See XD Records

(4011-600-0024)(GW4REV.1)(09-11-91)

BAIL DOWN/RECOVERY TEST DATA FORM 37791 - MW21

FILE: MW21_1B.WQ2
TEST DATE: 12/24/91
START TIME: 08:30:02 AM

REFERENCE: 22.48 FT

ELAPSED TIME (min)	DEPTH TO H20 FROM TOC (ft)	EXCESS HEAD (ft)
0	22.999	-0.519
0.0083	22.999	-0.519
0.0166	22.999	-0.519
0.025	22.999	-0.519
0.0333	22.995	-0.515
0.0416	22.999	-0.519
0.05	22.995	-0.515
0.0583	22.995	-0.515
0.0666	22.995	-0.515
0.075	22.992	-0.512
0.0833	22.995	-0.515
0.1	22.992	-0.512
0.1166	22.989	-0.509
0.1333	22.989	-0.509
0.15	22.989	-0.509
0.1666	22.986	-0.506
0.1833	22.983	-0.503
0.2	22.983	-0.503
0.2166	22.983	-0.503
0.2333	22.980	-0.500
0.25	22.980	-0.500
0.2666	22.976	-0.496
0.2833	22.976	-0.496
0.3	22.973	-0.493
0.3166	22.973	-0.493
0.3333	22.973	-0.493
0.4166	22.967	-0.487
0.5	22.961	-0.481
0.5833	22.954	-0.474
0.6666	22.948	-0.468
0.75	22.942	-0.462
0.8333	22.938	-0.458
0.9166	22.932	-0.452
1	22.926	-0.446
1.0833	22.923	-0.443
1.1666	22.916	-0.436
1.25	22.913	-0.433
1.3333	22.910	-0.430
1.4166	22.907	-0.427
1.5	22.904	-0.424
1.5833	22.900	-0.420
1.6666	22.897	-0.417
1.75	22.894	-0.414
1.8333	22.894	-0.414
1.9166	22.891	-0.411

BAIL DOWN/RECOVERY TEST DATA FORM 37791 - MW21

ELAPSED TIME (min)	DEPTH TO H20 FROM TOC (ft)	EXCESS HEAD (ft)
2	22.891	-0.411
2.5	22.882	-0.402
3	22.872	-0.392
3.5	22.869	-0.389
4	22.866	-0.386
4.5	22.859	-0.379
5	22.856	-0.376
5.5	22.853	-0.373
6	22.853	-0.373
6.5	22.850	-0.370
7	22.847	-0.367
7.5	22.847	-0.367
8	22.844	-0.364
8.5	22.840	-0.360
9	22.840	-0.360
9.5	22.837	-0.357
10	22.837	-0.357
12	22.834	-0.354
14	22.828	-0.348
16	22.825	-0.345
18	22.821	-0.341
20	22.818	-0.338
22	22.815	-0.335
24	22.812	-0.332
26	22.809	-0.329
28	22.806	-0.326
30	22.806	-0.326
32	22.802	-0.322
34	22.802	-0.322
36	22.799	-0.319
38	22.796	-0.316
40	22.796	-0.316
42	22.796	-0.316
44	22.793	-0.313
46	22.793	-0.313
48	22.790	-0.310
50	22.790	-0.310
52	22.787	-0.307
54	22.787	-0.307
56	22.787	-0.307
58	22.783	-0.303
60	22.783	-0.303
62	22.780	-0.300
64	22.780	-0.300
66	22.780	-0.300

BAIL DOWN/RECOVERY TEST DATA FORM 37791 - MW21

ELAPSED TIME (min)	DEPTH TO H20 FROM TOC (ft)	EXCESS HEAD (ft)
68	22.777	-0.297
70	22.777	-0.297
72	22.777	-0.297
74	22.774	-0.294
76	22.774	-0.294
78	22.771	-0.291
80	22.771	-0.291
82	22.771	-0.291
84	22.771	-0.291
86	22.768	-0.288
88	22.768	-0.288
90	22.768	-0.288
92	22.768	-0.288
94	22.768	-0.288
96	22.764	-0.284
98	22.764	-0.284
100	22.764	-0.284
110	22.761	-0.281
120	22.758	-0.278
130	22.752	-0.272
140	22.749	-0.269
150	22.745	-0.265
160	22.742	-0.262
170	22.739	-0.259
180	22.736	-0.256
190	22.736	-0.256
200	22.733	-0.253
210	22.730	-0.250
220	22.726	-0.246
230	22.723	-0.243
240	22.720	-0.240
250	22.717	-0.237
260	22.714	-0.234
270	22.711	-0.231
280	22.707	-0.227
290	22.711	-0.231
300	22.704	-0.224
310	22.701	-0.221
320	22.701	-0.221
330	22.695	-0.215
340	22.695	-0.215
350	22.692	-0.212
360	22.688	-0.208
370	22.685	-0.205
380	22.685	-0.205

ELAPSED TIME (min)	DEPTH TO H20 FROM TOC (ft)	EXCESS HEAD (ft)
390	22.685	-0.205
400	22.685	-0.205
410	22.679	-0.199
420	22.679	-0.199
430	22.679	-0.199
440	22.676	-0.196
450	22.673	-0.193
460	22.673	-0.193
470	22.666	-0.186
480	22.666	-0.186
490	22.663	-0.183
500	22.660	-0.180
510	22.660	-0.180
520	22.660	-0.180
530	22.657	-0.177
540	22.654	-0.174
550	22.654	-0.174
560	22.654	-0.174
570	22.650	-0.170
580	22.650	-0.170
590	22.647	-0.167
600	22.647	-0.167
610	22.647	-0.167
620	22.644	-0.164
630	22.641	-0.161
640	22.641	-0.161
650	22.641	-0.161
660	22.638	-0.158
670	22.638	-0.158
680	22.635	-0.155
690	22.635	-0.155
700	22.635	-0.155
710	22.631	-0.151
720	22.631	-0.151
730	22.631	-0.151
740	22.628	-0.148
750	22.625	-0.145
760	22.625	-0.145
770	22.625	-0.145
780	22.622	-0.142
790	22.625	-0.145
800	22.619	-0.139
810	22.619	-0.139
820	22.619	-0.139
830	22.619	-0.139

BAIL DOWN/RECOVERY TEST DATA FORM 37791 - MW21

ELAPSED TIME (min)	DEPTH TO H20 FROM TOC (ft)	EXCESS HEAD (ft)
840	22.616	-0.136
850	22.616	-0.136
860	22.612	-0.132
870	22.612	-0.132
880	22.612	-0.132
890	22.609	-0.129
900	22.609	-0.129
910	22.609	-0.129
920	22.606	-0.126
930	22.606	-0.126
940	22.603	-0.123
950	22.603	-0.123
960	22.603	-0.123
970	22.600	-0.120
980	22.600	-0.120
990	22.600	-0.120
1000	22.597	-0.117
1010	22.597	-0.117
1020	22.593	-0.113
1030	22.593	-0.113
1040	22.590	-0.110
1050	22.590	-0.110
1060	22.590	-0.110
1070	22.590	-0.110
1080	22.587	-0.107
1090	22.590	-0.110
1100	22.587	-0.107
1110	22.587	-0.107
1120	22.587	-0.107
1130	22.584	-0.104
1140	22.584	-0.104
1150	22.584	-0.104
1160	22.581	-0.101
1170	22.581	-0.101
1180	22.578	-0.098
1190	22.578	-0.098
1200	22.574	-0.094
1210	22.574	-0.094
1220	22.574	-0.094
1230	22.574	-0.094
1240	22.571	-0.091
1250	22.571	-0.091
1260	22.571	-0.091
1270	22.571	-0.091
1280	22.571	-0.091

BAIL DOWN/RECOVERY TEST DATA FORM 37791 - MW21

ELAPSED TIME (min)	DEPTH TO H20 FROM TOC (ft)	EXCESS HEAD (ft)
1290	22.568	-0.088
1300	22.568	-0.088
1310	22.568	-0.088
1320	22.565	-0.085
1330	22.565	-0.085
1340	22.565	-0.085
1350	22.562	-0.082
1360	22.562	-0.082
1370	22.559	-0.079
1380	22.559	-0.079
1390	22.559	-0.079
1400	22.559	-0.079
1410	22.555	-0.075
1420	22.559	-0.079
1430	22.552	-0.072
1440	22.555	-0.075
1450	22.555	-0.075
1460	22.555	-0.075
1470	22.552	-0.072
1480	22.552	-0.072
1490	22.552	-0.072
1500	22.552	-0.072
1510	22.552	-0.072
1520	22.549	-0.069
1530	22.549	-0.069
1540	22.549	-0.069
1550	22.549	-0.069
1560	22.549	-0.069
1570	22.546	-0.066
1580	22.546	-0.066
1590	22.546	-0.066
1600	22.546	-0.066
1610	22.546	-0.066
1620	22.543	-0.063
1630	22.543	-0.063
1640	22.543	-0.063
1650	22.543	-0.063
1660	22.54	-0.060
1670	22.54	-0.060
1680	22.536	-0.056
1690	22.536	-0.056
1700	22.536	-0.056
1710	22.533	-0.053
1720	22.533	-0.053
1730	22.533	-0.053

BAIL DOWN/RECOVERY TEST DATA FORM 37791 - MW21

ELAPSED TIME (min)	DEPTH TO H20 FROM TOC (ft)	EXCESS HEAD (ft)
1740	22.53	-0.050
1750	22.527	-0.047
1760	22.527	-0.047
1770	22.524	-0.044
1780	22.527	-0.047
1790	22.521	-0.041
1800	22.521	-0.041
1810	22.517	-0.037
1820	22.521	-0.041
1830	22.521	-0.041
1840	22.517	-0.037
1850	22.517	-0.037
1860	22.517	-0.037
1870	22.514	-0.034
1880	22.514	-0.034
1890	22.511	-0.031
1900	22.511	-0.031
1910	22.508	-0.028
1920	22.508	-0.028
1930	22.508	-0.028
1940	22.508	-0.028
1950	22.505	-0.025
1960	22.505	-0.025
1970	22.505	-0.025
1980	22.502	-0.022
1990	22.502	-0.022
2000	22.502	-0.022
2010	22.502	-0.022
2020	22.502	-0.022
2030	22.498	-0.018
2040	22.498	-0.018
2050	22.498	-0.018
2060	22.498	-0.018
2070	22.498	-0.018
2080	22.498	-0.018
2090	22.495	-0.015
2100	22.495	-0.015
2110	22.492	-0.012
2120	22.492	-0.012
2130	22.492	-0.012
2140	22.492	-0.012
2150	22.492	-0.012
2160	22.489	-0.009
2170	22.492	-0.012
2180	22.489	-0.009

BAIL DOWN/RECOVERY TEST DATA FORM 37791 - MW21

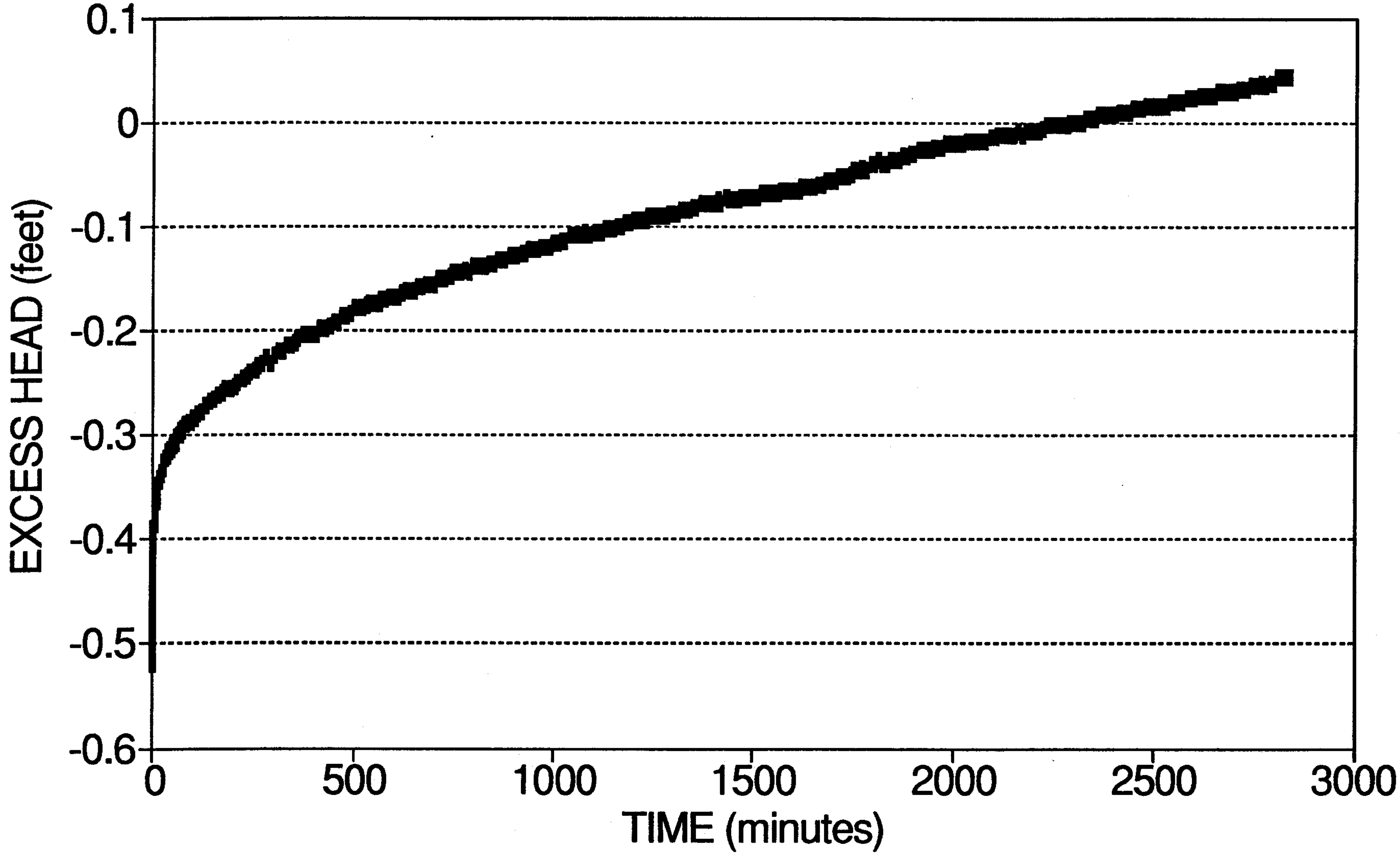
ELAPSED TIME (min)	DEPTH TO H20 FROM TOC (ft)	EXCESS HEAD (ft)
2190	22.489	-0.009
2200	22.489	-0.009
2210	22.489	-0.009
2220	22.486	-0.006
2230	22.483	-0.003
2240	22.483	-0.003
2250	22.483	-0.003
2260	22.483	-0.003
2270	22.483	-0.003
2280	22.483	-0.003
2290	22.48	0.000
2300	22.48	0.000
2310	22.48	0.000
2320	22.48	0.000
2330	22.476	0.004
2340	22.476	0.004
2350	22.476	0.004
2360	22.473	0.007
2370	22.473	0.007
2380	22.473	0.007
2390	22.473	0.007
2400	22.473	0.007
2410	22.47	0.010
2420	22.47	0.010
2430	22.47	0.010
2440	22.47	0.010
2450	22.467	0.013
2460	22.467	0.013
2470	22.467	0.013
2480	22.464	0.016
2490	22.464	0.016
2500	22.464	0.016
2510	22.464	0.016
2520	22.464	0.016
2530	22.464	0.016
2540	22.461	0.019
2550	22.461	0.019
2560	22.461	0.019
2570	22.461	0.019
2580	22.457	0.023
2590	22.457	0.023
2600	22.457	0.023
2610	22.454	0.026
2620	22.454	0.026
2630	22.454	0.026

BAIL DOWN/RECOVERY TEST DATA FORM 37791 - MW21

ELAPSED TIME (min)	DEPTH TO H20 FROM TOC (ft)	EXCESS HEAD (ft)
2640	22.454	0.026
2650	22.454	0.026
2660	22.451	0.029
2670	22.451	0.029
2680	22.451	0.029
2690	22.451	0.029
2700	22.451	0.029
2710	22.448	0.032
2720	22.448	0.032
2730	22.448	0.032
2740	22.445	0.035
2750	22.445	0.035
2760	22.445	0.035
2770	22.442	0.038
2780	22.445	0.035
2790	22.442	0.038
2800	22.442	0.038
2810	22.438	0.042
2820	22.438	0.042
2830	22.438	0.042
2840	22.438	0.042

BAILDOWN/RECOVERY TEST

37791 - MW21



INDEX OF BOREHOLE AND SINGLE WELL TEST DATA AND RESULTS

Borehole, well, or piezometer number: **37891 (MW27)**
(Work plan designation)

Data Available:

__ Packer Test – Set-up

__ Packer Test – Data Sheet (Flow vs. Time Data)

__ Packer Test – Data Logger Output (Head vs. Time Data)

__ Packer Test – Analysis and Results Calculation Sheet

✔ Single Well Test – Record of Initial Water Level Measurement

✔ Single Well Test – 10 Minute Calibration Plot

✔ Single Well Test – Head vs. Time Data Form

✔ Single Well Test – Head vs. Time Response Graph(s)

✔ Single Well Test – Bouwer and Rice Method Analytical Results

__ Single Well Test – Hvorslev Method Analytical Results

U.S. DEPARTMENT OF ENERGY ROCKY FLATS PLANT

FORM GW.1A

GROUNDWATER LEVELS MEASUREMENTS/CALCULATIONS

ROCKY FLATS PROJECT — Revision 1.2

Project No. OU 1

Date 12/18/91

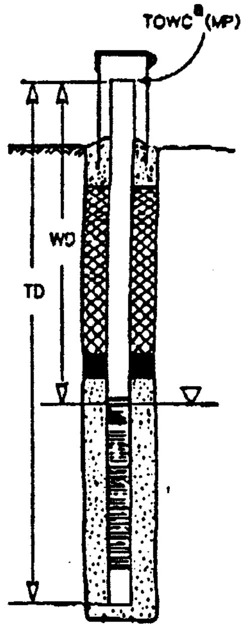
Personnel 1. J. Uhlinger

2. K. Maley

EQUIPMENT: Manufacturer Solinst Model ______ Serial No. 10373

CALIBRATION: Date Passed ______ Date Due ______

QC REVIEW: Name ______ Date ______



Well No. 37891	WD[b]	MTD[c]	Comments
Measurement 1	43.70	57' 1/4"	KM
Measurement 2	43.70	57' 1/4"	JFU
Measurement 3	43.70	57' 1/4"	KM
	43.70	57' 1/4"	+ ____ = ____ ____
	Average WD	Average MTD	Probe End[d] TD[e] Chk'd by

Well No.	WD[b]	MTD[c]	Comments
Measurement 1			
Measurement 2			
Measurement 3			
			+ ____ = ____ ____
	Average WD	Average MTD	Probe End[d] TD[e] Chk'd by

Well No.	WD[b]	MTD[c]	Comments
Measurement 1			
Measurement 2			
Measurement 3			
			+ ____ = ____ ____
	Average WD	Average MTD	Probe End[d] TD[e] Chk'd by

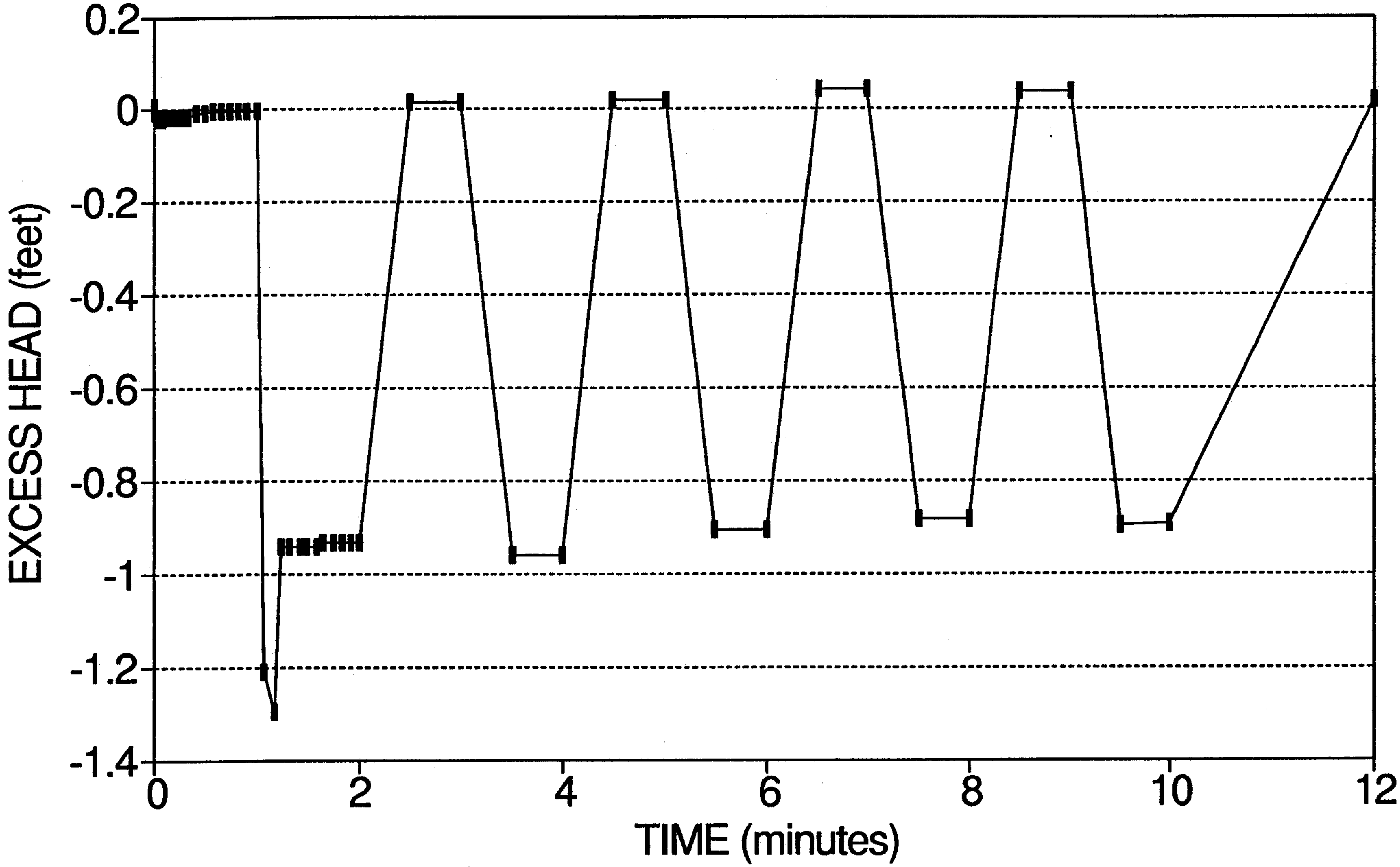
Footnotes:
A = TOWC = top of well casing
b = WD = depth to water from MP
c = MTD = measured total depth from MP
d = Probe End = length beyond measuring point on probe
e = TD = total depth of well from MP

Notes:
- All measurements are relative to Mark Point (MP) = north side of TOWC
- QC review by supervisor is a check of reasonableness
- Measurements 1 and 2 must be within .01 ft of a 3rd measurement must be taken

(4011-600-0022) (GW1-FORM.1A) (09-18-91) (4:18pm)

TEN MINUTE CALIBRATION TEST

37891 - MW27



SLUG TEST DATA FORM

Location OU1-881 Hillside
Borehole No. 37891 (MW27)
Test Date 12/18/91 - 12/21/91
Measuring Point TOC (PVC)
Type of Test Slug in/withdrawl
Transductor Probe Serial No. 1759DD
Datalogger Test Run No. ____
(include time and date for identification purposes)
MW27_1a.TST
MW27_1b.TST
MW27_1c.TST

Name J. Uhl... K. ...
Groundwater Elevation Before Test 43.70
Total Casing Depth 57.02'
Borehole Diameter 7"
Casing Diameter 2.07"
Screened Interval 55.0 - 45.0
Sand Pack Interval 57.0 - 41.80

Lithology Tested Weathered Bedrock Clayey Siltstone

Actual Time	Elapsed Time	Depth to Water from Top of Casing (ft)	H Excess Head (ft)	H/HO

See Transducer Records

SLUG INJECTION TEST DATA FORM 37891 - MW27

FILE: MW27_1B.WQ2
TEST DATE: 12/18/91
START TIME: 10:38:55 AM

REFERENCE: 43.66 FT

ELAPSED TIME (min)	DEPTH TO H20 FROM TOC (ft)	EXCESS HEAD (ft)
0	41.942	1.718
0.0083	41.948	1.712
0.0166	41.825	1.835
0.025	41.942	1.718
0.0333	41.888	1.772
0.0416	41.942	1.718
0.05	42.002	1.658
0.0583	41.958	1.702
0.0666	41.955	1.705
0.075	41.948	1.712
0.0833	41.951	1.709
0.1	41.955	1.705
0.1166	41.945	1.715
0.1333	41.958	1.702
0.15	41.958	1.702
0.1666	41.958	1.702
0.1833	41.958	1.702
0.2	41.958	1.702
0.2166	41.961	1.699
0.2333	41.958	1.702
0.25	41.929	1.731
0.2666	42.015	1.645
0.2833	41.958	1.702
0.3	41.961	1.699
0.3166	41.961	1.699
0.3333	41.961	1.699
0.4166	41.964	1.696
0.5	41.964	1.696
0.5833	41.964	1.696
0.6666	41.964	1.696
0.75	41.964	1.696
0.8333	41.964	1.696
0.9166	41.964	1.696
1	41.964	1.696
1.0833	41.967	1.693
1.1666	41.967	1.693
1.25	41.967	1.693
1.3333	41.967	1.693
1.4166	41.967	1.693
1.5	41.970	1.690
1.5833	41.970	1.690
1.6666	41.967	1.693
1.75	41.967	1.693
1.8333	41.967	1.693
1.9166	41.967	1.693

SLUG INJECTION TEST DATA FORM 37891 - MW27

ELAPSED TIME (min)	DEPTH TO H20 FROM TOC (ft)	EXCESS HEAD (ft)
2	41.955	1.705
2.5	41.967	1.693
3	41.977	1.683
3.5	41.964	1.696
4	41.983	1.677
4.5	41.986	1.674
5	41.970	1.690
5.5	41.986	1.674
6	41.977	1.683
6.5	41.999	1.661
7	41.999	1.661
7.5	42.005	1.655
8	42.008	1.652
8.5	42.011	1.649
9	42.018	1.642
9.5	42.018	1.642
10	42.024	1.636
12	42.030	1.630
14	42.027	1.633
16	42.030	1.630
18	42.040	1.620
20	42.046	1.614
22	42.049	1.611
24	42.081	1.579
26	42.090	1.570
28	42.100	1.560
30	42.106	1.554
32	42.112	1.548
34	42.122	1.538
36	42.128	1.532
38	42.135	1.525
40	42.141	1.519
42	42.147	1.513
44	42.150	1.510
46	42.154	1.506
48	42.160	1.500
50	42.163	1.497
52	42.169	1.491
54	42.172	1.488
56	42.179	1.481
58	42.185	1.475
60	42.188	1.472
62	42.195	1.465
64	42.198	1.462
66	42.204	1.456

SLUG INJECTION TEST DATA FORM 37891 - MW27

ELAPSED TIME (min)	DEPTH TO H20 FROM TOC (ft)	EXCESS HEAD (ft)
68	42.207	1.453
70	42.214	1.446
72	42.217	1.443
74	42.223	1.437
76	42.226	1.434
78	42.232	1.428
80	42.239	1.421
82	42.242	1.418
84	42.245	1.415
86	42.251	1.409
88	42.255	1.405
90	42.258	1.402
92	42.264	1.396
94	42.267	1.393
96	42.270	1.390
98	42.277	1.383
100	42.280	1.380
110	42.299	1.361
120	42.318	1.342
130	42.340	1.320
140	42.356	1.304
150	42.375	1.285
160	42.371	1.289
170	42.381	1.279
180	42.393	1.267
190	42.403	1.257
200	42.419	1.241
210	42.435	1.225
220	42.447	1.213
230	42.460	1.200
240	42.472	1.188
250	42.482	1.178
260	42.495	1.165
270	42.504	1.156
280	42.517	1.143
290	42.526	1.134
300	42.539	1.121
310	42.548	1.112
320	42.561	1.099
330	42.570	1.090
340	42.577	1.083
350	42.586	1.074
360	42.596	1.064
370	42.605	1.055
380	42.611	1.049

SLUG INJECTION TEST DATA FORM 37891 - MW27

ELAPSED TIME (min)	DEPTH TO H20 FROM TOC (ft)	EXCESS HEAD (ft)
390	42.618	1.042
400	42.624	1.036
410	42.630	1.030
420	42.637	1.023
430	42.643	1.017
440	42.649	1.011
450	42.652	1.008
460	42.659	1.001
470	42.665	0.995
480	42.668	0.992
490	42.674	0.986
500	42.681	0.979
510	42.684	0.976
520	42.687	0.973
530	42.690	0.970
540	42.693	0.967
550	42.697	0.963
560	42.700	0.960
570	42.703	0.957
580	42.706	0.954
590	42.706	0.954
600	42.709	0.951
610	42.712	0.948
620	42.719	0.941
630	42.719	0.941
640	42.722	0.938
650	42.725	0.935
660	42.728	0.932
670	42.728	0.932
680	42.731	0.929
690	42.728	0.932
700	42.728	0.932
710	42.728	0.932
720	42.728	0.932
730	42.731	0.929
740	42.731	0.929
750	42.734	0.926
760	42.734	0.926
770	42.731	0.929
780	42.731	0.929
790	42.731	0.929
800	42.731	0.929
810	42.731	0.929
820	42.731	0.929
830	42.731	0.929

SLUG INJECTION TEST DATA FORM 37891 - MW27

ELAPSED TIME (min)	DEPTH TO H20 FROM TOC (ft)	EXCESS HEAD (ft)
840	42.728	0.932
850	42.728	0.932
860	42.728	0.932
870	42.728	0.932
880	42.728	0.932
890	42.728	0.932
900	42.728	0.932
910	42.728	0.932
920	42.728	0.932
930	42.728	0.932
940	42.725	0.935
950	42.725	0.935
960	42.728	0.932
970	42.728	0.932
980	42.728	0.932
990	42.725	0.935
1000	42.725	0.935
1010	42.722	0.938
1020	42.722	0.938
1030	42.722	0.938
1040	42.725	0.935
1050	42.725	0.935
1060	42.725	0.935
1070	42.725	0.935
1080	42.725	0.935
1090	42.728	0.932
1100	42.722	0.938
1110	42.725	0.935
1120	42.728	0.932
1130	42.731	0.929
1140	42.731	0.929
1150	42.734	0.926
1160	42.738	0.922
1170	42.738	0.922
1180	42.738	0.922
1190	42.738	0.922
1200	42.734	0.926
1210	42.738	0.922
1220	42.738	0.922
1230	42.741	0.919
1240	42.744	0.916
1250	42.747	0.913
1260	42.747	0.913
1270	42.747	0.913
1280	42.747	0.913

SLUG INJECTION TEST DATA FORM 37891 - MW27

ELAPSED TIME (min)	DEPTH TO H20 FROM TOC (ft)	EXCESS HEAD (ft)
1290	42.750	0.910
1300	42.753	0.907
1310	42.760	0.900
1320	42.763	0.897
1330	42.769	0.891
1340	42.772	0.888
1350	42.776	0.884
1360	42.776	0.884
1370	42.779	0.881
1380	42.782	0.878
1390	42.791	0.869
1400	42.794	0.866
1410	42.791	0.869
1420	42.798	0.862
1430	42.798	0.862
1440	42.794	0.866
1450	42.788	0.872
1460	42.791	0.869
1470	42.791	0.869
1480	42.801	0.859
1490	42.801	0.859
1500	42.801	0.859
1510	42.798	0.862
1520	42.798	0.862
1530	42.788	0.872
1540	42.794	0.866
1550	42.794	0.866
1560	42.794	0.866
1570	42.794	0.866
1580	42.791	0.869
1590	42.791	0.869
1600	42.788	0.872
1610	42.788	0.872
1620	42.785	0.875
1630	42.788	0.872
1640	42.785	0.875
1650	42.788	0.872
1660	42.791	0.869
1670	42.791	0.869
1680	42.788	0.872
1690	42.798	0.862
1700	42.798	0.862
1710	42.801	0.859
1720	42.804	0.856
1730	42.804	0.856

SLUG INJECTION TEST DATA FORM 37891 - MW27

ELAPSED TIME (min)	DEPTH TO H20 FROM TOC (ft)	EXCESS HEAD (ft)
1740	42.804	0.856
1750	42.804	0.856
1760	42.813	0.847
1770	42.813	0.847
1780	42.810	0.850
1790	42.813	0.847
1800	42.813	0.847
1810	42.817	0.843
1820	42.820	0.840
1830	42.826	0.834
1840	42.832	0.828
1850	42.832	0.828
1860	42.839	0.821
1870	42.842	0.818
1880	42.848	0.812
1890	42.851	0.809
1900	42.854	0.806
1910	42.854	0.806
1920	42.861	0.799
1930	42.864	0.796
1940	42.867	0.793
1950	42.870	0.790
1960	42.873	0.787
1970	42.877	0.783
1980	42.880	0.780
1990	42.886	0.774
2000	42.886	0.774
2010	42.892	0.768
2020	42.895	0.765
2030	42.902	0.758
2040	42.905	0.755
2050	42.908	0.752
2060	42.911	0.749
2070	42.914	0.746
2080	42.918	0.742
2090	42.921	0.739
2100	42.924	0.736
2110	42.924	0.736
2120	42.927	0.733
2130	42.933	0.727
2140	42.937	0.723
2150	42.940	0.720
2160	42.946	0.714
2170	42.946	0.714
2180	42.952	0.708

ELAPSED TIME (min)	DEPTH TO H20 FROM TOC (ft)	EXCESS HEAD (ft)
2190	42.952	0.708
2200	42.955	0.705
2210	42.955	0.705
2220	42.959	0.701
2230	42.959	0.701
2240	42.959	0.701
2250	42.959	0.701
2260	42.962	0.698
2270	42.962	0.698
2280	42.965	0.695
2290	42.965	0.695
2300	42.965	0.695
2310	42.965	0.695
2320	42.968	0.692
2330	42.968	0.692
2340	42.968	0.692
2350	42.971	0.689
2360	42.971	0.689
2370	42.974	0.686
2380	42.978	0.682
2390	42.981	0.679
2400	42.981	0.679
2410	42.984	0.676
2420	42.984	0.676
2430	42.984	0.676
2440	42.984	0.676
2450	42.984	0.676
2460	42.984	0.676
2470	42.984	0.676
2480	42.984	0.676
2490	42.987	0.673
2500	42.987	0.673
2510	42.987	0.673
2520	42.990	0.670
2530	42.990	0.670
2540	42.993	0.667
2550	42.993	0.667
2560	42.997	0.663
2570	43.000	0.660
2580	43.000	0.660
2590	43.003	0.657
2600	43.006	0.654
2610	43.006	0.654
2620	43.006	0.654
2630	43.009	0.651

SLUG INJECTION TEST DATA FORM 37891 - MW27

ELAPSED TIME (min)	DEPTH TO H20 FROM TOC (ft)	EXCESS HEAD (ft)
2640	43.012	0.648
2650	43.015	0.645
2660	43.015	0.645
2670	43.019	0.641
2680	43.019	0.641

SLUG WITHDRAWAL TEST DATA FORM 37891 - MW27

FILE: MW27_1C.WQ2
TEST DATE: 12/20/91
START TIME: 07:30:34 AM

REFERENCE: 43.66 FT

ELAPSED TIME (min)	DEPTH TO H20 FROM TOC (ft)	EXCESS HEAD (ft)
0	44.910	-1.250
0.0083	44.919	-1.259
0.0166	44.907	-1.247
0.025	44.929	-1.269
0.0333	44.916	-1.256
0.0416	44.948	-1.288
0.05	44.954	-1.294
0.0583	44.976	-1.316
0.0666	45.077	-1.417
0.075	45.197	-1.537
0.0833	45.181	-1.521
0.1	45.229	-1.569
0.1166	45.342	-1.682
0.1333	45.333	-1.673
0.15	45.345	-1.685
0.1666	45.342	-1.682
0.1833	45.339	-1.679
0.2	45.336	-1.676
0.2166	45.333	-1.673
0.2333	45.333	-1.673
0.25	45.330	-1.670
0.2666	45.330	-1.670
0.2833	45.330	-1.670
0.3	45.330	-1.670
0.3166	45.326	-1.666
0.3333	45.326	-1.666
0.4166	45.311	-1.651
0.5	44.840	-1.180
0.5833	44.828	-1.168
0.6666	44.828	-1.168
0.75	44.840	-1.180
0.8333	44.837	-1.177
0.9166	44.834	-1.174
1	44.834	-1.174
1.0833	44.831	-1.171
1.1666	44.831	-1.171
1.25	44.828	-1.168
1.3333	44.828	-1.168
1.4166	44.828	-1.168
1.5	44.824	-1.164
1.5833	44.824	-1.164
1.6666	44.821	-1.161
1.75	44.821	-1.161
1.8333	44.821	-1.161
1.9166	44.821	-1.161

SLUG WITHDRAWAL TEST DATA FORM 37891 - MW27

ELAPSED TIME (min)	DEPTH TO H20 FROM TOC (ft)	EXCESS HEAD (ft)
2	44.818	-1.158
2.5	44.812	-1.152
3	44.809	-1.149
3.5	44.802	-1.142
4	44.783	-1.123
4.5	44.777	-1.117
5	44.774	-1.114
5.5	44.771	-1.111
6	44.768	-1.108
6.5	44.761	-1.101
7	44.758	-1.098
7.5	44.755	-1.095
8	44.749	-1.089
8.5	44.746	-1.086
9	44.742	-1.082
9.5	44.739	-1.079
10	44.736	-1.076
12	44.723	-1.063
14	44.711	-1.051
16	44.698	-1.038
18	44.682	-1.022
20	44.670	-1.010
22	44.660	-1.000
24	44.648	-0.988
26	44.635	-0.975
28	44.622	-0.962
30	44.610	-0.950
32	44.600	-0.940
34	44.588	-0.928
36	44.578	-0.918
38	44.566	-0.906
40	44.556	-0.896
42	44.547	-0.887
44	44.534	-0.874
46	44.525	-0.865
48	44.515	-0.855
50	44.506	-0.846
52	44.493	-0.833
54	44.483	-0.823
56	44.474	-0.814
58	44.465	-0.805
60	44.455	-0.795
62	44.446	-0.786
64	44.436	-0.776
66	44.427	-0.767

SLUG WITHDRAWAL TEST DATA FORM 37891 - MW27

ELAPSED TIME (min)	DEPTH TO H20 FROM TOC (ft)	EXCESS HEAD (ft)
68	44.417	-0.757
70	44.408	-0.748
72	44.398	-0.738
74	44.389	-0.729
76	44.382	-0.722
78	44.373	-0.713
80	44.364	-0.704
82	44.354	-0.694
84	44.348	-0.688
86	44.338	-0.678
88	44.329	-0.669
90	44.322	-0.662
92	44.313	-0.653
94	44.307	-0.647
96	44.297	-0.637
98	44.291	-0.631
100	44.281	-0.621
110	44.240	-0.580
120	44.206	-0.546
130	44.171	-0.511
140	44.136	-0.476
150	44.105	-0.445
160	44.073	-0.413
170	44.045	-0.385
180	44.013	-0.353
190	43.982	-0.322
200	43.953	-0.293
210	43.922	-0.262
220	43.890	-0.230
230	43.862	-0.202
240	43.833	-0.173
250	43.805	-0.145
260	43.779	-0.119
270	43.754	-0.094
280	43.732	-0.072
290	43.710	-0.050
300	43.688	-0.028
310	43.669	-0.009
320	43.650	0.010
330	43.628	0.032
340	43.609	0.051
350	43.590	0.070
360	43.574	0.086
370	43.555	0.105
380	43.540	0.120

SLUG WITHDRAWAL TEST DATA FORM 37891 - MW27

ELAPSED TIME (min)	DEPTH TO H20 FROM TOC (ft)	EXCESS HEAD (ft)
390	43.521	0.139
400	43.508	0.152
410	43.492	0.168
420	43.480	0.180
430	43.464	0.196
440	43.451	0.209
450	43.439	0.221
460	43.426	0.234
470	43.413	0.247
480	43.401	0.259
490	43.388	0.272
500	43.375	0.285
510	43.363	0.297
520	43.353	0.307
530	43.337	0.323
540	43.328	0.332
550	43.319	0.341
560	43.306	0.354
570	43.300	0.360
580	43.290	0.370
590	43.281	0.379
600	43.271	0.389
610	43.265	0.395
620	43.255	0.405
630	43.249	0.411
640	43.243	0.417
650	43.236	0.424
660	43.230	0.430
670	43.224	0.436
680	43.218	0.442
690	43.211	0.449
700	43.205	0.455
710	43.202	0.458
720	43.195	0.465
730	43.189	0.471
740	43.186	0.474
750	43.180	0.480
760	43.176	0.484
770	43.170	0.490
780	43.164	0.496
790	43.161	0.499
800	43.158	0.502
810	43.154	0.506
820	43.148	0.512
830	43.145	0.515

SLUG WITHDRAWAL TEST DATA FORM 37891 - MW27

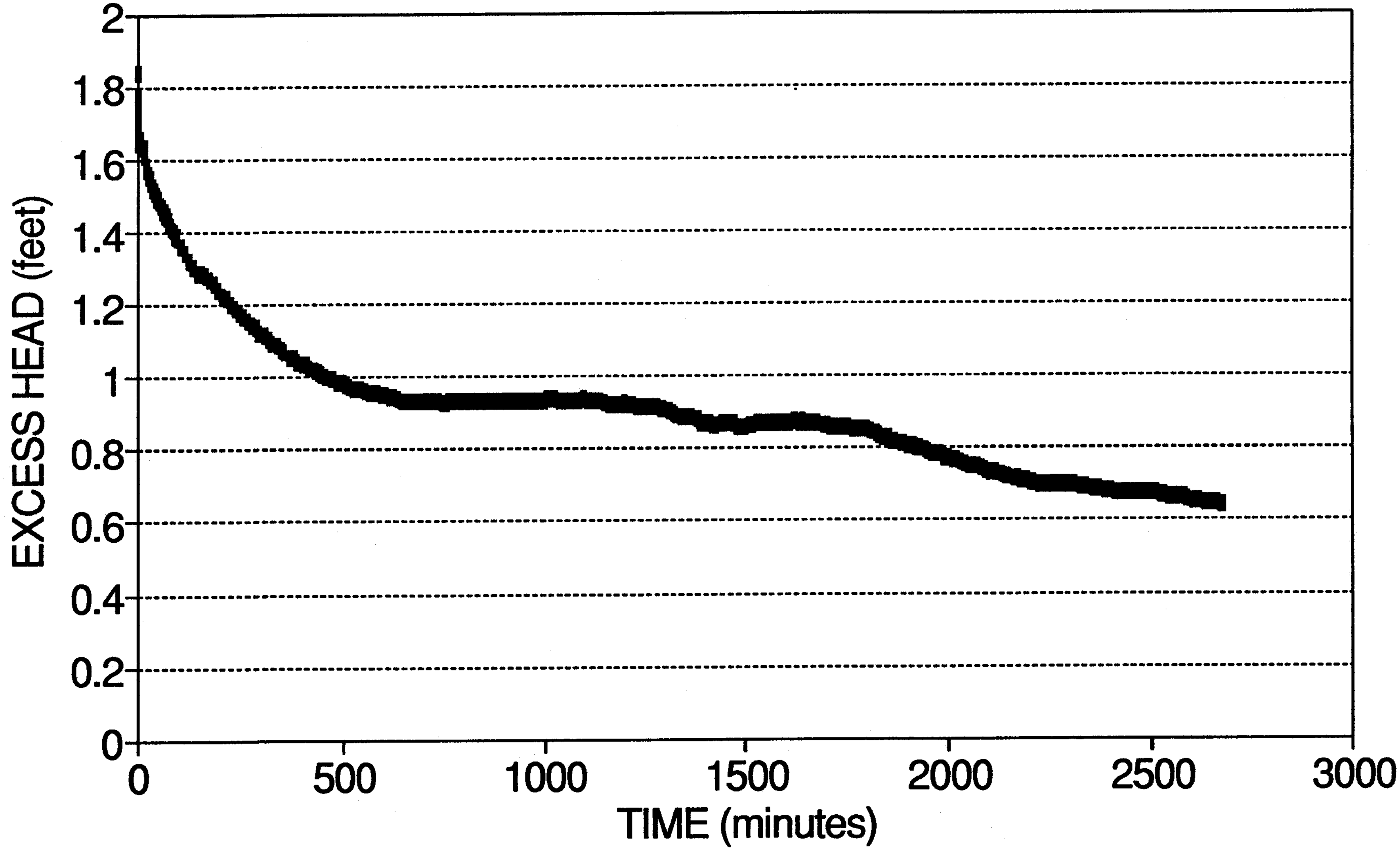
ELAPSED TIME (min)	DEPTH TO H20 FROM TOC (ft)	EXCESS HEAD (ft)
840	43.142	0.518
850	43.135	0.525
860	43.132	0.528
870	43.129	0.531
880	43.126	0.534
890	43.123	0.537
900	43.120	0.540
910	43.116	0.544
920	43.110	0.550
930	43.107	0.553
940	43.104	0.556
950	43.101	0.559
960	43.094	0.566
970	43.091	0.569
980	43.085	0.575
990	43.079	0.581
1000	43.072	0.588
1010	43.069	0.591
1020	43.063	0.597
1030	43.056	0.604
1040	43.053	0.607
1050	43.050	0.610
1060	43.044	0.616
1070	43.041	0.619
1080	43.038	0.622
1090	43.034	0.626
1100	43.031	0.629
1110	43.028	0.632
1120	43.025	0.635
1130	43.025	0.635
1140	43.025	0.635
1150	43.022	0.638
1160	43.022	0.638
1170	43.015	0.645
1180	43.012	0.648
1190	43.006	0.654
1200	43.003	0.657
1210	43.003	0.657
1220	42.997	0.663
1230	42.993	0.667
1240	42.990	0.670
1250	42.987	0.673
1260	42.984	0.676
1270	42.981	0.679
1280	42.978	0.682

SLUG WITHDRAWAL TEST DATA FORM 37891 - MW27

ELAPSED TIME (min)	DEPTH TO H20 FROM TOC (ft)	EXCESS HEAD (ft)
1290	42.974	0.686
1300	42.971	0.689
1310	42.968	0.692
1320	42.965	0.695
1330	42.962	0.698
1340	42.959	0.701
1350	42.955	0.705
1360	42.955	0.705
1370	42.952	0.708
1380	42.949	0.711
1390	42.946	0.714
1400	42.943	0.717
1410	42.940	0.720
1420	42.940	0.720
1430	42.937	0.723
1440	42.937	0.723
1450	42.937	0.723
1460	42.937	0.723
1470	42.937	0.723
1480	42.937	0.723
1490	42.933	0.727

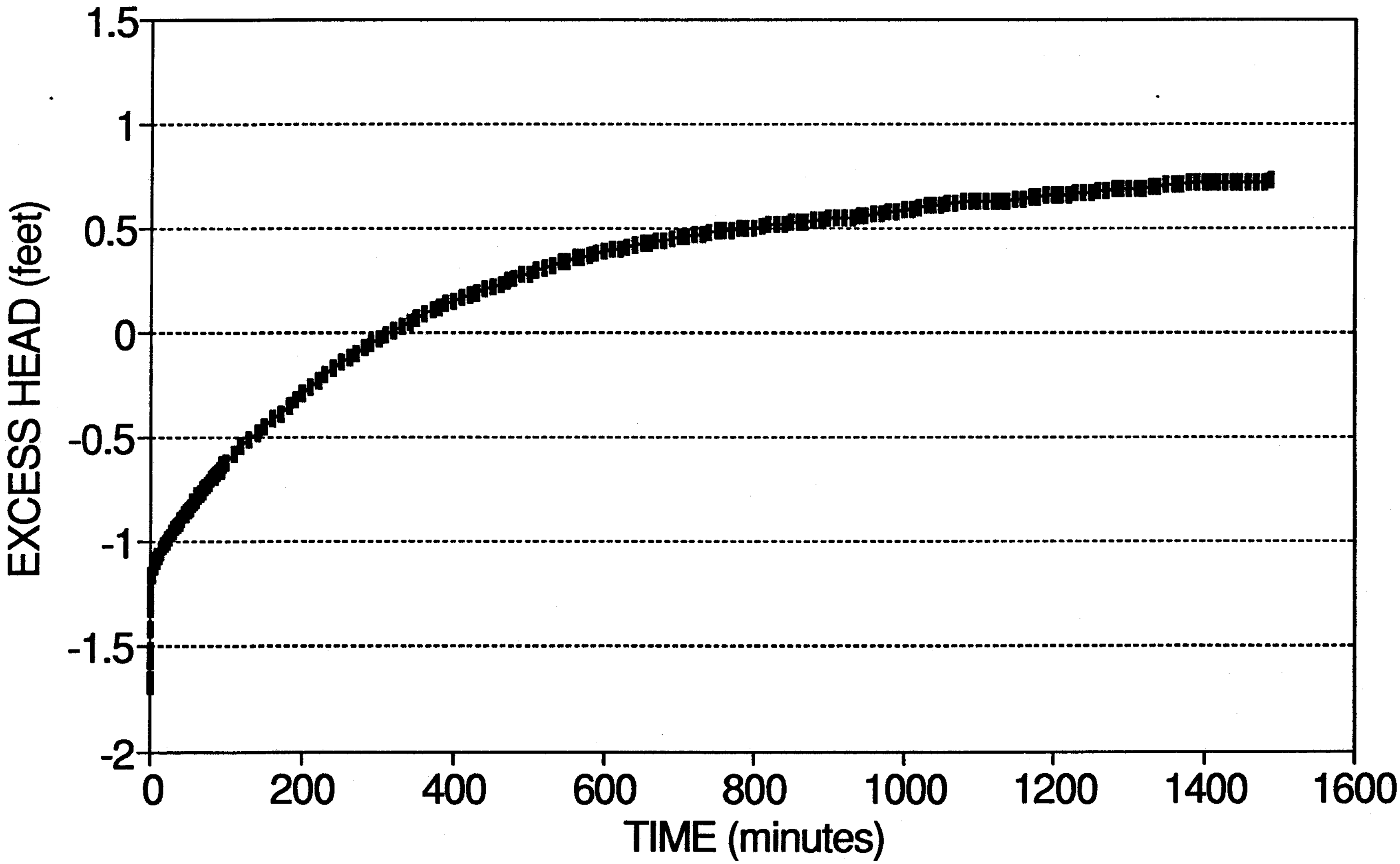
SLUG INJECTION TEST

37891 - MW27



SLUG WITHDRAWAL TEST

37891 - MW27



A Q T E S O L V   R E S U L T S
Version 1.10

05/08/92 14:09:09

==

TEST DESCRIPTION

```
Data set........... MW27INJ.DAT
Data set title..... SLUG INJECTION TEST 37891 - MW27
Project............ OPERABLE UNIT 1
Client............. EG&G ROCKY FLATS
Location........... 881 HILLSIDE
Test date.......... 12/20/91

Knowns and Constants:
   No. of data points................... 364
   Radius of well casing................ 0.0863
   Radius of well....................... 0.292
   Aquifer saturated thickness.......... 13.3
   Well screen length................... 9.6
   Static height of water in well....... 11.1
   Log(Re/Rw)........................... 2.47
   A, B, C.............................. 2.534, 0.413, 0.000
```

==

ANALYTICAL METHOD

Bouwer-Rice (Unconfined Aquifer Slug Test)

==

RESULTS FROM VISUAL CURVE MATCHING

VISUAL MATCH PARAMETER ESTIMATES

```
           Estimate
   K  =   1.0108E-006
   y0 =   1.5060E+000
```

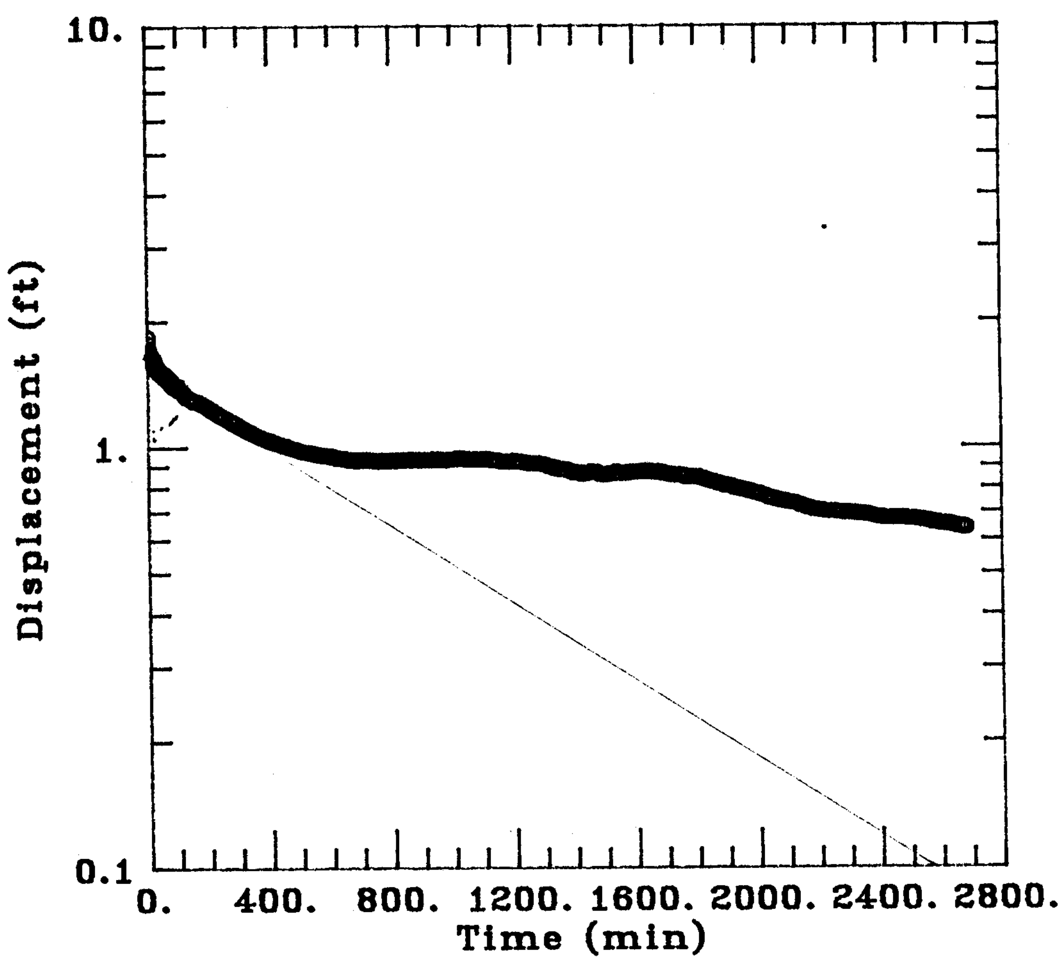
```
<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>
```

Client: EG&G ROCKY FLATS

Project No.: OPERABLE UNIT 1

Location: 881 HILLSIDE

SLUG INJECTION TEST 37891 – MW27



DATA SET:
MW27INJ.DAT
05/08/92

AQUIFER TYPE:
Unconfined

SOLUTION METHOD:
Bouwer-Rice

TEST DATE:
12/18/91

ESTIMATED PARAMETERS:
K = 1.0108E-06 ft/min
y0 = 1.506 ft

TEST DATA:

rc = 0.0863 ft
rw = 0.292 ft
L = 9.6 ft
b = 13.3 ft
H = 11.1 ft

AQTESOLV RESULTS
Version 1.10

05/08/92 14:24:09

TEST DESCRIPTION

Data set........... MW27WD.DAT
Data set title..... SLUG WITHDRAWAL TEST 37891 - MW27
Project............ OPERABLE UNIT 1
Client............. EG&G ROCKY FLATS
Location........... 881 HILLSIDE
Test date.......... 12/20/91

Knowns and Constants:
No. of data points.................. 232
Radius of well casing............... 0.0863
Radius of well...................... 0.292
Aquifer saturated thickness......... 13.3
Well screen length.................. 9.6
Static height of water in well...... 11.1
Log(Re/Rw).......................... 2.47
A, B, C............................. 2.534, 0.413, 0.000

ANALYTICAL METHOD

Bouwer-Rice (Unconfined Aquifer Slug Test)

RESULTS FROM VISUAL CURVE MATCHING

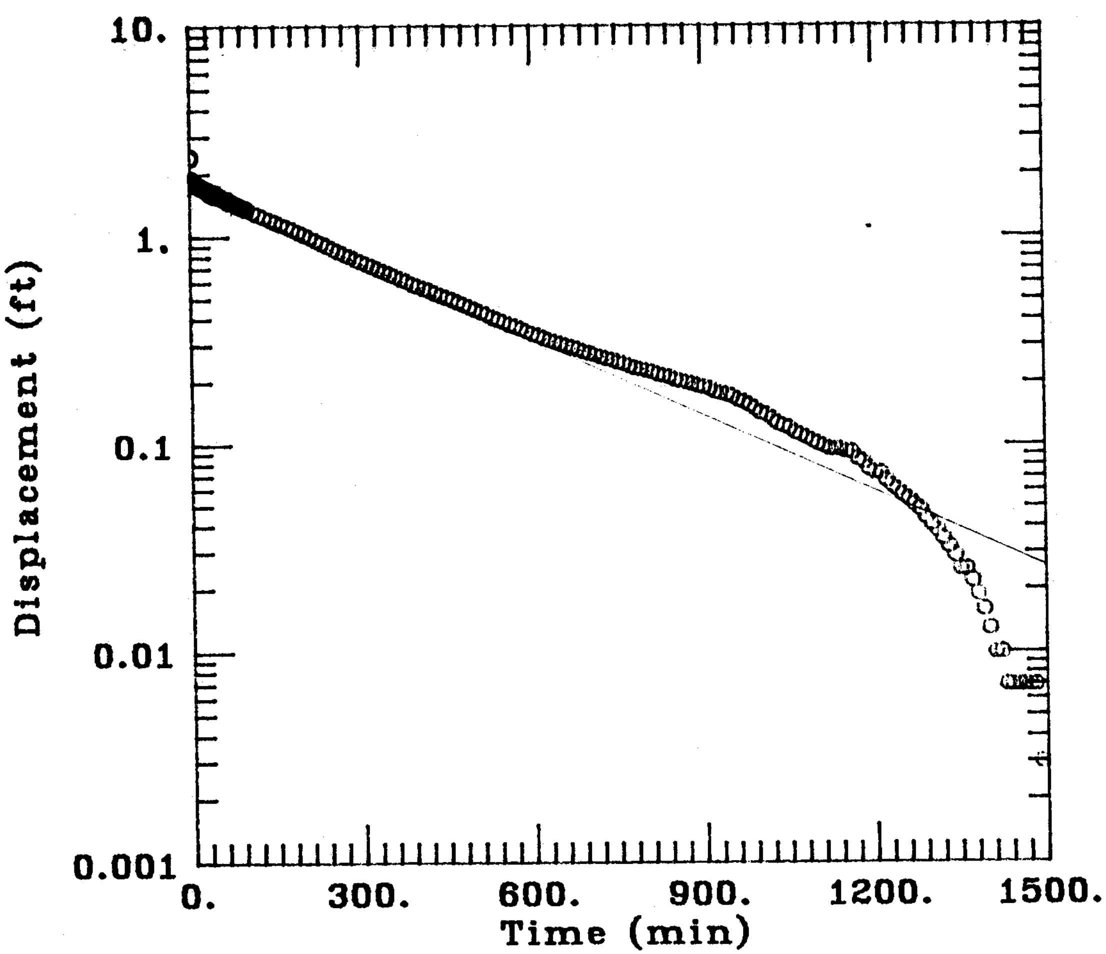
VISUAL MATCH PARAMETER ESTIMATES

	Estimate
K =	2.6836E-006
y0 =	1.7378E+000

<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<>>

	Client: EG&G ROCKY FLATS
Project No.: OPERABLE UNIT 1	Location: 881 HILLSIDE

SLUG WITHDRAWAL TEST 37891 - MW27



DATA SET:
MW27WD.DAT
05/08/92

AQUIFER TYPE:
Unconfined

SOLUTION METHOD:
Bouwer-Rice

TEST DATE:
12/20/91

ESTIMATED PARAMETERS:
K = 2.6836E-06 ft/min
y0 = 1.738 ft

TEST DATA:
rc = 0.0863 ft
rw = 0.292 ft
L = 9.6 ft
b = 13.3 ft
H = 11.1 ft

INDEX OF BOREHOLE AND SINGLE WELL TEST DATA AND RESULTS

Borehole, well, or piezometer number: **37991 (MW29)**
(Work plan designation)

Data Available:

__ Packer Test – Set-up

__ Packer Test – Data Sheet (Flow vs. Time Data)

__ Packer Test – Data Logger Output (Head vs. Time Data)

__ Packer Test – Analysis and Results Calculation Sheet

✔ Single Well Test – Record of Initial Water Level Measurement

✔ Single Well Test – 10 Minute Calibration Plot

✔ Single Well Test – Head vs. Time Data Form

✔ Single Well Test – Head vs. Time Response Graph(s)

✔ Single Well Test – Bouwer and Rice Method Analytical Results

__ Single Well Test – Hvorslev Method Analytical Results

U.S. DEPARTMENT OF ENERGY ROCKY FLATS PLANT

FORM GW.1A

GROUNDWATER LEVELS MEASUREMENTS/CALCULATIONS

ROCKY FLATS PROJECT Revision 1.2

Project No. OU1

Date 121891

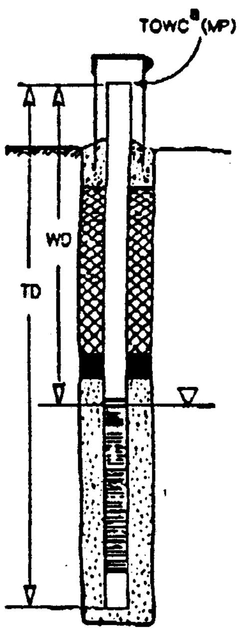
Personnel 1. J. Uhlinger

2. K. Maley

EQUIPMENT: Manufacturer Solinst Model ______ Serial No. 10373

CALIBRATION: Date Passed ______ Date Due ______

QC REVIEW: Name ______ Date ______



Well No. 37991	WD[b]	MTD[c]	Comments
Measurement 1	50.91	58'10 3/8"	JFU
Measurement 2	50.88	58'10 3/8"	KM
Measurement 3	50.87	58'10 3/8"	JFU
	50.89 Average WD	58'10 3/8" Average MTD	+ ____ Probe End[d] = ____ TD[e] ____ Chk'd by

Well No.	WD[b]	MTD[c]	Comments
Measurement 1			
Measurement 2			
Measurement 3			
	Average WD	Average MTD	+ ____ Probe End[d] = ____ TD[e] ____ Chk'd by

Well No.	WD[b]	MTD[c]	Comments
Measurement 1			
Measurement 2			
Measurement 3			
	Average WD	Average MTD	+ ____ Probe End[d] = ____ TD[e] ____ Chk'd by

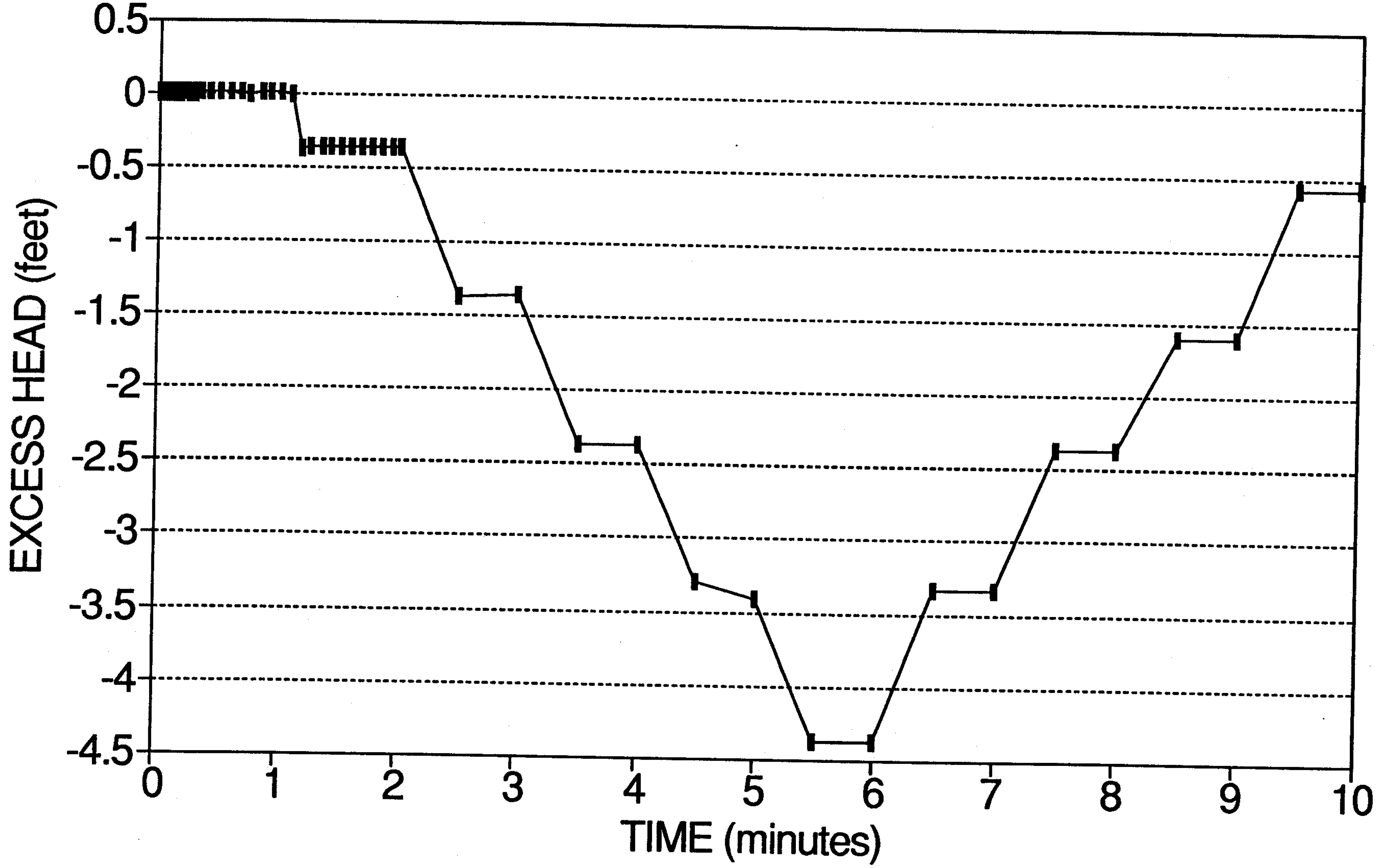
Footnotes:
A = TOWC = top of well casing
b = WD = depth to water from MP
c = MTD = measured total depth from MP
d = Probe End = length beyond measuring point on probe
e = TD = total depth of well from MP

Notes:
- All measurements are relative to Mark Point (MP) = north side of TOWC
- QC review by supervisor is a check of reasonableness
- Measurements 1 and 2 must be within .01 ft of a 3rd measurement must be taken

(4011-600-0022) (GW1-FORM.1A) (09-18-91) (4:18pm)

TEN MINUTE CALIBRATION TEST

37991 - MW29



BAIL-DOWN/RECOVERY ~~SLUG~~ TEST DATA FORM

Location OU1 881 Hillside
Name Depth [illegible] 121891
Borehole No. 37991 MW29
Groundwater ~~Elevation~~ Before Test 50.89
Test Date 121891
Total Casing Depth 58' 10 3/8"
Measuring Point TOC
Borehole Diameter 7"
Type of Test Baildown
Casing Diameter 2"
Transductor Probe Serial No. 323255
Screened Interval 47.3 - 57.3'
Datalogger Test Run No. 4, 5
Sand Pack Interval 45.1' - ~~57.3'~~ 58.9'
(include time and date for identification purposes) Hermit # 2K188
MW29-1a.TST
MW29-1b.TST
Lithology Tested clayey siltstone

Actual Time	Elapsed Time	Depth to Water from Top of Casing (ft)	H Excess Head (ft)	H/HO

SEE XD Records

BAIL DOWN/RECOVERY TEST DATA FORM 37991 - MW29

FILE: MW29_1B.WQ2
TEST DATE: 12/18/91
START TIME: 09:12:06 AM

REFERENCE: 50.89 FT

ELAPSED TIME (min)	DEPTH TO H20 FROM TOC (ft)	EXCESS HEAD (ft)
0	56.391	-5.501
0.0083	56.388	-5.498
0.0166	56.385	-5.495
0.025	56.381	-5.491
0.0333	56.381	-5.491
0.0416	56.378	-5.488
0.05	56.375	-5.485
0.0583	56.372	-5.482
0.0666	56.372	-5.482
0.075	56.369	-5.479
0.0833	56.366	-5.476
0.1	56.362	-5.472
0.1166	56.356	-5.466
0.1333	56.350	-5.460
0.15	56.347	-5.457
0.1666	56.343	-5.453
0.1833	56.337	-5.447
0.2	56.334	-5.444
0.2166	56.328	-5.438
0.2333	56.324	-5.434
0.25	56.321	-5.431
0.2666	56.315	-5.425
0.2833	56.309	-5.419
0.3	56.305	-5.415
0.3166	56.299	-5.409
0.3333	56.296	-5.406
0.4166	56.277	-5.387
0.5	56.255	-5.365
0.5833	56.232	-5.342
0.6666	56.210	-5.320
0.75	56.188	-5.298
0.8333	56.166	-5.276
0.9166	56.144	-5.254
1	56.125	-5.235
1.0833	56.106	-5.216
1.1666	56.086	-5.196
1.25	56.067	-5.177
1.3333	56.048	-5.158
1.4166	56.033	-5.143
1.5	56.014	-5.124
1.5833	55.995	-5.105
1.6666	55.979	-5.089
1.75	55.963	-5.073
1.8333	55.944	-5.054
1.9166	55.928	-5.038

BAIL DOWN/RECOVERY TEST DATA FORM 37991 - MW29

ELAPSED TIME (min)	DEPTH TO H20 FROM TOC (ft)	EXCESS HEAD (ft)
2	55.912	-5.022
2.5	55.817	-4.927
3	55.715	-4.825
3.5	55.636	-4.746
4	55.566	-4.676
4.5	55.506	-4.616
5	55.462	-4.572
5.5	55.424	-4.534
6	55.389	-4.499
6.5	55.357	-4.467
7	55.325	-4.435
7.5	55.294	-4.404
8	55.265	-4.375
8.5	55.230	-4.340
9	55.198	-4.308
9.5	55.170	-4.280
10	55.138	-4.248
12	55.046	-4.156
14	54.970	-4.080
16	54.907	-4.017
18	54.853	-3.963
20	54.805	-3.915
22	54.764	-3.874
24	54.726	-3.836
26	54.688	-3.798
28	54.656	-3.766
30	54.624	-3.734
32	54.596	-3.706
34	54.567	-3.677
36	54.542	-3.652
38	54.513	-3.623
40	54.488	-3.598
42	54.466	-3.576
44	54.440	-3.550
46	54.415	-3.525
48	54.393	-3.503
50	54.371	-3.481
52	54.345	-3.455
54	54.323	-3.433
56	54.301	-3.411
58	54.279	-3.389
60	54.256	-3.366
62	54.237	-3.347
64	54.212	-3.322
66	54.193	-3.303

BAIL DOWN/RECOVERY TEST DATA FORM 37991 - MW29

ELAPSED TIME (min)	DEPTH TO H20 FROM TOC (ft)	EXCESS HEAD (ft)
68	54.171	-3.281
70	54.155	-3.265
72	54.139	-3.249
74	54.120	-3.230
76	54.104	-3.214
78	54.088	-3.198
80	54.072	-3.182
82	54.057	-3.167
84	54.041	-3.151
86	54.031	-3.141
88	54.015	-3.125
90	54.006	-3.116
92	53.993	-3.103
94	53.977	-3.087
96	53.961	-3.071
98	53.952	-3.062
100	53.942	-3.052
110	53.879	-2.989
120	53.825	-2.935
130	53.774	-2.884
140	53.727	-2.837
150	53.682	-2.792
160	53.635	-2.745
170	53.587	-2.697
180	53.536	-2.646
190	53.486	-2.596
200	53.438	-2.548
210	53.400	-2.510
220	53.362	-2.472
230	53.327	-2.437
240	53.298	-2.408
250	53.267	-2.377
260	53.232	-2.342
270	53.207	-2.317
280	53.178	-2.288
290	53.162	-2.272
300	53.134	-2.244
310	53.111	-2.221
320	53.089	-2.199
330	53.067	-2.177
340	53.045	-2.155
350	53.026	-2.136
360	53.007	-2.117
370	52.984	-2.094
380	52.969	-2.079

BAIL DOWN/RECOVERY TEST DATA FORM 37991 - MW29

ELAPSED TIME (min)	DEPTH TO H20 FROM TOC (ft)	EXCESS HEAD (ft)
390	52.950	-2.060
400	52.927	-2.037
410	52.911	-2.021
420	52.892	-2.002
430	52.873	-1.983
440	52.858	-1.968
450	52.839	-1.949
460	52.820	-1.930
470	52.804	-1.914
480	52.785	-1.895
490	52.766	-1.876
500	52.750	-1.860
510	52.728	-1.838
520	52.708	-1.818
530	52.693	-1.803
540	52.674	-1.784
550	52.655	-1.765
560	52.636	-1.746
570	52.613	-1.723
580	52.594	-1.704
590	52.575	-1.685
600	52.553	-1.663
610	52.534	-1.644
620	52.515	-1.625
630	52.499	-1.609
640	52.480	-1.590
650	52.461	-1.571
660	52.442	-1.552
670	52.426	-1.536
680	52.407	-1.517
690	52.391	-1.501
700	52.372	-1.482
710	52.356	-1.466
720	52.337	-1.447
730	52.318	-1.428
740	52.299	-1.409
750	52.283	-1.393
760	52.264	-1.374
770	52.248	-1.358
780	52.229	-1.339
790	52.210	-1.320
800	52.195	-1.305
810	52.176	-1.286
820	52.156	-1.266
830	52.141	-1.251

BAIL DOWN/RECOVERY TEST DATA FORM 37991 - MW29

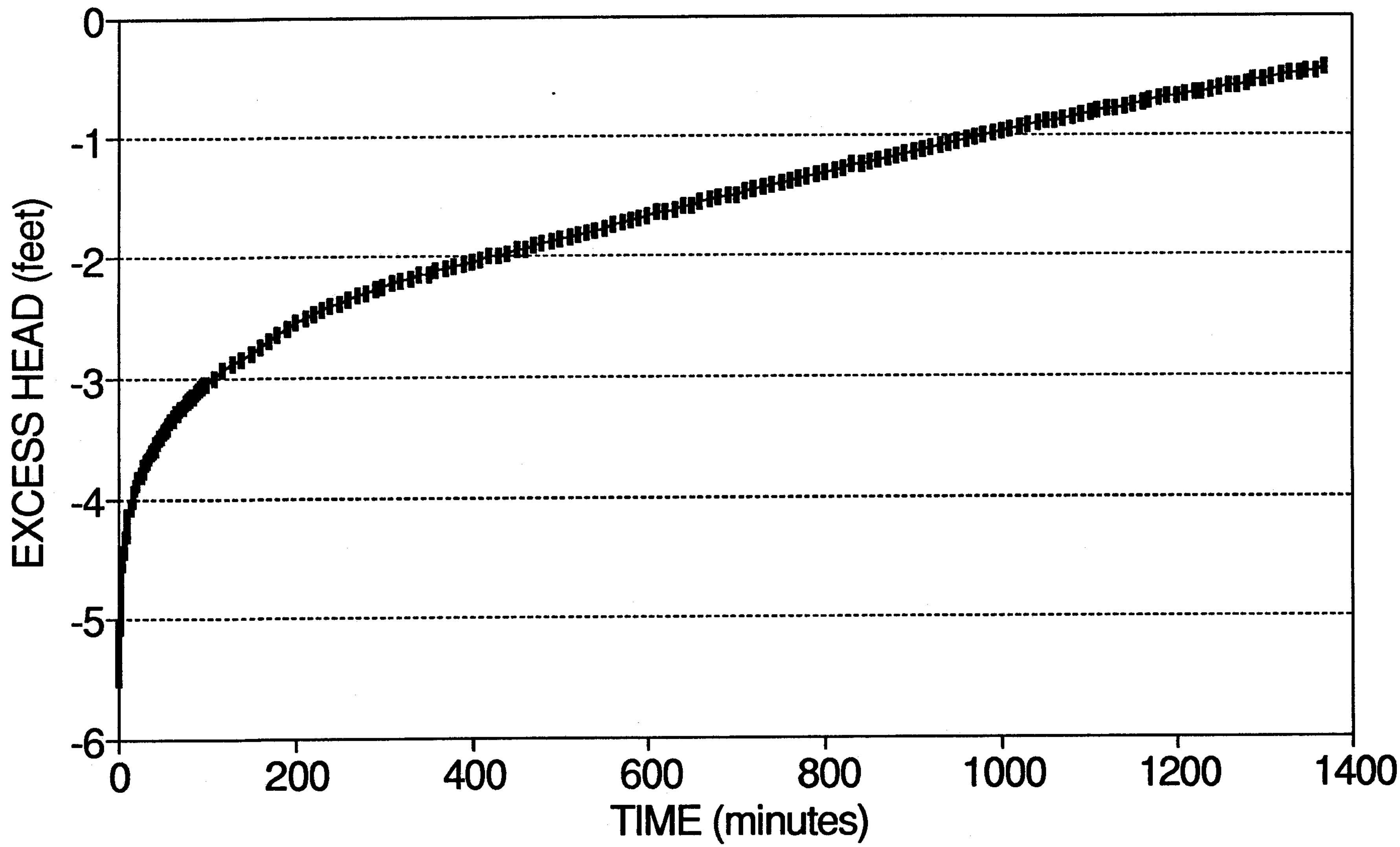
ELAPSED TIME (min)	DEPTH TO H20 FROM TOC (ft)	EXCESS HEAD (ft)
840	52.125	-1.235
850	52.106	-1.216
860	52.090	-1.200
870	52.071	-1.181
880	52.055	-1.165
890	52.039	-1.149
900	52.020	-1.130
910	52.004	-1.114
920	51.988	-1.098
930	51.969	-1.079
940	51.953	-1.063
950	51.938	-1.048
960	51.922	-1.032
970	51.906	-1.016
980	51.890	-1.000
990	51.871	-0.981
1000	51.855	-0.965
1010	51.839	-0.949
1020	51.827	-0.937
1030	51.808	-0.918
1040	51.792	-0.902
1050	51.779	-0.889
1060	51.763	-0.873
1070	51.747	-0.857
1080	51.735	-0.845
1090	51.719	-0.829
1100	51.703	-0.813
1110	51.690	-0.800
1120	51.674	-0.784
1130	51.662	-0.772
1140	51.646	-0.756
1150	51.633	-0.743
1160	51.617	-0.727
1170	51.601	-0.711
1180	51.592	-0.702
1190	51.576	-0.686
1200	51.560	-0.670
1210	51.547	-0.657
1220	51.532	-0.642
1230	51.519	-0.629
1240	51.506	-0.616
1250	51.493	-0.603
1260	51.481	-0.591
1270	51.468	-0.578
1280	51.452	-0.562

BAIL DOWN/RECOVERY TEST DATA FORM 37991 - MW29

ELAPSED TIME (min)	DEPTH TO H20 FROM TOC (ft)	EXCESS HEAD (ft)
1290	51.436	-0.546
1300	51.424	-0.534
1310	51.411	-0.521
1320	51.398	-0.508
1330	51.386	-0.496
1340	51.376	-0.486
1350	51.360	-0.470
1360	51.351	-0.461
1370	51.335	-0.445

BAIL DOWN/RECOVERY TEST

37991 - MW29



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                    A Q T E S O L V   R E S U L T S
                             Version  1.10

05/08/92                                                        08:33:19

================================================================================
                            TEST DESCRIPTION

Data set........... MW29BDR.DAT
Data set title..... BAIL DOWN RECOVERY TEST 37991 - MW29
Project............ OPERABLE UNIT 1
Client............. EG&G ROCKY FLATS
Location........... 881 HILLSIDE
Test date.......... 12/18/91

Knowns and Constants:
   No. of data points.................. 233
   Radius of well casing............... 0.1755
   Radius of well...................... 0.292
   Aquifer saturated thickness......... 8.5
   Well screen length.................. 6.22
   Static height of water in well...... 6.22
   Log(Re/Rw).......................... 2.018
   A, B, C.............................  2.186,  0.346,  0.000

================================================================================
                            ANALYTICAL METHOD

Bouwer-Rice (Unconfined Aquifer Slug Test)

================================================================================
                    RESULTS FROM VISUAL CURVE MATCHING


VISUAL MATCH PARAMETER ESTIMATES

           Estimate
   K  =   1.3384E-005
   y0 =   4.0270E+000


<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>
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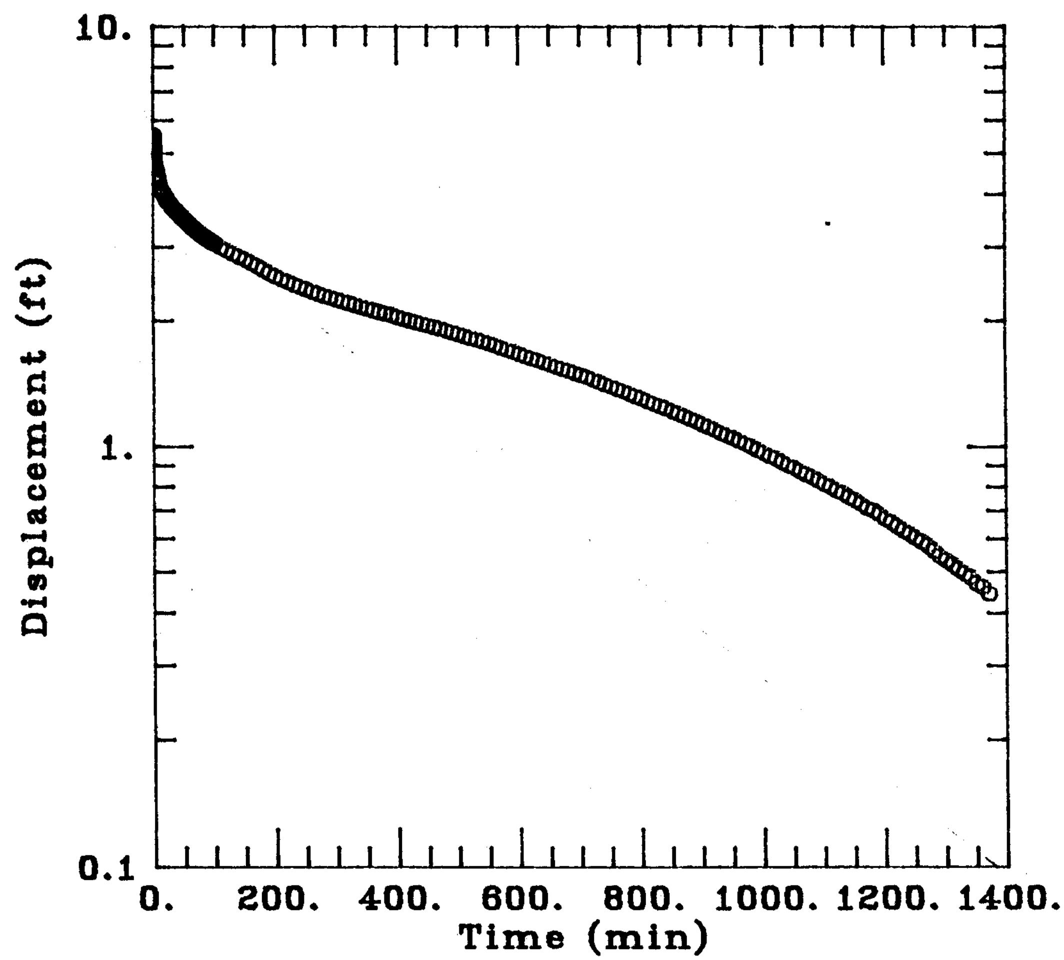
Project No.: OPERABLE UNIT 1	Client: EG&G ROCKY FLATS
	Location: 881 HILLSIDE

BAIL DOWN RECOVERY TEST 37991 – MW29



DATA SET:
MW29BDR.DAT
05/08/92

AQUIFER TYPE:
Unconfined
SOLUTION METHOD:
Bouwer-Rice
TEST DATE:
12/18/91

ESTIMATED PARAMETERS:
K = 1.3384E-05 ft/min
y0 = 4.027 ft

TEST DATA:

rc = 0.1755 ft
rw = 0.292 ft
L = 6.22 ft
b = 8.5 ft
H = 6.22 ft

INDEX OF BOREHOLE AND SINGLE WELL TEST DATA AND RESULTS

Borehole, well, or piezometer number: **38191 (PZ05)**
(Work plan designation)

Data Available:

__ Packer Test – Set-up

__ Packer Test Data Sheet (Flow vs. Time Data)

__ Packer Test – Data Logger Output (Head vs. Time Data)

__ Packer Test – Analysis and Results Calculation Sheet

✔ Single Well Test – Record of Initial Water Level Measurement

✔ Single Well Test – 10 Minute Calibration Plot

✔ Single Well Test – Head vs. Time Data Form

✔ Single Well Test – Head vs. Time Response Graph(s)

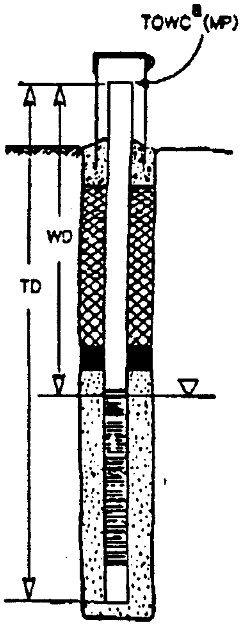
✔ Single Well Test – Bouwer and Rice Method Analytical Results

__ Single Well Test – Hvorslev Method Analytical Results

GROUNDWATER LEVELS MEASUREMENTS/CALCULATIONS

ROCKY FLATS PROJECT Revision 1.2
Project No. EMAD (on 881 Hillside)
Date 121491
Personnel 1. K. Maley
2. S. Bradfield

EQUIPMENT: Manufacturer Solinst Model ______ Serial No. None (owned by EDEN)
CALIBRATION: Date Passed ______ Date Due ______
QC REVIEW: Name ______ Date ______



Well No. 38791	WD^b	MTD^c	Comments		
Measurement 1	11.40	19' 1¾"	KMM		
Measurement 2	11.375	19' 1¾"	SB		
Measurement 3	11.375	19' 1¾"	KM		
	11.375	19. 1¾"	+ ______	= ______	______
	Average WD	Average MTD	Probe End^d	TD^e	Chk'd by

Well No.	WD^b	MTD^c	Comments		
Measurement 1					
Measurement 2					
Measurement 3					
			+ ______	= ______	______
	Average WD	Average MTD	Probe End^d	TD^e	Chk'd by

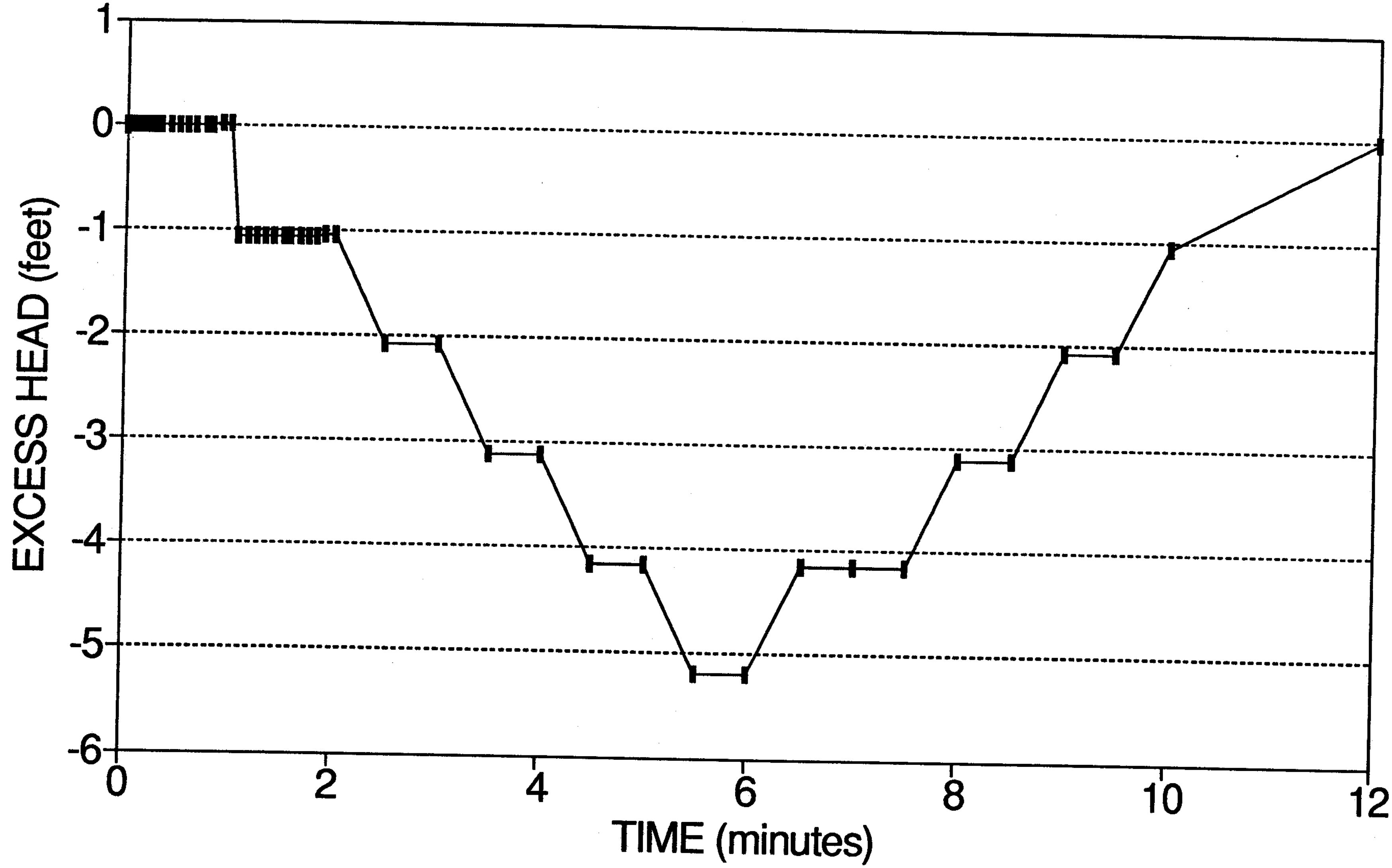
Well No.	WD^b	MTD^c	Comments		
Measurement 1					
Measurement 2					
Measurement 3					
			+ ______	= ______	______
	Average WD	Average MTD	Probe End^d	TD^e	Chk'd by

Footnotes:
A = TOWC = top of well casing
b = WD = depth to water from MP
c = MTD = measured total depth from MP
d = Probe End = length beyond measuring point on probe
e = TD = total depth of well from MP

Notes:
- All measurements are relative to Mark Point (MP) = north side of TOWC
- QC review by supervisor is a check of reasonableness
- Measurements 1 and 2 must be within .01 ft of a 3rd measurement must be taken

TEN MINUTE CALIBRATION TEST

38191 - PZ05



SLUG TEST DATA FORM

Location OU1
Borehole No. 38191 P205
Test Date 121491
Measuring Point TOC
Type of Test Slug + Withdrawal
Transductor Probe Serial No. 265825
Datalogger Test Run No. 0, 1, 2
(include time and date for identification purposes) #2K-319
MW P205_1a.TST
P205-1b.TST
P205-1c.TST

Name J. UHLINGER
Groundwater Elevation Before Test 11.375 below TOC
Total Casing Depth 19' 13/4"
Borehole Diameter 11"
Casing Diameter 2.07" OD
Screened Interval 12.2' - 17.2'
Sand Pack Interval 10.3 - 17.2'
Lithology Tested Gravel, Sand, Clay

Actual Time	Elapsed Time	Depth to Water from Top of Casing (ft)	H Excess Head (ft)	H/HO

SEE DATA PRINTOUT

SLUG INJECTION TEST DATA FORM 38191 - PZ05

FILE: PZ05_1B.WQ2
TEST DATE: 12/14/91
START TIME: 12:02:33 PM

REFERENCE: 11.38 FT

ELAPSED TIME (min)	DEPTH TO H20 FROM TOC (ft)	EXCESS HEAD (ft)
0	9.542	1.838
0.0083	9.585	1.795
0.0166	9.904	1.476
0.025	9.578	1.802
0.0333	9.763	1.617
0.0416	9.66	1.72
0.05	9.621	1.759
0.0583	9.693	1.687
0.0666	9.683	1.697
0.075	9.69	1.69
0.0833	9.697	1.683
0.1	9.71	1.67
0.1166	9.723	1.657
0.1333	9.73	1.65
0.15	9.723	1.657
0.1666	9.746	1.634
0.1833	9.753	1.627
0.2	9.766	1.614
0.2166	9.772	1.608
0.2333	9.779	1.601
0.25	9.786	1.594
0.2666	9.792	1.588
0.2833	9.796	1.584
0.3	9.799	1.581
0.3166	9.805	1.575
0.3333	9.809	1.571
0.4166	9.828	1.552
0.5	9.835	1.545
0.5833	9.845	1.535
0.6666	9.861	1.519
0.75	9.858	1.522
0.8333	9.858	1.522
0.9166	9.861	1.519
1	9.871	1.509
1.0833	9.871	1.509
1.1666	9.865	1.515
1.25	9.865	1.515
1.3333	9.871	1.509
1.4166	9.868	1.512
1.5	9.868	1.512
1.5833	9.868	1.512
1.6666	9.868	1.512
1.75	9.868	1.512
1.8333	9.871	1.509
1.9166	9.871	1.509

SLUG INJECTION TEST DATA FORM 38191 - PZ05

ELAPSED TIME (min)	DEPTH TO H20 FROM TOC (ft)	EXCESS HEAD (ft)
2	9.871	1.509
2.5	9.871	1.509
3	9.881	1.499
3.5	9.891	1.489
4	9.901	1.479
4.5	9.904	1.476
5	9.911	1.469
5.5	9.924	1.456
6	9.924	1.456
6.5	9.944	1.436
7	9.947	1.433
7.5	9.947	1.433
8	9.95	1.43
8.5	9.957	1.423
9	9.97	1.41
9.5	9.997	1.383
10	10.006	1.374
12	10.049	1.331
14	10.082	1.298
16	10.122	1.258
18	10.158	1.222
20	10.181	1.199
22	10.214	1.166
24	10.267	1.113
26	10.31	1.07
28	10.316	1.064
30	10.356	1.024
32	10.379	1.001
34	10.419	0.961
36	10.432	0.948
38	10.465	0.915
40	10.478	0.902
42	10.514	0.866
44	10.527	0.853
46	10.527	0.853
48	10.534	0.846
50	10.531	0.849
52	10.527	0.853
54	10.541	0.839
56	10.55	0.83
58	10.56	0.82
60	10.55	0.83
62	10.59	0.79
64	10.59	0.79
66	10.593	0.787

SLUG INJECTION TEST DATA FORM 38191 - PZ05

ELAPSED TIME (min)	DEPTH TO H20 FROM TOC (ft)	EXCESS HEAD (ft)
68	10.606	0.774
70	10.603	0.777
72	10.679	0.701
74	10.682	0.698
76	10.689	0.691
78	10.689	0.691
80	10.699	0.681
82	10.686	0.694
84	10.689	0.691
86	10.689	0.691
88	10.699	0.681
90	10.692	0.688
92	10.695	0.685
94	10.695	0.685
96	10.692	0.688
98	10.695	0.685
100	10.699	0.681
110	10.699	0.681
120	10.728	0.652
130	10.722	0.658
140	10.732	0.648
150	10.725	0.655
160	10.735	0.645
170	10.709	0.671
180	10.715	0.665
190	10.715	0.665
200	10.719	0.661

SLUG WITHDRAWAL TEST DATA FORM 38191 - PZ05

ELAPSED TIME (min)	DEPTH TO H20 FROM TOC (ft)	EXCESS HEAD (ft)
2	12.195	-0.82
2.5	12.185	-0.81
3	12.175	-0.8
3.5	12.172	-0.797
4	12.172	-0.797
4.5	12.182	-0.807
5	12.182	-0.807
5.5	12.179	-0.804
6	12.162	-0.787
6.5	12.169	-0.794
7	12.159	-0.784
7.5	12.175	-0.8
8	12.152	-0.777
8.5	12.152	-0.777
9	12.149	-0.774
9.5	12.146	-0.771
10	12.146	-0.771
12	12.123	-0.748
14	12.119	-0.744
16	12.11	-0.735
18	12.106	-0.731
20	12.1	-0.725
22	12.093	-0.718
24	12.083	-0.708
26	12.073	-0.698
28	12.063	-0.688
30	12.057	-0.682
32	12.05	-0.675
34	12.04	-0.665
36	12.03	-0.655
38	12.027	-0.652
40	12.021	-0.646
42	12.011	-0.636
44	12.001	-0.626
46	11.994	-0.619
48	11.988	-0.613
50	11.978	-0.603
52	11.971	-0.596
54	11.965	-0.59
56	11.958	-0.583
58	11.948	-0.573
60	11.941	-0.566
62	11.935	-0.56
64	11.928	-0.553
66	11.922	-0.547

SLUG WITHDRAWAL TEST DATA FORM 38191 - PZ05

ELAPSED TIME (min)	DEPTH TO H20 FROM TOC (ft)	EXCESS HEAD (ft)
68	11.915	-0.54
70	11.909	-0.534
72	11.902	-0.527
74	11.895	-0.52
76	11.885	-0.51
78	11.885	-0.51
80	11.879	-0.504
82	11.872	-0.497
84	11.866	-0.491
86	11.862	-0.487
88	11.856	-0.481
90	11.849	-0.474
92	11.843	-0.468
94	11.839	-0.464
96	11.833	-0.458
98	11.826	-0.451
100	11.823	-0.448
110	11.793	-0.418
120	11.767	-0.392
130	11.74	-0.365
140	11.717	-0.342
150	11.694	-0.319
160	11.671	-0.296
170	11.648	-0.273
180	11.609	-0.234
190	11.585	-0.21
200	11.572	-0.197
210	11.543	-0.168
220	11.523	-0.148
230	11.5	-0.125
240	11.493	-0.118
250	11.454	-0.079
260	11.44	-0.065
270	11.421	-0.046
280	11.398	-0.023
290	11.384	-0.009
300	11.365	0.01
310	11.355	0.02
320	11.338	0.037
330	11.325	0.05
340	11.315	0.06
350	11.302	0.073
360	11.289	0.086
370	11.279	0.096
380	11.262	0.113

SLUG WITHDRAWAL TEST DATA FORM 38191 - PZ05

FILE: PZ05_1C.WQ2
TEST DATE: 12/14/91
START TIME: 15:24:503 PM

REFERENCE: 11.38 FT

ELAPSED TIME (min)	DEPTH TO H20 FROM TOC (ft)	EXCESS HEAD (ft)
0	12.228	-0.853
0.0083	12.228	-0.853
0.0166	12.228	-0.853
0.025	12.225	-0.85
0.0333	12.228	-0.853
0.0416	12.225	-0.85
0.05	12.228	-0.853
0.0583	12.228	-0.853
0.0666	12.228	-0.853
0.075	12.228	-0.853
0.0833	12.228	-0.853
0.1	12.228	-0.853
0.1166	12.228	-0.853
0.1333	12.225	-0.85
0.15	12.225	-0.85
0.1666	12.225	-0.85
0.1833	12.222	-0.847
0.2	12.222	-0.847
0.2166	12.218	-0.843
0.2333	12.222	-0.847
0.25	12.225	-0.85
0.2666	12.222	-0.847
0.2833	12.222	-0.847
0.3	12.222	-0.847
0.3166	12.222	-0.847
0.3333	12.222	-0.847
0.4166	12.218	-0.843
0.5	12.218	-0.843
0.5833	12.218	-0.843
0.6666	12.215	-0.84
0.75	12.215	-0.84
0.8333	12.215	-0.84
0.9166	12.212	-0.837
1	12.212	-0.837
1.0833	12.208	-0.833
1.1666	12.205	-0.83
1.25	12.205	-0.83
1.3333	12.202	-0.827
1.4166	12.202	-0.827
1.5	12.199	-0.824
1.5833	12.199	-0.824
1.6666	12.195	-0.82
1.75	12.195	-0.82
1.8333	12.195	-0.82
1.9166	12.195	-0.82

SLUG WITHDRAWAL TEST DATA FORM 38191 - PZ05

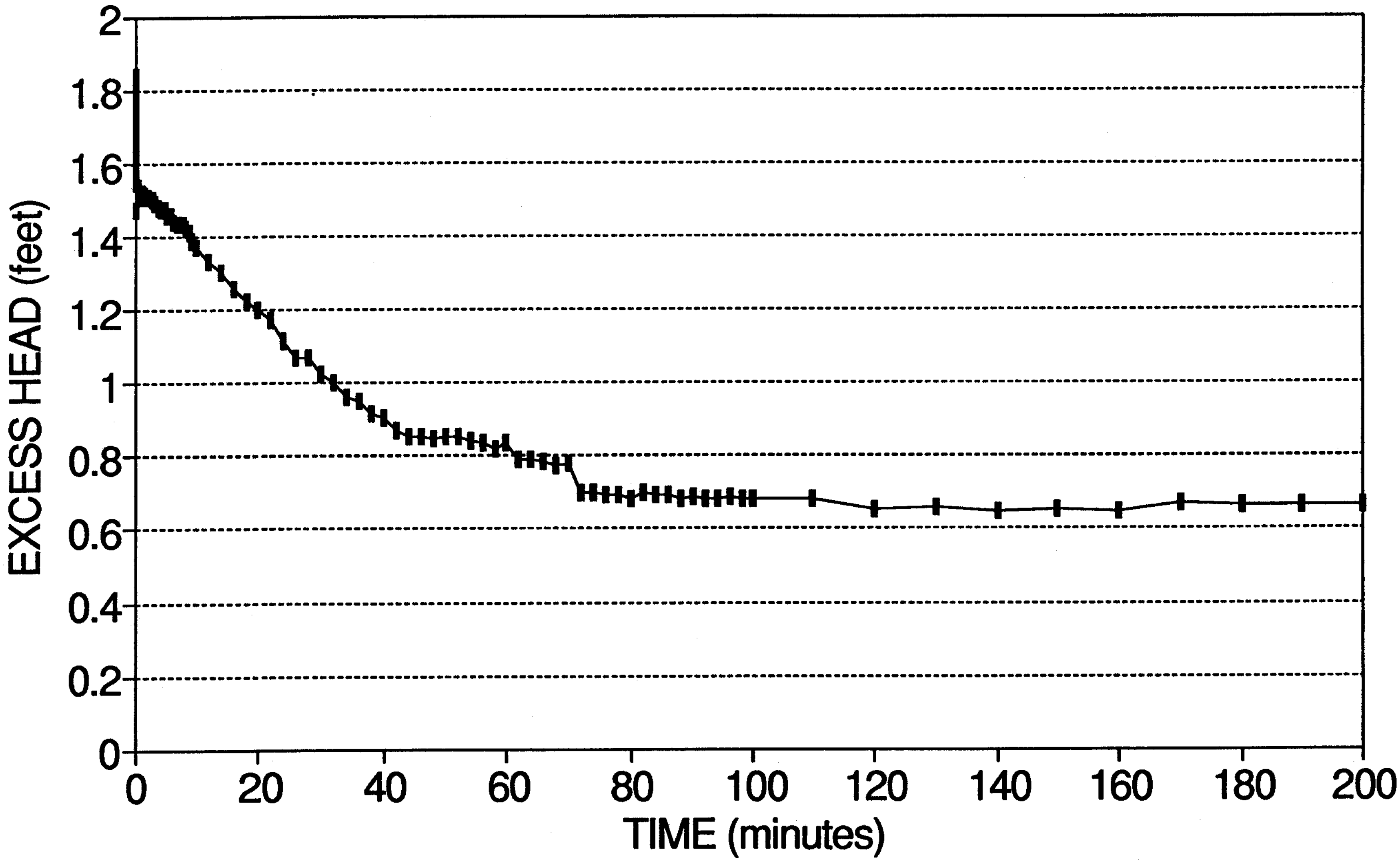
ELAPSED TIME (min)	DEPTH TO H20 FROM TOC (ft)	EXCESS HEAD (ft)
390	11.246	0.129
400	11.236	0.139
410	11.223	0.152
420	11.216	0.159
430	11.2	0.175
440	11.183	0.192
450	11.173	0.202
460	11.16	0.215
470	11.15	0.225
480	11.14	0.235
490	11.127	0.248
500	11.121	0.254
510	11.107	0.268
520	11.094	0.281
530	11.088	0.287
540	11.075	0.3
550	11.065	0.31
560	11.055	0.32
570	11.045	0.33
580	11.038	0.337
590	11.025	0.35
600	11.018	0.357
610	11.009	0.366
620	11.002	0.373
630	10.989	0.386
640	10.979	0.396
650	10.972	0.403
660	10.962	0.413
670	10.953	0.422
680	10.953	0.422
690	10.943	0.432
700	10.936	0.439
710	10.929	0.446
720	10.92	0.455
730	10.91	0.465
740	10.903	0.472
750	10.897	0.478
760	10.89	0.485
770	10.88	0.495
780	10.87	0.505
790	10.87	0.505
800	10.86	0.515
810	10.86	0.515
820	10.857	0.518
830	10.844	0.531

SLUG WITHDRAWAL TEST DATA FORM 38191 - PZ05

ELAPSED TIME (min)	DEPTH TO H20 FROM TOC (ft)	EXCESS HEAD (ft)
840	10.84	0.535
850	10.834	0.541
860	10.827	0.548
870	10.827	0.548
880	10.824	0.551
890	10.817	0.558
900	10.817	0.558
910	10.808	0.567
920	10.808	0.567
930	10.811	0.564
940	10.804	0.571
950	10.798	0.577
960	10.801	0.574
970	10.791	0.584
980	10.781	0.594
990	10.778	0.597
1000	10.775	0.6
1010	10.781	0.594
1020	10.778	0.597
1030	10.775	0.6
1040	10.761	0.614
1050	10.745	0.63
1060	10.742	0.633
1070	10.738	0.637
1080	10.745	0.63
1090	10.735	0.64
1100	10.748	0.627
1110	10.745	0.63
1120	10.742	0.633
1130	10.745	0.63
1140	10.745	0.63
1150	10.742	0.633
1160	10.742	0.633
1170	10.738	0.637
1180	10.735	0.64
1190	10.735	0.64
1200	10.728	0.647

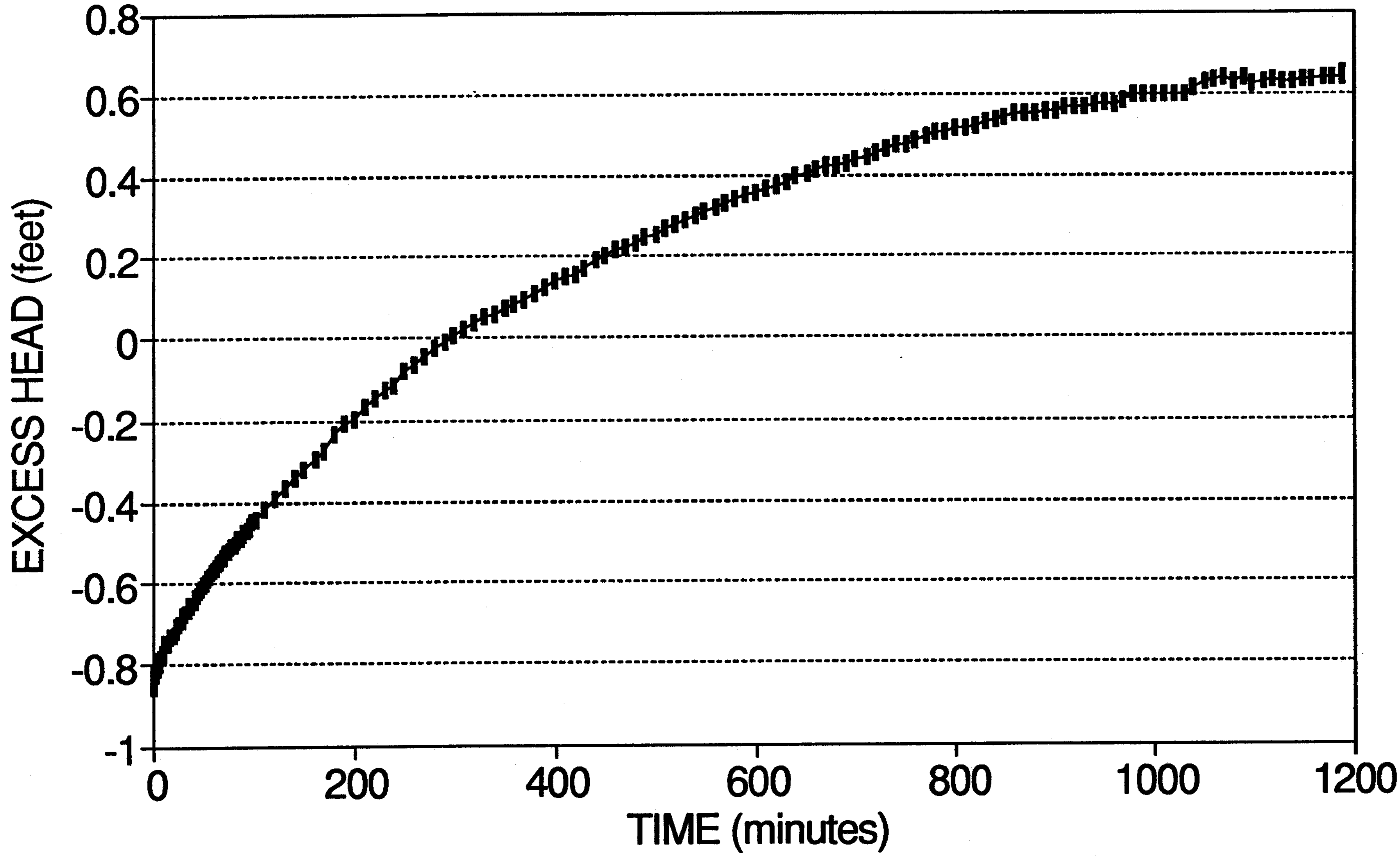
SLUG WITHDRAWAL TEST

38191 - PZ05



SLUG WITHDRAWAL TEST

38191 - PZ05



A Q T E S O L V   R E S U L T S
Version 1.10

03/12/92 13:13:56

==

TEST DESCRIPTION

```
Data set........... pz05inj.dat
Data set title..... SLUG INJECTION TEST 38191 - PZ05
Project............ OPERABLE UNIT 1
Client............. EG&G ROCKY FLATS
Location........... 881 HILLSIDE
Test date.......... 12/14/91

Knowns and Constants:
   No. of data points.................. 116
   Radius of well casing............... 0.0863
   Radius of well...................... 0.458
   Aquifer saturated thickness......... 5.52
   Well screen length.................. 4.8
   Static height of water in well...... 5.52
   Log(Re/Rw).......................... 1.765
   A, B, C.............................  0.000,   0.000,   1.308
```

==

ANALYTICAL METHOD

Bouwer-Rice (Unconfined Aquifer Slug Test)

==

RESULTS FROM VISUAL CURVE MATCHING

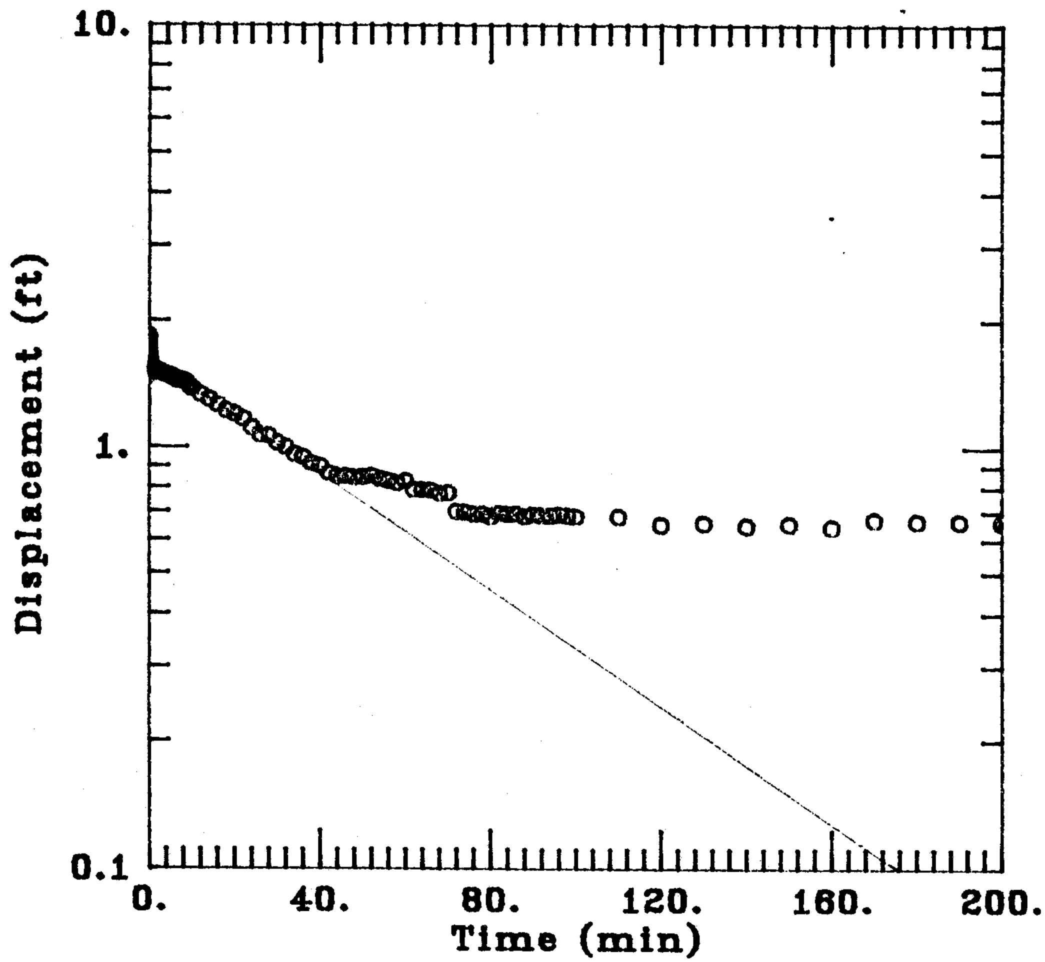
VISUAL MATCH PARAMETER ESTIMATES

```
         Estimate
K  =   2.1826E-005
y0 =   1.6409E+000
```

<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<>>

	Client: EG&G ROCKY FLATS
Project No.: OPERABLE UNIT 1	Location: 881 HILLSIDE

SLUG INJECTION TEST 38191 - PZ05



DATA SET:
PZ05INJ.DAT
03/02/92

AQUIFER TYPE:
Unconfined
SOLUTION METHOD:
Bouwer-Rice
TEST DATE:
12/14/91

ESTIMATED PARAMETERS:
K = 2.1826E-05 ft/min
y0 = 1.641 ft

TEST DATA:

rc = 0.0863 ft
rw = 0.458 ft
L = 4.8 ft
b = 5.52 ft
H = 5.52 ft

A Q T E S O L V   R E S U L T S
Version 1.10

03/07/92 11:50:20

===

TEST DESCRIPTION

Data set........... PZ05WD.DAT
Data set title..... SLUG WITHDRAWAL TEST 38191 - PZ05
Project............ OPERABLE UNIT 1
Client............. EG&G ROCKY FLATS
Location........... 881 HILLSIDE
Test date.......... 12/14/91

Knowns and Constants:
- No. of data points.................. 215
- Radius of well casing............... 0.0863
- Radius of well...................... 0.458
- Aquifer saturated thickness......... 5.52
- Well screen length.................. 4.8
- Static height of water in well...... 5.52
- Log(Re/Rw).......................... 1.765
- A, B, C............................. 0.000, 0.000, 1.308

===

ANALYTICAL METHOD

Bouwer-Rice (Unconfined Aquifer Slug Test)

===

RESULTS FROM VISUAL CURVE MATCHING

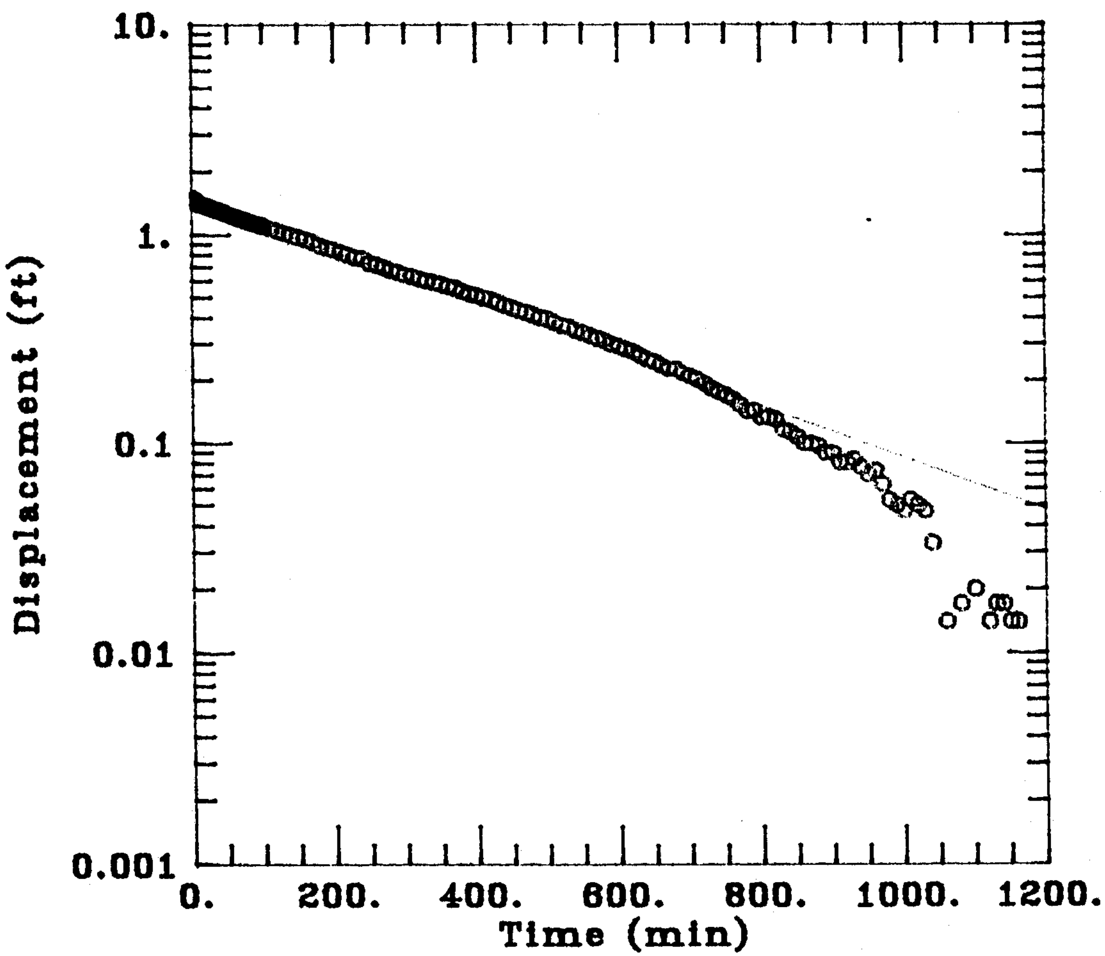
VISUAL MATCH PARAMETER ESTIMATES

	Estimate
K =	3.8877E-006
y0 =	1.4726E+000

<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<>>

Project No.: OPERABLE UNIT 1	Client: EG&G ROCKY FLATS
	Location: 881 HILLSIDE

SLUG WITHDRAWAL TEST 38191 - PZ05



DATA SET:
PZ05WD.DAT
03/02/92

AQUIFER TYPE:
Unconfined

SOLUTION METHOD:
Bouwer-Rice

TEST DATE:
12/14/91

ESTIMATED PARAMETERS:
K = 3.8879E-06 ft/min
y0 = 1.473 ft

TEST DATA:

rc = 0.0863 ft
rw = 0.458 ft
L = 4.8 ft
b = 5.52 ft
H = 5.52 ft

INDEX OF BOREHOLE AND SINGLE WELL TEST DATA AND RESULTS

Borehole, well, or piezometer number: **38591 (MW34)**
(Work plan designation)

Data Available:

__ Packer Test – Set-up

__ Packer Test – Data Sheet (Flow vs. Time Data)

__ Packer Test – Data Logger Output (Head vs. Time Data)

__ Packer Test – Analysis and Results Calculation Sheet

✔ Single Well Test – Record of Initial Water Level Measurement

✔ Single Well Test – 10 Minute Calibration Plot

✔ Single Well Test – Head vs. Time Data Form

✔ Single Well Test – Head vs. Time Response Graph(s)

✔ Single Well Test – Bouwer and Rice Method Analytical Results

__ Single Well Test – Hvorslev Method Analytical Results

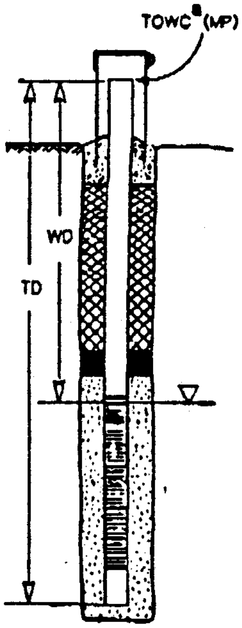
U.S. DEPARTMENT OF ENERGY ROCKY FLATS PLANT

FORM GW.1A

GROUNDWATER LEVELS MEASUREMENTS/CALCULATIONS

ROCKY FLATS PROJECT   Revision 1.2
Project No. OU1 881 Hillside
Date 12/20/91
Personnel 1. J. Uhlinger
2. C. Bienvillius

EQUIPMENT: Manufacturer Solinst Model ______ Serial No. 10373
CALIBRATION: Date Passed ______ Date Due ______
QC REVIEW: Name ______ Date ______



Well No. 38591	WD[b]	MTD[c]	Comments
Measurement 1	8.50	11.81	
Measurement 2	8.50	11.81	
Measurement 3	8.50	11.81	
	Average WD	Average MTD 11.81	+ 0 Probe End[d] = 11.81 TD[e] ______ Chk'd by

Well No.	WD[b]	MTD[c]	Comments
Measurement 1			
Measurement 2			
Measurement 3			
	Average WD	Average MTD	+ ______ Probe End[d] = ______ TD[e] ______ Chk'd by

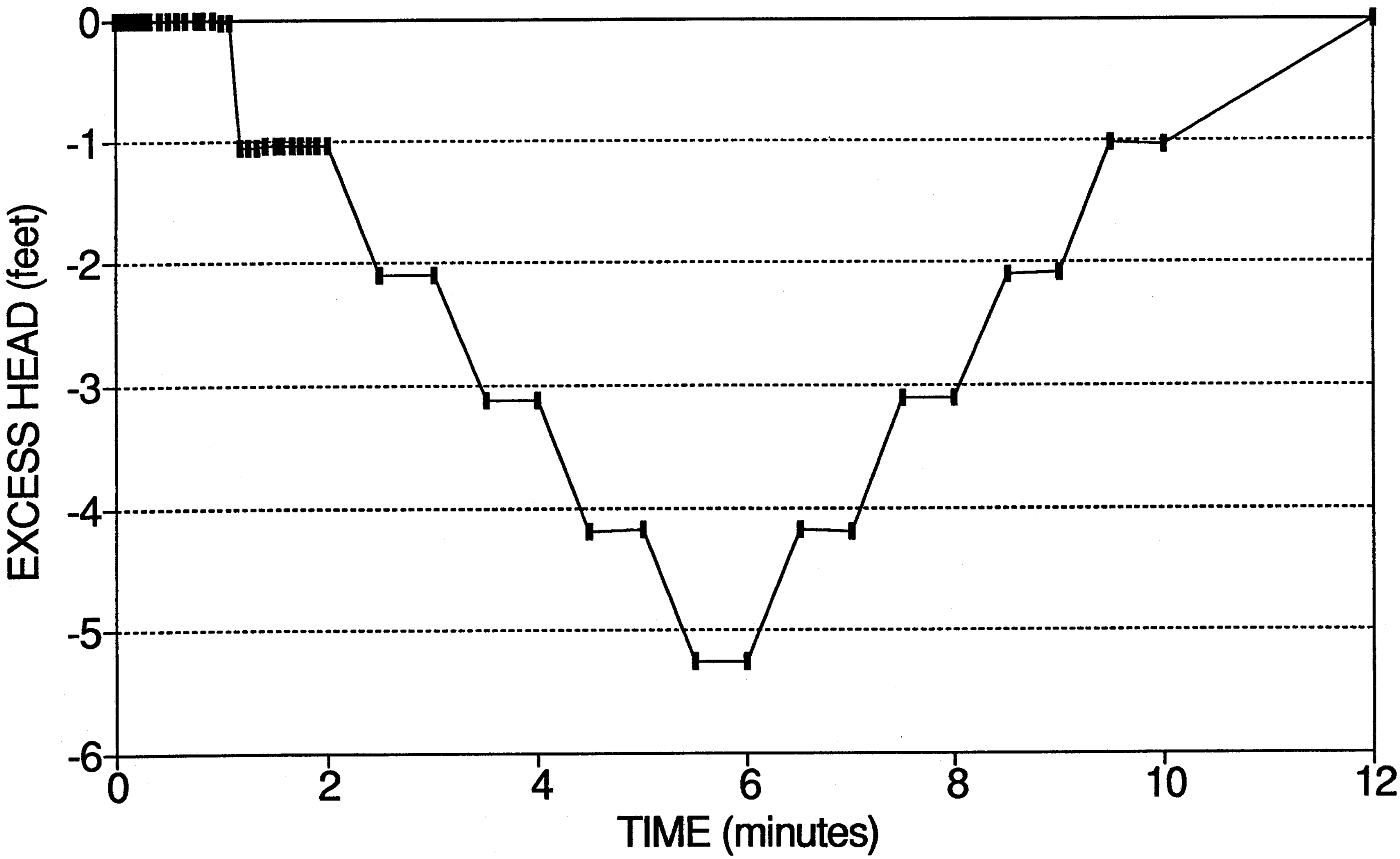
Well No.	WD[b]	MTD[c]	Comments
Measurement 1			
Measurement 2			
Measurement 3			
	Average WD	Average MTD	+ ______ Probe End[d] = ______ TD[e] ______ Chk'd by

Footnotes:
A = TOWC = top of well casing
b = WD = depth to water from MP
c = MTD = measured total depth from MP
d = Probe End = length beyond measuring point on probe
e = TD = total depth of well from MP

Notes:
- All measurements are relative to Mark Point (MP) = north side of TOWC
- QC review by supervisor is a check of reasonableness
- Measurements 1 and 2 must be within .01 ft of a 3rd measurement must be taken

TEN MINUTE CALIBRATION TEST

38991 - PZ03



U.S. DEPARTMENT OF ENERGY ROCKY FLATS PLANT

FORM GW.4A

BAILDOWN/RECOVERY
~~SLUG~~ TEST DATA FORM

Location 881 Hillside OU1
Borehole No. 38591 MW34
Test Date 12/20
Measuring Point Top PVC Casing
Type of Test Baildown Recovery
Transductor Probe Serial No. 265825
Datalogger Test Run No.
(include time and date for identification purposes)
MW34-1a.TST
MW34-1b.TST

Name J. Uhlinger, C. Biendlis
Groundwater Elevation Before Test 8.50
Total Casing Depth 11.81
Borehole Diameter 11"
Casing Diameter 2.07"
Screened Interval 7.66' - 9.66'
Sand Pack Interval 7.00 - 10.00
Lithology Tested Alluvium - Clay & gravel

Actual Time	Elapsed Time	Depth to Water from Top of Casing (ft)	H Excess Head (ft)	H/HO

See Transducer Records

(4011-600-[illegible]-11-91)

BAIL DOWN/RECOVERY TEST DATA FORM 38591 - MW34

FILE: MW34_1B.WQ2
TEST DATE: 12/20/91
START TIME: 09:57:34 AM

REFERENCE: 8.48 FT

ELAPSED TIME (min)	DEPTH TO H20 FROM TOC (ft)	EXCESS HEAD (ft)
0	9.603	-1.123
0.0083	9.593	-1.113
0.0166	9.587	-1.107
0.025	9.581	-1.101
0.0333	9.571	-1.091
0.0416	9.565	-1.085
0.05	9.555	-1.075
0.0583	9.549	-1.069
0.0666	9.543	-1.063
0.075	9.536	-1.056
0.0833	9.530	-1.050
0.1	9.517	-1.037
0.1166	9.505	-1.025
0.1333	9.492	-1.012
0.15	9.479	-0.999
0.1666	9.466	-0.986
0.1833	9.454	-0.974
0.2	9.444	-0.964
0.2166	9.432	-0.952
0.2333	9.422	-0.942
0.25	9.409	-0.929
0.2666	9.400	-0.920
0.2833	9.393	-0.913
0.3	9.381	-0.901
0.3166	9.371	-0.891
0.3333	9.362	-0.882
0.4166	9.324	-0.844
0.5	9.289	-0.809
0.5833	9.260	-0.780
0.6666	9.232	-0.752
0.75	9.209	-0.729
0.8333	9.187	-0.707
0.9166	9.168	-0.688
1	9.149	-0.669
1.0833	9.136	-0.656
1.1666	9.121	-0.641
1.25	9.111	-0.631
1.3333	9.098	-0.618
1.4166	9.089	-0.609
1.5	9.076	-0.596
1.5833	9.070	-0.590
1.6666	9.060	-0.580
1.75	9.051	-0.571
1.8333	9.044	-0.564
1.9166	9.035	-0.555

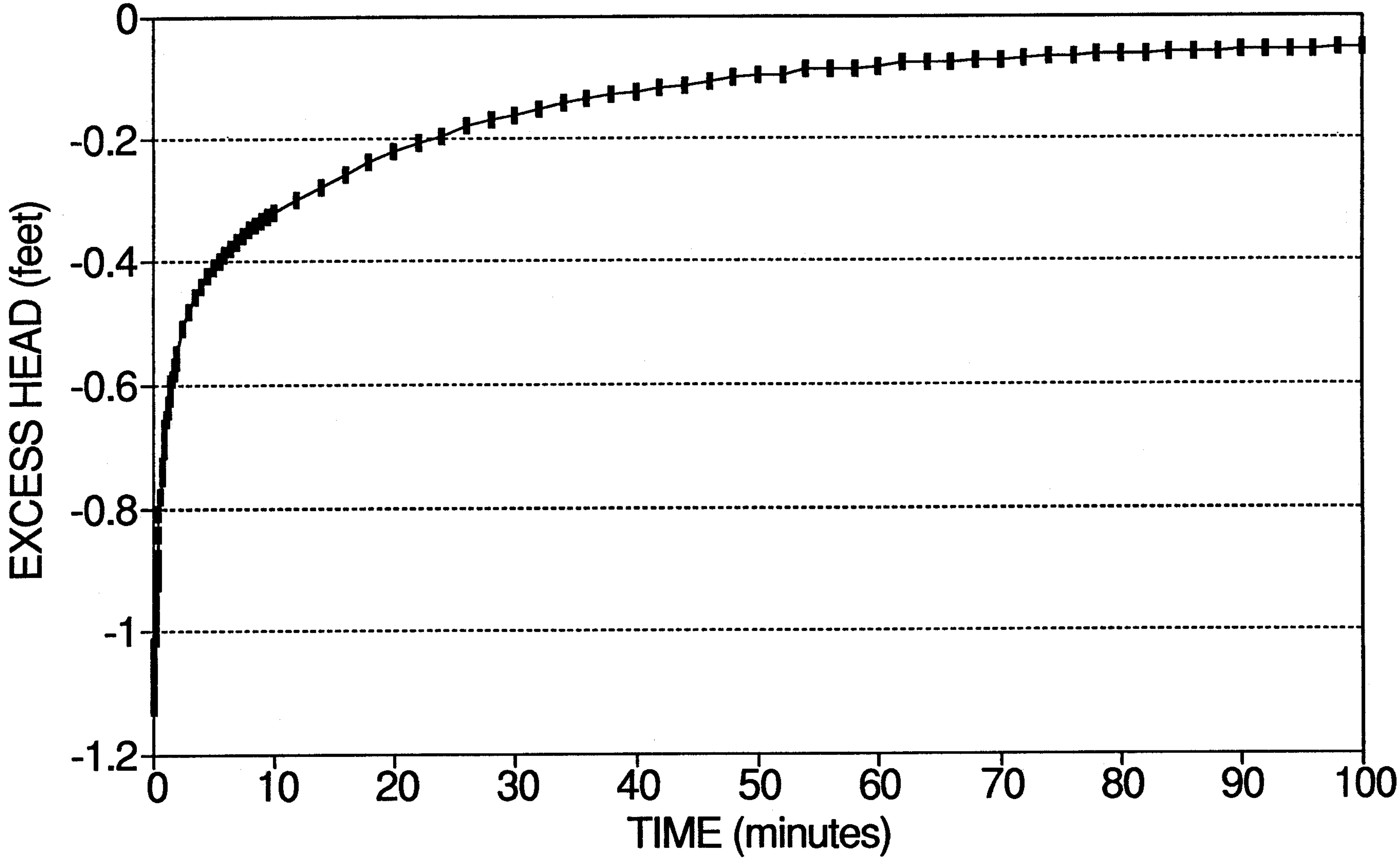
BAIL DOWN/RECOVERY TEST DATA FORM 38591 - MW34

ELAPSED TIME (min)	DEPTH TO H20 FROM TOC (ft)	EXCESS HEAD (ft)
2	9.029	-0.549
2.5	8.990	-0.510
3	8.962	-0.482
3.5	8.936	-0.456
4	8.917	-0.437
4.5	8.902	-0.422
5	8.889	-0.409
5.5	8.876	-0.396
6	8.867	-0.387
6.5	8.857	-0.377
7	8.848	-0.368
7.5	8.838	-0.358
8	8.829	-0.349
8.5	8.822	-0.342
9	8.813	-0.333
9.5	8.806	-0.326
10	8.800	-0.320
12	8.778	-0.298
14	8.756	-0.276
16	8.737	-0.257
18	8.718	-0.238
20	8.702	-0.222
22	8.689	-0.209
24	8.676	-0.196
26	8.660	-0.180
28	8.651	-0.171
30	8.641	-0.161
32	8.632	-0.152
34	8.622	-0.142
36	8.616	-0.136
38	8.610	-0.130
40	8.603	-0.123
42	8.597	-0.117
44	8.594	-0.114
46	8.587	-0.107
48	8.581	-0.101
50	8.578	-0.098
52	8.575	-0.095
54	8.568	-0.088
56	8.568	-0.088
58	8.565	-0.085
60	8.562	-0.082
62	8.559	-0.079
64	8.556	-0.076
66	8.556	-0.076

ELAPSED TIME (min)	DEPTH TO H20 FROM TOC (ft)	EXCESS HEAD (ft)
68	8.552	-0.072
70	8.552	-0.072
72	8.549	-0.069
74	8.546	-0.066
76	8.546	-0.066
78	8.543	-0.063
80	8.543	-0.063
82	8.543	-0.063
84	8.540	-0.060
86	8.540	-0.060
88	8.540	-0.060
90	8.537	-0.057
92	8.537	-0.057
94	8.537	-0.057
96	8.537	-0.057
98	8.533	-0.053
100	8.533	-0.053

BAILDOWN/RECOVERY TEST

38591 - MW34



A Q T E S O L V   R E S U L T S
Version 1.10

03/12/92 13:10:01

TEST DESCRIPTION

Data set........... mw34bdr.dat
Data set title..... BAILDOWN/RECOVERY TEST 38591 - MW34
Project............ OPERABLE UNIT 1
Client............. EG&G ROCKY FLATS
Location........... 881 HILLSIDE
Test date.......... 12/20/91

Knowns and Constants:
   No. of data points.................. 106
   Radius of well casing............... 0.261
   Radius of well...................... 0.458
   Aquifer saturated thickness......... 1.16
   Well screen length.................. 1.16
   Static height of water in well...... 1.16
   Log(Re/Rw).......................... 0.7004
   A, B, C............................. 0.000, 0.000, 0.618

ANALYTICAL METHOD

Bouwer-Rice (Unconfined Aquifer Slug Test)

RESULTS FROM VISUAL CURVE MATCHING

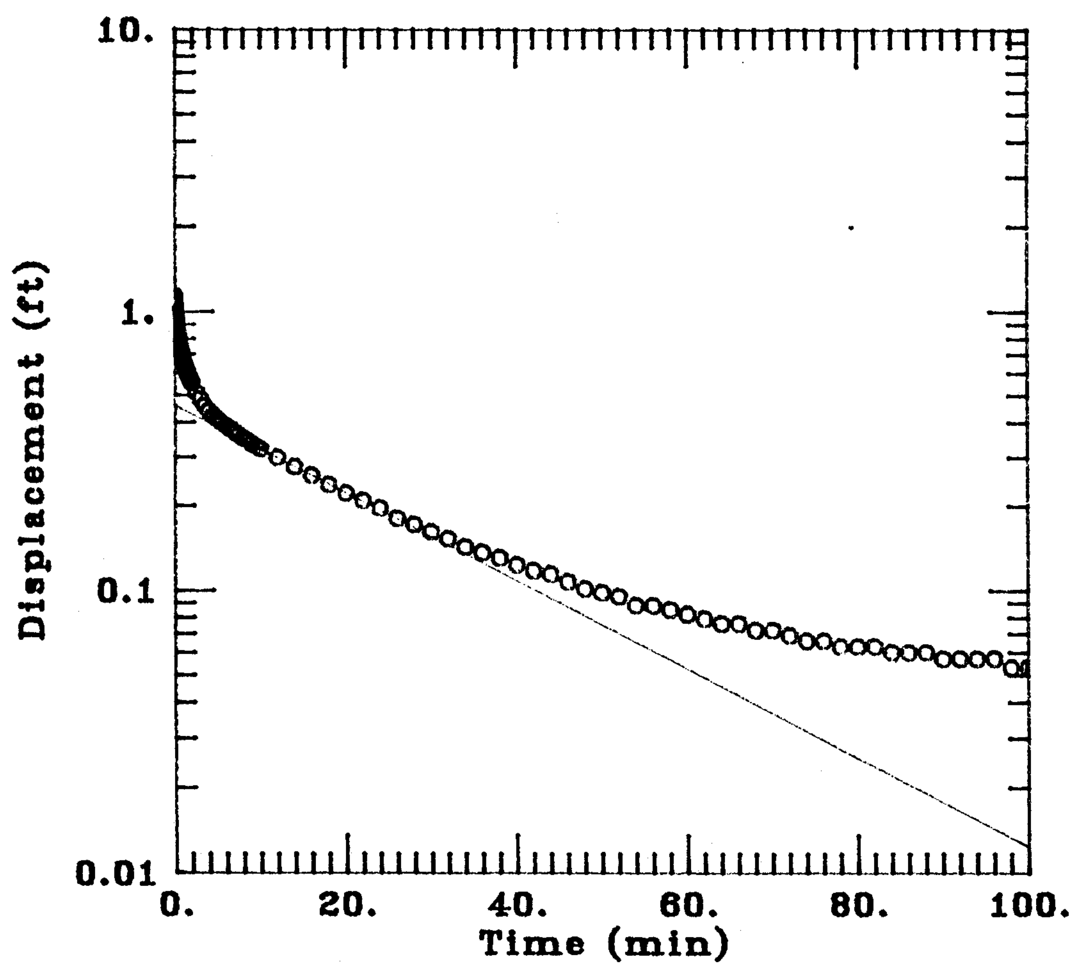
VISUAL MATCH PARAMETER ESTIMATES

	Estimate
K =	7.4389E-004
y0 =	4.6243E-001

<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<>>

Project No.: OPERABLE UNIT 1	Client: EG&G ROCKY FLATS
	Location: 881 HILLSIDE

BAILDOWN/RECOVERY TEST 38591 – MW34



DATA SET:
MW34BDR.DAT
03/03/92

AQUIFER TYPE:
Unconfined

SOLUTION METHOD:
Bouwer-Rice

TEST DATE:
12/20/91

ESTIMATED PARAMETERS:
K = 0.000744 ft/min
y0 = 0.4624 ft

TEST DATA:

rc = 0.261 ft
rw = 0.458 ft
L = 1.16 ft
b = 1.16 ft
H = 1.16 ft

INDEX OF BOREHOLE AND SINGLE WELL TEST DATA AND RESULTS

Borehole, well, or piezometer number: **38991 (PZ03)**
(Work plan designation)

Data Available:

__ Packer Test – Set-up

__ Packer Test – Data Sheet (Flow vs. Time Data)

__ Packer Test – Data Logger Output (Head vs. Time Data)

__ Packer Test – Analysis and Results Calculation Sheet

✔ Single Well Test – Record of Initial Water Level Measurement

✔ Single Well Test – 10 Minute Calibration Plot

✔ Single Well Test – Head vs. Time Data Form

✔ Single Well Test – Head vs. Time Response Graph(s)

✔ Single Well Test – Bouwer and Rice Method Analytical Results

__ Single Well Test – Hvorslev Method Analytical Results

U.S. DEPARTMENT OF ENERGY ROCKY FLATS PLANT — FORM GW.1A

GROUNDWATER LEVELS MEASUREMENTS/CALCULATIONS

ROCKY FLATS PROJECT — Revision 1.2

Project No. OU2 881 Hillside

Date 12/16/91

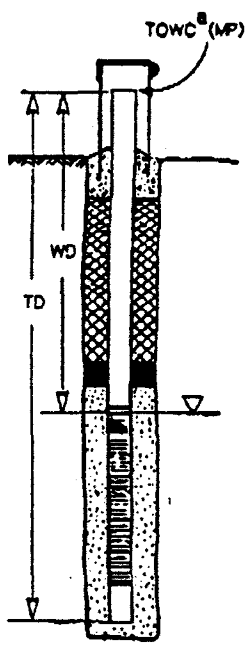
Personnel 1. J. Uhlinger

2. C. Bierkulius

EQUIPMENT: Manufacturer Solinst Model ______ Serial No. None Ebasco's

CALIBRATION: Date Passed ______ Date Due ______

QC REVIEW: Name ______ Date ______



Well No. 38991 JFU	WD[b]	MTD[c]	Comments
Measurement 1	30.15	41.40	CB
Measurement 2	30.15	41.40	JFU
Measurement 3	30.15	41.40	CB
	30.15	41.40	+ 0 = 41.40 ______
	Average WD	Average MTD	Probe End[d] TD[e] Chk'd by

Well No.	WD[b]	MTD[c]	Comments
Measurement 1			
Measurement 2			
Measurement 3			
			+ ______ = ______ ______
	Average WD	Average MTD	Probe End[d] TD[e] Chk'd by

Well No.	WD[b]	MTD[c]	Comments
Measurement 1			
Measurement 2			
Measurement 3			
			+ ______ = ______ ______
	Average WD	Average MTD	Probe End[d] TD[e] Chk'd by

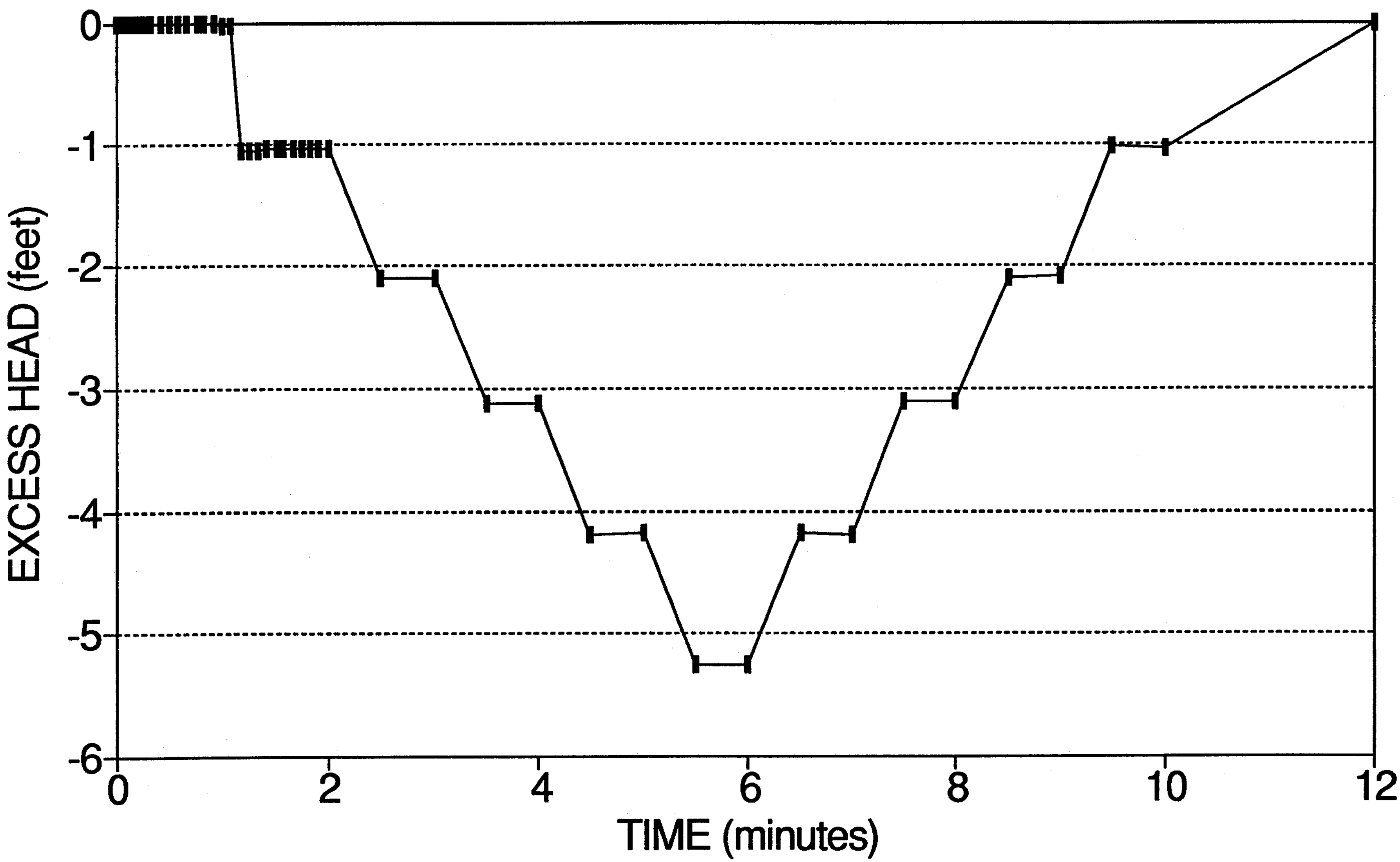
Footnotes:
- A = TOWC = top of well casing
- b = WD = depth to water from MP
- c = MTD = measured total depth from MP
- d = Probe End = length beyond measuring point on probe
- e = TD = total depth of well from MP

Notes:
- All measurements are relative to Mark Point (MP) = north side of TOWC
- QC review by supervisor is a check of reasonableness
- Measurements 1 and 2 must be within .01 ft of a 3rd measurement must be taken

(4011-600-0022) (GW1-FORM.1A) (09-18-91) (4:18pm)

TEN MINUTE CALIBRATION TEST

38991 - PZ03



U.S. DEPARTMENT OF ENERGY ROCKY FLATS PLANT

FORM GW.4A

Bail-Down / Recovery Test ~~SLUG TEST~~ DATA FORM

JFU 12/16/91

Location OU1 - 881 Hillside
Borehole No. 38991 P203
Test Date 12/16/91
Measuring Point Top PVC Casing
Type of Test Bail down / recovery
Transducor Probe Serial No. 175900
Datalogger Test Run No.
(include time and date for identification purposes)
P203_1a.TST
P203_1b.TST

Name J. Uhlinger JFU 12/16/91
Groundwater Elevation Before Test ~~30.02~~ 30.15
Total Casing Depth 41.40'
Borehole Diameter ~~4"~~ 7" JFU
Casing Diameter 2.07"
Screened Interval 29.15 - 39.15
Sand Pack Interval 27.15 - 40.15
Lithology Tested Claystone

Actual Time	Elapsed Time	Depth to Water from Top of Casing (ft)	H Excess Head (ft)	H/HO

SEE XD Records in Logger Files

(4011-600-0024)(GW4REV.1)(09-11-91)

BAIL DOWN/RECOVERY TEST DATA FORM 38991 - PZ03

FILE: PZ03_1B.WQ2
TEST DATE: 12/16/91
START TIME: 14:38:25 PM

REFERENCE: 30.02 FT

ELAPSED TIME (min)	DEPTH TO H20 FROM TOC (ft)	EXCESS HEAD (ft)
0	38.827	-8.807
0.0083	38.821	-8.801
0.0166	38.815	-8.795
0.025	38.809	-8.789
0.0333	38.805	-8.785
0.0416	38.802	-8.782
0.05	38.796	-8.776
0.0583	38.783	-8.763
0.0666	38.780	-8.760
0.075	38.777	-8.757
0.0833	38.771	-8.751
0.1	38.764	-8.744
0.1166	38.752	-8.732
0.1333	38.742	-8.722
0.15	38.733	-8.713
0.1666	38.720	-8.700
0.1833	38.711	-8.691
0.2	38.698	-8.678
0.2166	38.685	-8.665
0.2333	38.682	-8.662
0.25	38.666	-8.646
0.2666	38.666	-8.646
0.2833	38.644	-8.624
0.3	38.635	-8.615
0.3166	38.622	-8.602
0.3333	38.610	-8.590
0.4166	38.569	-8.549
0.5	38.518	-8.498
0.5833	38.468	-8.448
0.6666	38.423	-8.403
0.75	38.382	-8.362
0.8333	38.335	-8.315
0.9166	38.294	-8.274
1	38.256	-8.236
1.0833	38.212	-8.192
1.1666	38.168	-8.148
1.25	38.130	-8.110
1.3333	38.095	-8.075
1.4166	38.051	-8.031
1.5	38.013	-7.993
1.5833	37.972	-7.952
1.6666	37.931	-7.911
1.75	37.899	-7.879
1.8333	37.862	-7.842
1.9166	37.824	-7.804

BAIL DOWN/RECOVERY TEST DATA FORM 38991 - PZ03

ELAPSED TIME (min)	DEPTH TO H20 FROM TOC (ft)	EXCESS HEAD (ft)
2	37.786	-7.766
2.5	37.562	-7.542
3	37.363	-7.343
3.5	37.186	-7.166
4	37.038	-7.018
4.5	36.908	-6.888
5	36.795	-6.775
5.5	36.694	-6.674
6	36.611	-6.591
6.5	36.520	-6.500
7	36.454	-6.434
7.5	36.400	-6.380
8	36.343	-6.323
8.5	36.289	-6.269
9	36.236	-6.216
9.5	36.166	-6.146
10	36.138	-6.118
12	35.990	-5.970
14	35.857	-5.837
16	35.756	-5.736
18	35.671	-5.651
20	35.579	-5.559
22	35.503	-5.483
24	35.437	-5.417
26	35.380	-5.360
28	35.311	-5.291
30	35.257	-5.237
32	35.207	-5.187
34	35.159	-5.139
36	35.121	-5.101
38	35.077	-5.057
40	35.043	-5.023
42	35.005	-4.985
44	34.976	-4.956
46	34.951	-4.931
48	34.913	-4.893
50	34.885	-4.865
52	34.859	-4.839
54	34.840	-4.820
56	34.809	-4.789
58	34.790	-4.770
60	34.765	-4.745
62	34.743	-4.723
64	34.724	-4.704
66	34.702	-4.682

BAIL DOWN/RECOVERY TEST DATA FORM 38991 - PZ03

ELAPSED TIME (min)	DEPTH TO H20 FROM TOC (ft)	EXCESS HEAD (ft)
68	34.683	-4.663
70	34.661	-4.641
72	34.642	-4.622
74	34.626	-4.606
76	34.607	-4.587
78	34.591	-4.571
80	34.572	-4.552
82	34.556	-4.536
84	34.541	-4.521
86	34.528	-4.508
88	34.509	-4.489
90	34.500	-4.480
92	34.484	-4.464
94	34.474	-4.454
96	34.462	-4.442
98	34.440	-4.420
100	34.440	-4.420
110	34.370	-4.350
120	34.316	-4.296
130	34.266	-4.246
140	34.219	-4.199
150	34.171	-4.151
160	34.124	-4.104
170	34.076	-4.056
180	34.039	-4.019
190	34.004	-3.984
200	33.969	-3.949
210	33.941	-3.921
220	33.909	-3.889
230	33.878	-3.858
240	33.849	-3.829
250	33.818	-3.798
260	33.792	-3.772
270	33.764	-3.744
280	33.739	-3.719
290	33.710	-3.690
300	33.688	-3.668
310	33.660	-3.640
320	33.638	-3.618
330	33.612	-3.592
340	33.587	-3.567
350	33.562	-3.542
360	33.537	-3.517
370	33.515	-3.495
380	33.489	-3.469

BAIL DOWN/RECOVERY TEST DATA FORM 38991 - PZ03

ELAPSED TIME (min)	DEPTH TO H20 FROM TOC (ft)	EXCESS HEAD (ft)
390	33.464	-3.444
400	33.442	-3.422
410	33.420	-3.400
420	33.398	-3.378
430	33.376	-3.356
440	33.350	-3.330
450	33.328	-3.308
460	33.306	-3.286
470	33.284	-3.264
480	33.262	-3.242
490	33.243	-3.223
500	33.221	-3.201
510	33.202	-3.182
520	33.180	-3.160
530	33.161	-3.141
540	33.139	-3.119
550	33.117	-3.097
560	33.098	-3.078
570	33.076	-3.056
580	33.057	-3.037
590	33.035	-3.015
600	33.013	-2.993
610	32.994	-2.974
620	32.975	-2.955
630	32.956	-2.936
640	32.937	-2.917
650	32.918	-2.898
660	32.902	-2.882
670	32.883	-2.863
680	32.864	-2.844
690	32.845	-2.825
700	32.829	-2.809
710	32.814	-2.794
720	32.795	-2.775
730	32.776	-2.756
740	32.760	-2.740
750	32.741	-2.721
760	32.722	-2.702
770	32.706	-2.686
780	32.691	-2.671
790	32.672	-2.652
800	32.656	-2.636
810	32.637	-2.617
820	32.621	-2.601
830	32.605	-2.585

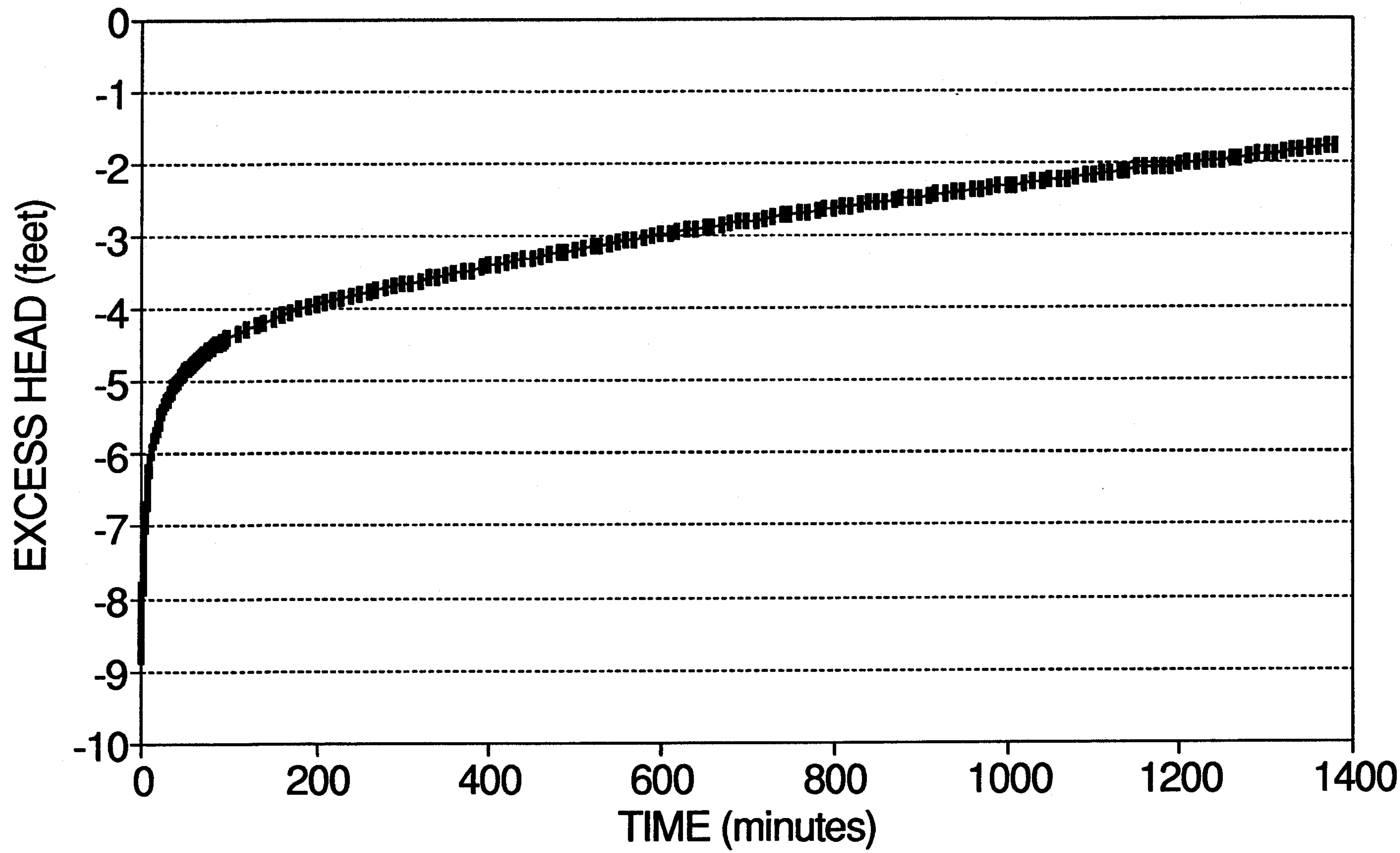
BAIL DOWN/RECOVERY TEST DATA FORM 38991 - PZ03

ELAPSED TIME (min)	DEPTH TO H20 FROM TOC (ft)	EXCESS HEAD (ft)
840	32.589	-2.569
850	32.574	-2.554
860	32.558	-2.538
870	32.542	-2.522
880	32.526	-2.506
890	32.507	-2.487
900	32.495	-2.475
910	32.479	-2.459
920	32.463	-2.443
930	32.447	-2.427
940	32.432	-2.412
950	32.416	-2.396
960	32.400	-2.380
970	32.384	-2.364
980	32.372	-2.352
990	32.356	-2.336
1000	32.340	-2.320
1010	32.324	-2.304
1020	32.309	-2.289
1030	32.293	-2.273
1040	32.280	-2.260
1050	32.264	-2.244
1060	32.249	-2.229
1070	32.233	-2.213
1080	32.223	-2.203
1090	32.204	-2.184
1100	32.192	-2.172
1110	32.179	-2.159
1120	32.160	-2.140
1130	32.147	-2.127
1140	32.132	-2.112
1150	32.097	-2.077
1160	32.081	-2.061
1170	32.091	-2.071
1180	32.078	-2.058
1190	32.065	-2.045
1200	32.053	-2.033
1210	32.040	-2.020
1220	32.028	-2.008
1230	32.015	-1.995
1240	32.002	-1.982
1250	31.986	-1.966
1260	31.971	-1.951
1270	31.958	-1.938
1280	31.945	-1.925

BAIL DOWN/RECOVERY TEST DATA FORM 38991 - PZ03

ELAPSED TIME (min)	DEPTH TO H20 FROM TOC (ft)	EXCESS HEAD (ft)
1290	31.926	-1.906
1300	31.917	-1.897
1310	31.904	-1.884
1320	31.892	-1.872
1330	31.870	-1.850
1340	31.854	-1.834
1350	31.838	-1.818
1360	31.822	-1.802
1370	31.807	-1.787
1380	31.791	-1.771

BAIL DOWN/RECOVERY TEST
38991 - PZ03



A Q T E S O L V   R E S U L T S
Version 1.10

06/05/92 10:50:44

==

TEST DESCRIPTION

Data set........... PZ03BDR.DAT
Data set title..... BAIL DOWN RECOVERY TEST 38991 - PZ03
Project............ OPERABLE UNIT 1
Client............. EG&G ROCKY FLATS
Location........... 881 HILLSIDE
Test date.......... 12/16/91

Knowns and Constants:
No. of data points.................. 234
Radius of well casing............... 0.1755
Radius of well...................... 0.292
Aquifer saturated thickness......... 10
Well screen length.................. 8.8
Static height of water in well...... 8.8
Log(Re/Rw).......................... 2.365
A, B, C............................. 2.448, 0.398, 0.000

==

ANALYTICAL METHOD

Bouwer-Rice (Unconfined Aquifer Slug Test)

==

RESULTS FROM VISUAL CURVE MATCHING

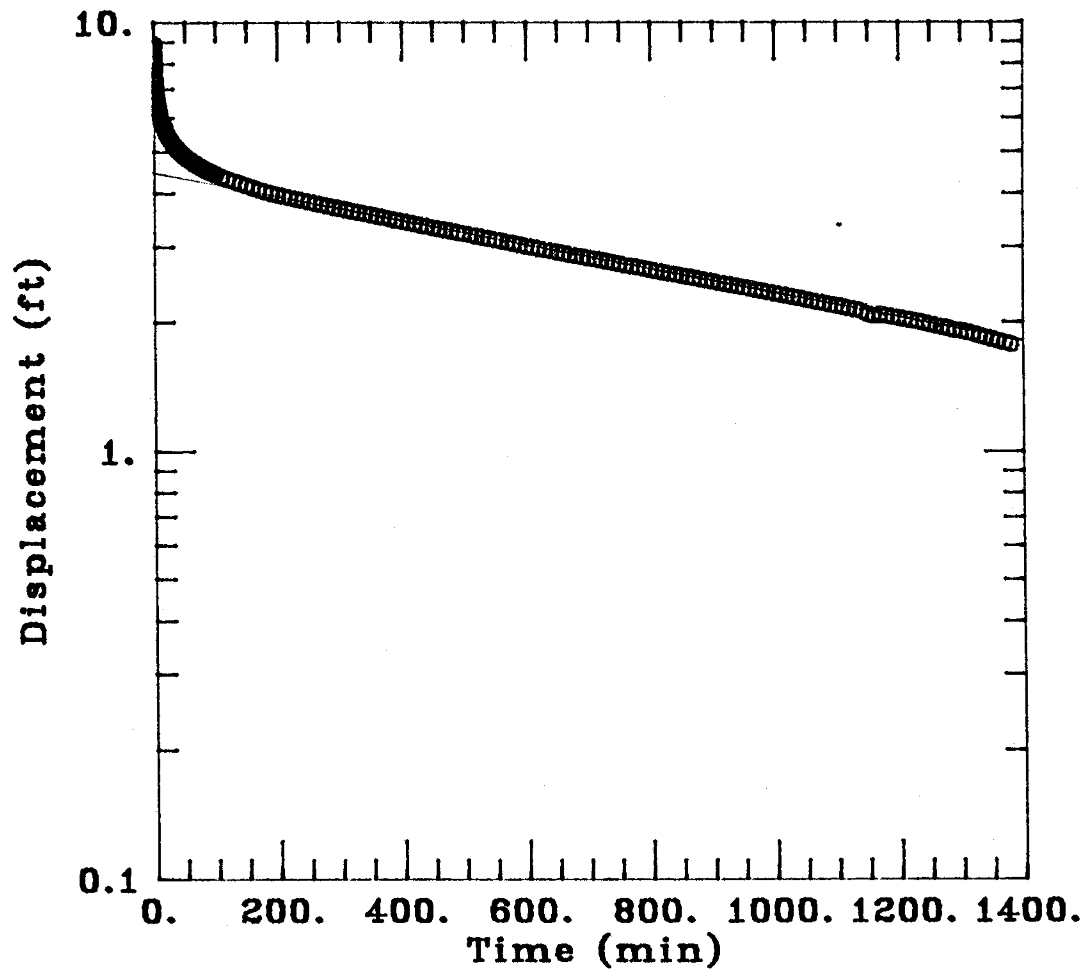
VISUAL MATCH PARAMETER ESTIMATES

	Estimate
K =	2.6804E-006
y0 =	4.4926E+000

<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<>>

	Client: EG&G ROCKY FLATS
Project No.: OPERABLE UNIT 1	Location: 881 HILLSIDE

BAIL DOWN RECOVERY TEST 38991 – PZ03



DATA SET:
PZ03BDR.DAT
06/05/92

AQUIFER TYPE:
Unconfined

SOLUTION METHOD:
Bouwer-Rice

TEST DATE:
12/16/91

ESTIMATED PARAMETERS:
K = 2.6804E-06 ft/min
y0 = 4.493 ft

TEST DATA:

rc = 0.1755 ft
rw = 0.292 ft
L = 8.8 ft
b = 10. ft
H = 8.8 ft

INDEX OF BOREHOLE AND SINGLE WELL TEST DATA AND RESULTS

Borehole, well, or piezometer number: **39191 (MW28)**
(Work plan designation)

Data Available:

✔ Packer Test – Set-up

✔ Packer Test – Data Sheet (Flow vs. Time Data)

✔ Packer Test – Data Logger Output (Head vs. Time Data)

✔ Packer Test – Analysis and Results Calculation Sheet

✔ Single Well Test – Record of Initial Water Level Measurement

✔ Single Well Test – 10 Minute Calibration Plot

✔ Single Well Test – Head vs. Time Data Form

✔ Single Well Test – Head vs. Time Response Graph(s)

✔ Single Well Test – Bouwer and Rice Method Analytical Results

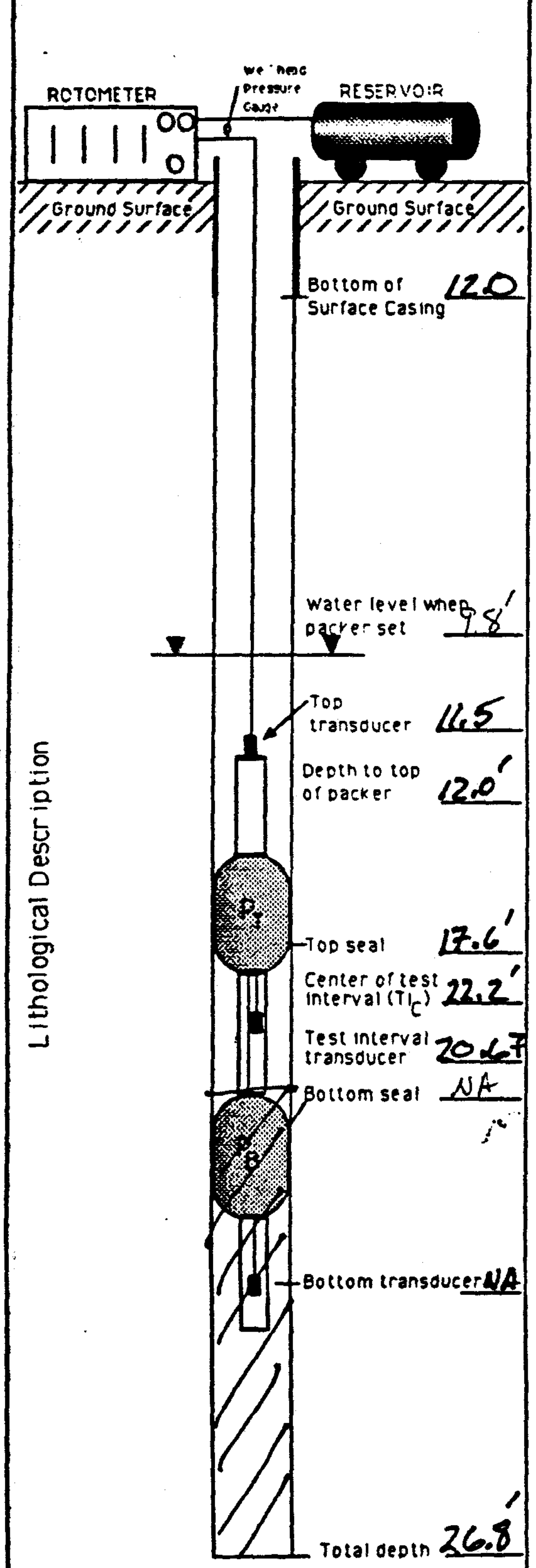
__ Single Well Test – Hvorslev Method Analytical Results

Packer Test Set Up

Project No. OU1
Date ~~3/11/29/91~~ 12/05/91
Borehole No. ~~39291~~ JFU 2/6/92 JFU ~~31991~~ MW28 39191

Packer Serial #'s 3939.1 Top.
NA Bottom

Set Up Diagram



Set Up Data

Type of test(s):

(Constant Head) Constant Flow Pressure Pulse
(Circle)

Geologist(s) & Company(s) J. Uhlinger

Test interval selected 12.0 to TD @ 26.8

Bore Hole Diameter As Drilled 6.5"

Lithology of test interval Claystone

Test interval borehole diameter (from caliper log) Max ~~7.75~~ ~~9.0~~ JFU 8.2 Min 7.0

Center of test interval (TI_C) 22.2

Level of water in Reservoir Full Source RFP

Water volume in borehole before test NA

After Packer Set 9.8'

Description of borehole water NA

Water volume added to borehole 23 gal to fill + test

Max. Excess Head Allowed ($0.07 * TI_C$) 1.6 psi

A) Max. Borehole Diff. Pressure ($0.43(TI_C$ + Max Excess Head)) 9.55 psi

B) Pressure to Stretch Packer Element (see specifications) 75 psi

C) Seating Pressure (0.2*A) 1.9 psi

Packer Inflation Pressure Calculated (A+B+C) 86.5 psi

Used 175 psi, 260 psi psi

Packer string weight

Packer String Joint Strength 3800 lbs

TEST Interval After Inflation 17.6 to 26.8

Stabilized test interval shut-in pressure 2.84 ft of water

Data Logger files used in tests:

MW28_1A.TST
MW28_1A.DAT

Comments: Seal @ 260 PSI in 7" diameter section Not below water table. Also 2 most sensitive flow meters could not be purged of ~~water~~ air JFU 12/5/91 bubbles.

PACKER TEST DATA SHEET

①

BOREHOLE NO. 39191 (MW28)
PROJECT NO. OU1
DATE 12/5
GEOLOGIST(S) J. Uhlinger
K. Maley

TEMPERATURE(START/FINISH):
AQUIFER 8.9°C / Thermometer malfunction
RESERVOIR / Thermometer malfunction (F)
AIR (NA) ≈ 55-60° F
BAROMETRIC PRESSURE(START/FINISH) (mmHg)

TEST:
TYPE Constant Head
INTERVAL 12.6-26.8 (ft)
DEPTH (ft)
DIAMETER ~~7.0-7.9"~~ 7.0-8.2" JFU 4/20/92
START 12:39 PM
FINISH 13:45 PM

MAXIMUM ALLOWABLE EXCESS HEAD: (0.07 PSI/ft depth) 1.6 PSI above Test Interval Center
STABILIZED SHUT IN PRESSURE 2.8 PSI (PSI)
PACKER INFLATION PRESSURE 260 (PSI)
TRANSDUCER ID(s)/LOCATION:
INPUT 1 1944DE / ABOVE PACKER
INPUT 2 1905DE / Interval
INPUT 3 NOT USED
TRANSDUCER DATA FILES MW28-1A.TST
MW28-1A.DAT

TIME (min)		FLOW METER SERIAL NO.	FLOW METER READING	EQUIVALENT FLOW(GPM)	TRANSDUCER READING (ft) INPUT 1	INPUT 2	INPUT 3 (Not used)	WELLHEAD GAUGE PRESSURE (PSI)	RESEVOIR PRESSURE(PSI)	COMMENTS
12:40	1	50314	~~50314~~ 3	1.15x10⁻²	See XD RECORDS	Print OUT		1 PSI	50 PSI	Apparent Packer seal, Attained
12:41	2	↓	3	↓				↓	↓	
12:42	3		3							
12:43	4		3							
12:44	5		3							
12:45	6		MISSED							
12:46	7		3	1.15x10⁻²						
12:47	8		2.8	1.06x10⁻²						
12:48	9		2.8	↓						
12:49	10		2.8							
12:50	11		2.8							
12:52	13		3	1.15x10⁻²						
12:54	15		3	↓						
12:56	17		2.8	1.06x10⁻²						
12:58	19		2.8	↓						
13:00	21		3	1.15x10⁻²						
(See Next PAGE)										

COMMENTS

(2)

See Previous Page

PACKER TEST DATA SHEET

BOREHOLE NO. ____
PROJECT NO. ____
DATE ____
GEOLOGIST(S) ____

TEMPERATURE(START/FINISH):
AQUIFER ____ (°F)
RESERVOIR ____ (°F)
AIR ____ (°F)
BAROMETRIC PRESSURE(START/FINISH) ____ (mmHg)

TEST:
TYPE ____ (ft)
INTERVAL ____ (ft)
DEPTH ____ (ft)
DIAMETER ____
START ____
FINISH ____

MAXIMUM ALLOWABLE EXCESS HEAD:
(0.07 PSI/ft depth) ____ (PSI)
STAVILIZED SHUT IN PRESSURE ____ (PSI)
PACKER INFLATION PRESSURE ____
TRANSDUCER ID(s)/LOCATION:
INPUT 1 ____
INPUT 2 ____
INPUT 3 ____
TRANSDUCER DATA FILES ____

TIME	FLOW METER SERIAL NO.	FLOW METER READING	EQUIVALENT FLOW(GPM)	TRANSDUCER READING (ft) INPUT 1	INPUT 2	INPUT 3	WELLHEAD GAUGE PRESSURE (PSI)	RESEVOIR PRESSURE(PSI)	COMMENTS
13:04 25	50314	3	1.15×10^{-2}				1 PSI	↓	
13:08 29	↓	missed					↓		
13:12 33		3	1.15×10^{-2}						
13:16 37		3	↓						
13:20 41		4	1.54×10^{-2}						
13:25 45		2.8	1.06×10^{-2}						
13:30 50		2.0	6.4×10^{-3}						
13:35 55		2.3	8.24×10^{-3}						
13:40 60		1.8	6.29×10^{-3}						

TEST TERMINATED - FLOW TOO LOW to READ GAGE - more sensATIVE Flow METERS NOT ACCURATE - COULD NOT BE PURGED of AIR DURING TEST

COMMENTS ____

SE2000
Environmental Logger
12/05 16:37

Unit# 00000000 Test 0

Setups:	INPUT 1	INPUT 2
Type	Level (F)	Level (F)
Mode	Surface	Surface
I.D.	1944DE	1905DE
Reference	0.000	0.000
SG	1.000	1.000
Linearity	0.000	0.000
Scale factor	100.000	30.000
Offset	0.000	0.000
Delay mSEC	50.000	50.000

Step 0 12/05 12:39:46

Elapsed Time	INPUT 1	INPUT 2
0.0000	2.874	24.941
1.0000	2.874	24.894
2.0000	2.874	24.894
3.0000	2.906	24.884
4.0000	2.906	24.894
5.0000	2.874	24.913
6.0000	2.906	24.903
7.0000	2.906	24.932
8.0000	2.906	25.027
9.0000	2.906	24.951
10.0000	2.906	24.932
11.0000	2.906	24.884
12.0000	2.906	24.818
13.0000	2.906	24.676
14.0000	2.906	24.534
15.0000	2.906	24.486
16.0000	2.906	24.553
17.0000	2.874	24.581
18.0000	2.906	24.610
19.0000	2.906	24.638
20.0000	2.874	24.809
21.0000	2.906	24.828
22.0000	2.874	24.913
23.0000	2.906	24.875
24.0000	2.906	24.866
25.0000	2.906	24.828
26.0000	2.906	24.818
27.0000	2.906	24.828
28.0000	2.906	24.903
29.0000	2.906	24.676
30.0000	2.906	24.543
31.0000	2.937	24.562
32.0000	2.937	23.946
33.0000	2.937	23.643
34.0000	2.906	23.766
35.0000	2.937	23.842
36.0000	2.937	23.927
37.0000	2.937	24.070
38.0000	2.937	24.306
39.0000	2.937	24.060
40.0000	2.937	23.975
41.0000	2.969	24.183
42.0000	2.969	24.411
43.0000	2.969	24.610
44.0000	2.969	24.799
45.0000	3.000	24.941
46.0000	2.969	24.941
47.0000	2.969	24.894
48.0000	2.969	24.847
49.0000	2.969	24.856
50.0000	2.969	24.922
51.0000	2.937	24.941
52.0000	2.937	24.922
53.0000	2.937	24.903
54.0000	2.937	24.941
55.0000	2.937	24.998
56.0000	2.937	24.979
57.0000	2.937	24.922
58.0000	2.937	24.951
59.0000	2.969	24.989
60.0000	2.969	24.960
61.0000	2.969	24.847
62.0000	2.969	24.856
63.0000	2.937	25.017
64.0000	2.969	25.102
65.0000	2.937	24.648
66.0000	2.937	24.155

END

Borehole Packer Test

Date of Test:	12/05/91	Project:	OU1 PHASE III RI
Borehole:	39191	Client:	EG&G ROCKY FLATS
Test Interval:	17.60 - 26.80 ft	Loction:	881 Hillside
Water Level:	Dry	Test Type:	Constant Head Injection

Field Permeability:
(after U.S. Department of the Interior, 1974)

$$k = \frac{Q}{2\,pi\,(L)\,(H)} \ln (L/r)$$

pi = constant	3.14	unitless
L = length of test interval:	9.2	feet
r = radius of borehole:	0.323	feet
H = head applied in test interval:	24.686	feet of water
Q = injection rate:	0.0014	cubic feet/min

k = 3.3E-06 ft/min x 0.508 cm-min/sec-ft

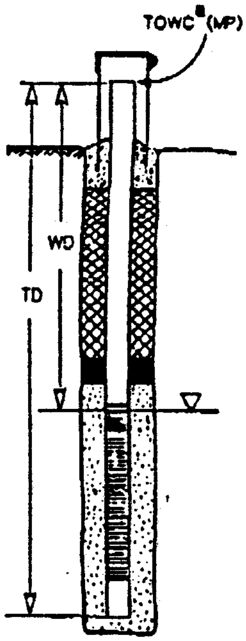
k = 1.7E-06 cm/sec

U.S. DEPARTMENT OF ENERGY ROCKY FLATS PLANT FORM GW.1A

GROUNDWATER LEVELS
MEASUREMENTS/CALCULATIONS

ROCKY FLATS PROJECT Revision 1.2
Project No. OU1
Date 12/21/91
Personnel 1. J. Uhlinger
2. J. Coen

EQUIPMENT:	Manufacturer Solinst	Model	Serial No. 10373	
CALIBRATION:	Date Passed		Date Due	
QC REVIEW:	Name		Date	



Well No. 39191	WD[b]	MTD[c] (JFU 12/21/91)	Comments
Measurement 1	37.56	~~46.50~~ 48.7	JC
Measurement 2	37.56	~~46.50~~ 48.7	JFU
Measurement 3	37.56	~~46.50~~ 48.7	JC
	Average WD	Average MTD	+ Probe End[d] = TD[e] Chk'd by

Well No.	WD[b]	MTD[c]	Comments
Measurement 1			
Measurement 2			
Measurement 3			
	Average WD	Average MTD	+ Probe End[d] = TD[e] Chk'd by

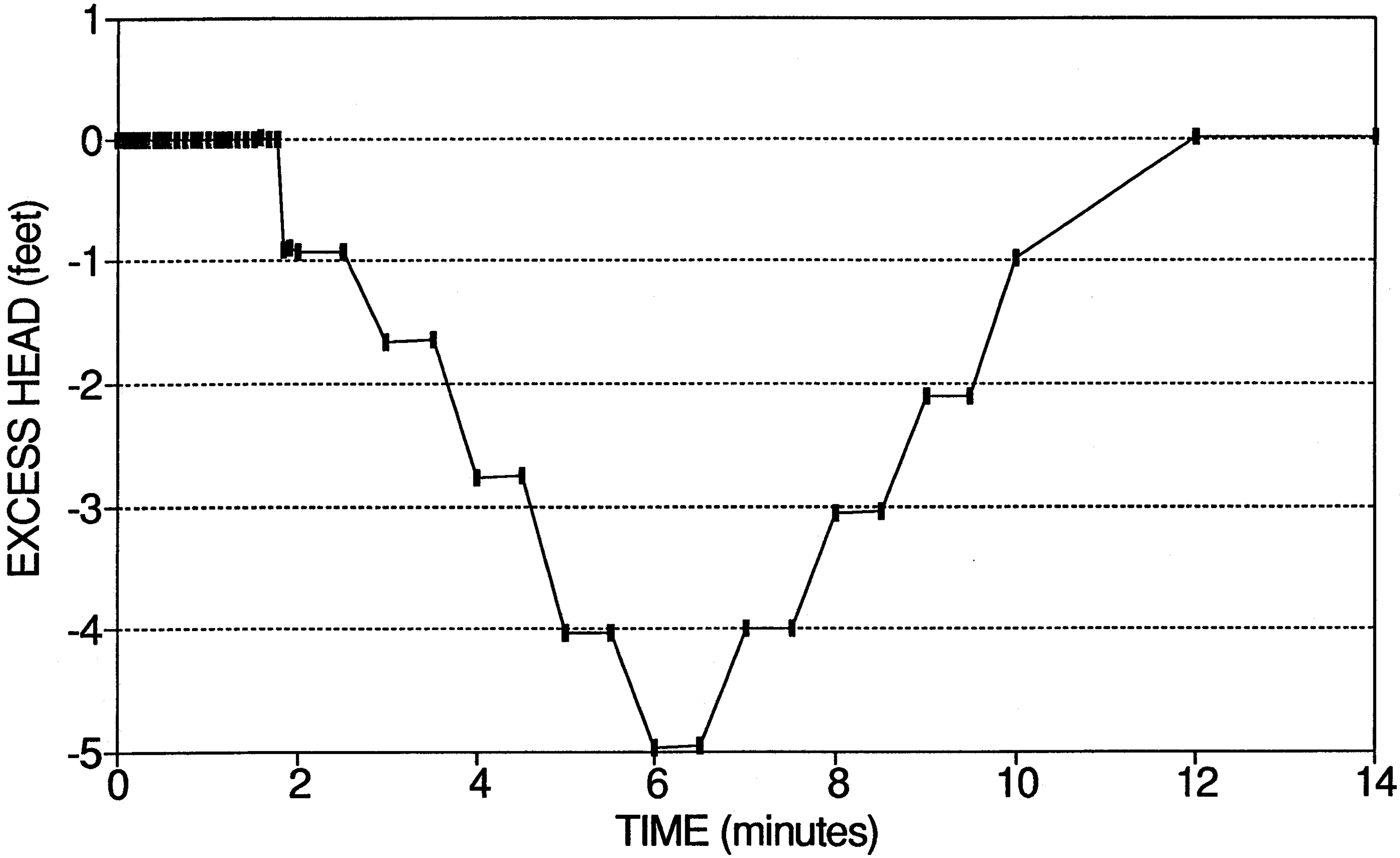
Well No.	WD[b]	MTD[c]	Comments
Measurement 1			
Measurement 2			
Measurement 3			
	Average WD	Average MTD	+ Probe End[d] = TD[e] Chk'd by

Footnotes:
A = TOWC = top of well casing
b = WD = depth to water from MP
c = MTD = measured total depth from MP
d = Probe End = length beyond measuring point on probe
e = TD = total depth of well from MP

Notes:
- All measurements are relative to Mark Point (MP) = north side of TOWC
- QC review by supervisor is a check of reasonableness
- Measurements 1 and 2 must be within .01 ft of a 3rd measurement must be taken

TEN MINUTE CALIBRATION TEST

39191 - MW28



BAIL DOWN/RECOVERY TEST ~~SLUG TEST~~ DATA FORM

Location OU1
Borehole No. MW28 39191
Test Date 12/21/91
Measuring Point Top PVC
Type of Test BAIL DOWN/RECOVERY
Transductor Probe Serial No. 265825
Datalogger Test Run No.
(include time and date for identification purposes) MW28-1a.TST MW28-1b.TST

Name J. Uhlinger
Groundwater Elevation Before Test 37.56 from MP
Total Casing Depth 46.50 Below GS, 48.70 from MP
Borehole Diameter 7"
Casing Diameter 2.07"
Screened Interval 45.0-35.0
Sand Pack Interval 32.2 - 47.2
Lithology Tested Silty/Sandy Claystone

Actual Time	Elapsed Time	Depth to Water from Top of Casing (ft)	H Excess Head (ft)	H/HO

SEE XD Recorder

BAIL DOWN/RECOVERY TEST DATA FORM 39191 - MW28

FILE: MW28_1B.WQ2
TEST DATE: 12/21/91
START TIME: 09:11:10 AM

REFERENCE: 37.35 FT

ELAPSED TIME (min)	DEPTH TO H20 FROM TOC (ft)	EXCESS HEAD (ft)
0	44.954	-7.604
0.0083	44.954	-7.604
0.0166	44.951	-7.601
0.025	44.951	-7.601
0.0333	44.951	-7.601
0.0416	44.951	-7.601
0.05	44.951	-7.601
0.0583	44.951	-7.601
0.0666	44.957	-7.607
0.075	44.954	-7.604
0.0833	44.954	-7.604
0.1	44.954	-7.604
0.1166	44.942	-7.592
0.1333	44.961	-7.611
0.15	44.961	-7.611
0.1666	44.961	-7.611
0.1833	44.961	-7.611
0.2	44.957	-7.607
0.2166	44.957	-7.607
0.2333	44.954	-7.604
0.25	44.954	-7.604
0.2666	44.954	-7.604
0.2833	44.951	-7.601
0.3	44.951	-7.601
0.3166	44.948	-7.598
0.3333	44.948	-7.598
0.4166	44.942	-7.592
0.5	44.938	-7.588
0.5833	44.932	-7.582
0.6666	44.926	-7.576
0.75	44.922	-7.572
0.8333	44.916	-7.566
0.9166	44.913	-7.563
1	44.910	-7.560
1.0833	44.903	-7.553
1.1666	44.900	-7.550
1.25	44.894	-7.544
1.3333	44.891	-7.541
1.4166	44.884	-7.534
1.5	44.881	-7.531
1.5833	44.875	-7.525
1.6666	44.872	-7.522
1.75	44.869	-7.519
1.8333	44.862	-7.512
1.9166	44.856	-7.506

BAIL DOWN/RECOVERY TEST DATA FORM 39191 - MW28

ELAPSED TIME (min)	DEPTH TO H20 FROM TOC (ft)	EXCESS HEAD (ft)
2	44.853	-7.503
2.5	44.821	-7.471
3	44.789	-7.439
3.5	44.761	-7.411
4	44.729	-7.379
4.5	44.700	-7.350
5	44.669	-7.319
5.5	44.637	-7.287
6	44.608	-7.258
6.5	44.577	-7.227
7	44.542	-7.192
7.5	44.507	-7.157
8	44.475	-7.125
8.5	44.440	-7.090
9	44.412	-7.062
9.5	44.367	-7.017
10	44.300	-6.950
12	44.126	-6.776
14	43.951	-6.601
16	43.821	-6.471
18	43.720	-6.370
20	43.634	-6.284
22	43.542	-6.192
24	43.450	-6.100
26	43.367	-6.017
28	43.256	-5.906
30	43.155	-5.805
32	43.053	-5.703
34	42.955	-5.605
36	42.891	-5.541
38	42.853	-5.503
40	42.815	-5.465
42	42.685	-5.335
44	42.564	-5.214
46	42.444	-5.094
48	42.326	-4.976
50	42.212	-4.862
52	42.101	-4.751
54	41.993	-4.643
56	41.892	-4.542
58	41.787	-4.437
60	41.688	-4.338
62	41.593	-4.243
64	41.501	-4.151
66	41.409	-4.059

BAIL DOWN/RECOVERY TEST DATA FORM 39191 - MW28

ELAPSED TIME (min)	DEPTH TO H20 FROM TOC (ft)	EXCESS HEAD (ft)
68	41.320	-3.970
70	41.231	-3.881
72	41.149	-3.799
74	41.066	-3.716
76	40.987	-3.637
78	40.911	-3.561
80	40.832	-3.482
82	40.759	-3.409
84	40.689	-3.339
86	40.619	-3.269
88	40.552	-3.202
90	40.486	-3.136
92	40.422	-3.072
94	40.359	-3.009
96	40.298	-2.948
98	40.238	-2.888
100	40.181	-2.831
110	39.914	-2.564
120	39.676	-2.326
130	39.470	-2.120
140	39.283	-1.933
150	39.121	-1.771
160	38.978	-1.628
170	38.854	-1.504
180	38.746	-1.396
190	38.648	-1.298
200	38.562	-1.212
210	38.483	-1.133
220	38.413	-1.063
230	38.349	-0.999
240	38.295	-0.945
250	38.241	-0.891
260	38.197	-0.847
270	38.153	-0.803
280	38.118	-0.768
290	38.083	-0.733
300	38.057	-0.707
310	38.029	-0.679
320	38.003	-0.653
330	37.984	-0.634
340	37.965	-0.615
350	37.949	-0.599
360	37.934	-0.584
370	37.918	-0.568
380	37.905	-0.555

BAIL DOWN/RECOVERY TEST DATA FORM 39191 - MW28

ELAPSED TIME (min)	DEPTH TO H20 FROM TOC (ft)	EXCESS HEAD (ft)
390	37.892	-0.542
400	37.880	-0.530
410	37.867	-0.517
420	37.854	-0.504
430	37.845	-0.495
440	37.835	-0.485
450	37.829	-0.479
460	37.822	-0.472
470	37.816	-0.466
480	37.810	-0.460
490	37.807	-0.457
500	37.800	-0.450
510	37.797	-0.447
520	37.788	-0.438
530	37.781	-0.431
540	37.784	-0.434
550	37.778	-0.428
560	37.778	-0.428
570	37.778	-0.428
580	37.778	-0.428
590	37.778	-0.428
600	37.778	-0.428
610	37.775	-0.425
620	37.769	-0.419
630	37.765	-0.415
640	37.759	-0.409
650	37.756	-0.406
660	37.753	-0.403
670	37.749	-0.399
680	37.746	-0.396
690	37.746	-0.396
700	37.743	-0.393
710	37.743	-0.393
720	37.743	-0.393
730	37.746	-0.396
740	37.746	-0.396
750	37.743	-0.393
760	37.743	-0.393
770	37.740	-0.390
780	37.740	-0.390
790	37.740	-0.390
800	37.737	-0.387
810	37.737	-0.387
820	37.737	-0.387
830	37.734	-0.384

ELAPSED TIME (min)	DEPTH TO H20 FROM TOC (ft)	EXCESS HEAD (ft)
840	37.730	-0.380
850	37.730	-0.380
860	37.730	-0.380
870	37.727	-0.377
880	37.727	-0.377
890	37.724	-0.374
900	37.718	-0.368
910	37.718	-0.368
920	37.715	-0.365
930	37.711	-0.361
940	37.708	-0.358
950	37.705	-0.355
960	37.705	-0.355
970	37.705	-0.355
980	37.705	-0.355
990	37.708	-0.358
1000	37.705	-0.355
1010	37.696	-0.346
1020	37.696	-0.346
1030	37.692	-0.342
1040	37.696	-0.346
1050	37.696	-0.346
1060	37.692	-0.342
1070	37.689	-0.339
1080	37.686	-0.336
1090	37.683	-0.333
1100	37.676	-0.326
1110	37.670	-0.320
1120	37.670	-0.320
1130	37.670	-0.320
1140	37.670	-0.320
1150	37.673	-0.323
1160	37.676	-0.326
1170	37.683	-0.333
1180	37.686	-0.336
1190	37.692	-0.342
1200	37.692	-0.342
1210	37.692	-0.342
1220	37.692	-0.342
1230	37.692	-0.342
1240	37.692	-0.342
1250	37.692	-0.342
1260	37.692	-0.342
1270	37.689	-0.339
1280	37.686	-0.336

BAIL DOWN/RECOVERY TEST DATA FORM 39191 - MW28

ELAPSED TIME (min)	DEPTH TO H20 FROM TOC (ft)	EXCESS HEAD (ft)
1290	37.686	-0.336
1300	37.686	-0.336
1310	37.686	-0.336
1320	37.683	-0.333
1330	37.680	-0.330
1340	37.680	-0.330
1350	37.680	-0.330
1360	37.683	-0.333
1370	37.683	-0.333
1380	37.686	-0.336
1390	37.689	-0.339
1400	37.689	-0.339
1410	37.692	-0.342
1420	37.692	-0.342
1430	37.692	-0.342
1440	37.692	-0.342
1450	37.692	-0.342
1460	37.692	-0.342
1470	37.692	-0.342
1480	37.689	-0.339
1490	37.689	-0.339
1500	37.686	-0.336
1510	37.686	-0.336
1520	37.689	-0.339
1530	37.689	-0.339
1540	37.696	-0.346
1550	37.699	-0.349
1560	37.702	-0.352
1570	37.702	-0.352
1580	37.702	-0.352
1590	37.705	-0.355
1600	37.702	-0.352
1610	37.699	-0.349
1620	37.699	-0.349
1630	37.696	-0.346
1640	37.696	-0.346
1650	37.696	-0.346
1660	37.692	-0.342
1670	37.689	-0.339
1680	37.686	-0.336
1690	37.683	-0.333
1700	37.68	-0.330
1710	37.68	-0.330
1720	37.683	-0.333
1730	37.686	-0.336

BAIL DOWN/RECOVERY TEST DATA FORM 39191 - MW28

ELAPSED TIME (min)	DEPTH TO H20 FROM TOC (ft)	EXCESS HEAD (ft)
1740	37.689	-0.339
1750	37.696	-0.346
1760	37.699	-0.349
1770	37.702	-0.352
1780	37.708	-0.358
1790	37.711	-0.361
1800	37.718	-0.368
1810	37.727	-0.377
1820	37.737	-0.387
1830	37.746	-0.396
1840	37.753	-0.403
1850	37.762	-0.412
1860	37.769	-0.419
1870	37.775	-0.425
1880	37.781	-0.431
1890	37.788	-0.438
1900	37.794	-0.444
1910	37.797	-0.447
1920	37.803	-0.453
1930	37.807	-0.457
1940	37.81	-0.460
1950	37.813	-0.463
1960	37.813	-0.463
1970	37.816	-0.466
1980	37.819	-0.469
1990	37.822	-0.472
2000	37.829	-0.479
2010	37.832	-0.482
2020	37.832	-0.482
2030	37.835	-0.485
2040	37.838	-0.488
2050	37.842	-0.492
2060	37.842	-0.492
2070	37.845	-0.495
2080	37.845	-0.495
2090	37.848	-0.498
2100	37.848	-0.498
2110	37.848	-0.498
2120	37.848	-0.498
2130	37.848	-0.498
2140	37.851	-0.501
2150	37.848	-0.498
2160	37.851	-0.501
2170	37.851	-0.501
2180	37.851	-0.501

BAIL DOWN/RECOVERY TEST DATA FORM 39191 - MW28

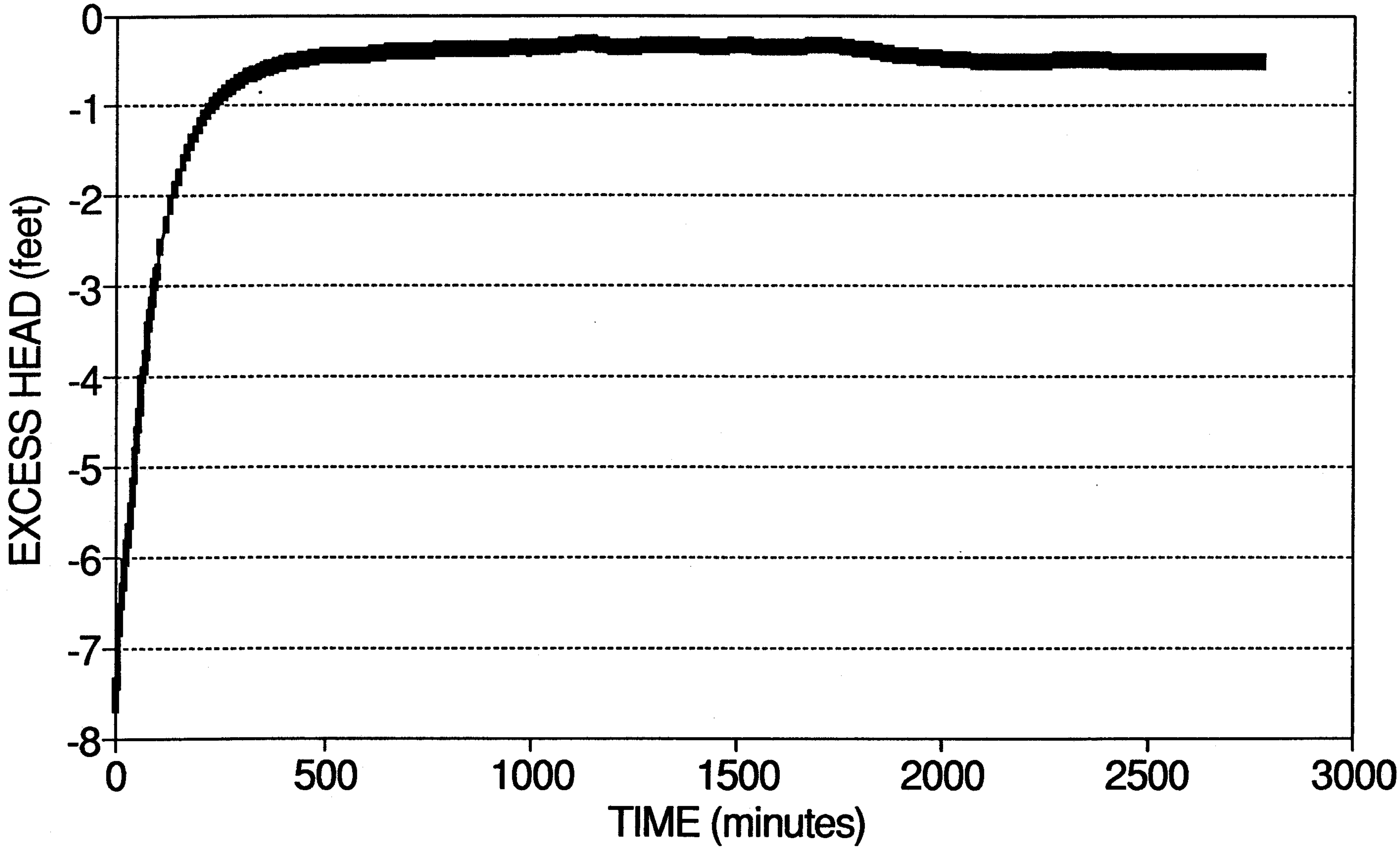
ELAPSED TIME (min)	DEPTH TO H20 FROM TOC (ft)	EXCESS HEAD (ft)
2190	37.851	-0.501
2200	37.848	-0.498
2210	37.848	-0.498
2220	37.848	-0.498
2230	37.848	-0.498
2240	37.848	-0.498
2250	37.845	-0.495
2260	37.845	-0.495
2270	37.842	-0.492
2280	37.842	-0.492
2290	37.842	-0.492
2300	37.838	-0.488
2310	37.838	-0.488
2320	37.835	-0.485
2330	37.838	-0.488
2340	37.838	-0.488
2350	37.838	-0.488
2360	37.838	-0.488
2370	37.838	-0.488
2380	37.842	-0.492
2390	37.842	-0.492
2400	37.842	-0.492
2410	37.845	-0.495
2420	37.845	-0.495
2430	37.845	-0.495
2440	37.845	-0.495
2450	37.845	-0.495
2460	37.845	-0.495
2470	37.845	-0.495
2480	37.848	-0.498
2490	37.848	-0.498
2500	37.848	-0.498
2510	37.848	-0.498
2520	37.851	-0.501
2530	37.848	-0.498
2540	37.848	-0.498
2550	37.848	-0.498
2560	37.848	-0.498
2570	37.848	-0.498
2580	37.848	-0.498
2590	37.848	-0.498
2600	37.845	-0.495
2610	37.848	-0.498
2620	37.848	-0.498
2630	37.848	-0.498

BAIL DOWN/RECOVERY TEST DATA FORM 39191 - MW28

ELAPSED TIME (min)	DEPTH TO H20 FROM TOC (ft)	EXCESS HEAD (ft)
2640	37.848	-0.498
2650	37.848	-0.498
2660	37.851	-0.501
2670	37.851	-0.501
2680	37.851	-0.501
2690	37.854	-0.504
2700	37.857	-0.507
2710	37.857	-0.507
2720	37.857	-0.507
2730	37.857	-0.507
2740	37.857	-0.507
2750	37.857	-0.507
2760	37.857	-0.507
2770	37.857	-0.507
2780	37.857	-0.507

BAIL DOWN/RECOVERY TEST

39191 - MW28



A Q T E S O L V   R E S U L T S
Version 1.10

05/08/92 10:10:44

TEST DESCRIPTION

Data set........... mw28bdr.dat
Data set title..... BAIL DOWN RECOVERY TEST 39191 - MW28
Project............ OPERABLE UNIT 1
Client............. EG&G ROCKY FLATS
Location........... 881 HILLSIDE
Test date.......... 12/21/91

Knowns and Constants:
No. of data points.................. 374
Radius of well casing............... 0.1755
Radius of well...................... 0.292
Aquifer saturated thickness......... 9.64
Well screen length.................. 7.2
Static height of water in well...... 7.2
Log(Re/Rw).......................... 2.14
A, B, C...:......................... 2.282, 0.367, 0.000

ANALYTICAL METHOD

Bouwer-Rice (Unconfined Aquifer Slug Test)

RESULTS FROM VISUAL CURVE MATCHING

VISUAL MATCH PARAMETER ESTIMATES

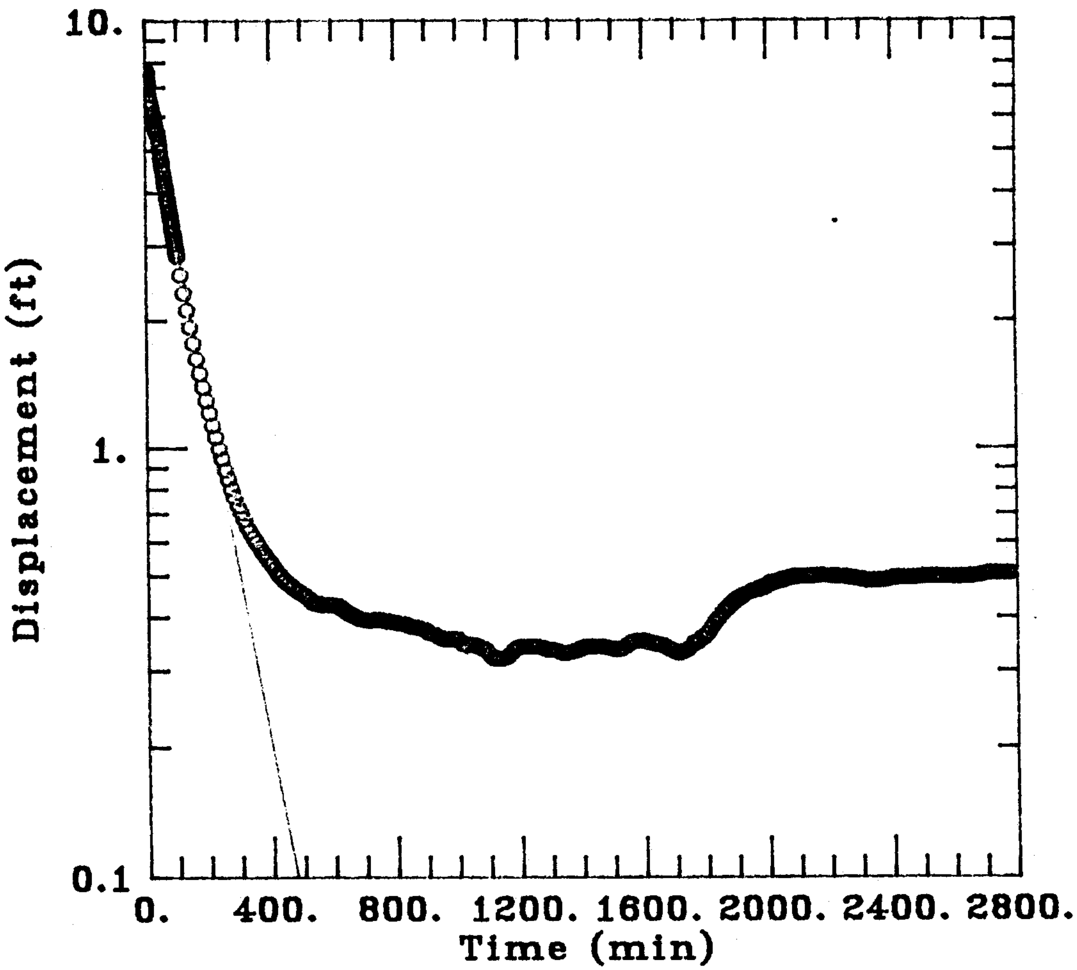
	Estimate
K =	4.1780E-005
y0 =	7.3710E+000

<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<>>>

Client: **EG&G ROCKY FLATS**

Project No.: **OPERABLE UNIT 1** Location: **881 HILLSIDE**

BAIL DOWN RECOVERY TEST 39191 – MW28



DATA SET:
mw28bdr.dat
05/08/92

AQUIFER TYPE:
Unconfined

SOLUTION METHOD:
Bouwer-Rice

TEST DATE:
12/21/91

ESTIMATED PARAMETERS:
K = 4.178E-05 ft/min
y0 = 7.371 ft

TEST DATA:

rc = 0.1755 ft
rw = 0.292 ft
L = 7.2 ft
b = 9.64 ft
H = 7.2 ft

INDEX OF BOREHOLE AND SINGLE WELL TEST DATA AND RESULTS

Borehole, well, or piezometer number: **39291 (PZ01)**
(Work plan designation)

Data Available:

__ Packer Test – Set-up

__ Packer Test – Data Sheet (Flow vs. Time Data)

__ Packer Test – Data Logger Output (Head vs. Time Data)

__ Packer Test – Analysis and Results Calculation Sheet

✔ Single Well Test – Record of Initial Water Level Measurement

✔ Single Well Test – 10 Minute Calibration Plot

✔ Single Well Test – Head vs. Time Data Form

✔ Single Well Test – Head vs. Time Response Graph(s)

✔ Single Well Test – Bouwer and Rice Method Analytical Results

✔ Single Well Test – Hvorslev Method Analytical Results

U.S. DEPARTMENT OF ENERGY ROCKY FLATS PLANT

FORM GW.1A

GROUNDWATER LEVELS MEASUREMENTS/CALCULATIONS

ROCKY FLATS PROJECT Revision 1.2

Project No. EMAD (OU1 881 Hillside)

Date 121591

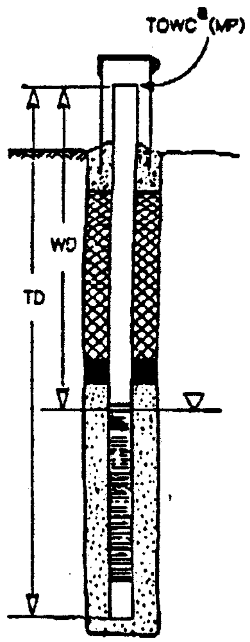
Personnel 1. K. Maley

2. J. Uhlinger

EQUIPMENT: Manufacturer Solinst Model ______ Serial No. None (EDE Solinst)

CALIBRATION: Date Passed ______ Date Due ______

QC REVIEW: Name ______ Date ______



Well No. 39291	WD[b]	MTD[c]	Comments
Measurement 1	32.22	47.75	KM
Measurement 2	32.23	47.75	JFU
Measurement 3	32.22	47.75	KM
	32.22 Average WD	47.75 Average MTD	+ ____ Probe End[d] = ____ TD[e] ____ Chk'd by

Well No.	WD[b]	MTD[c]	Comments
Measurement 1			
Measurement 2			
Measurement 3			
	Average WD	Average MTD	+ ____ Probe End[d] = ____ TD[e] ____ Chk'd by

Well No.	WD[b]	MTD[c]	Comments
Measurement 1			
Measurement 2			
Measurement 3			
	Average WD	Average MTD	+ ____ Probe End[d] = ____ TD[e] ____ Chk'd by

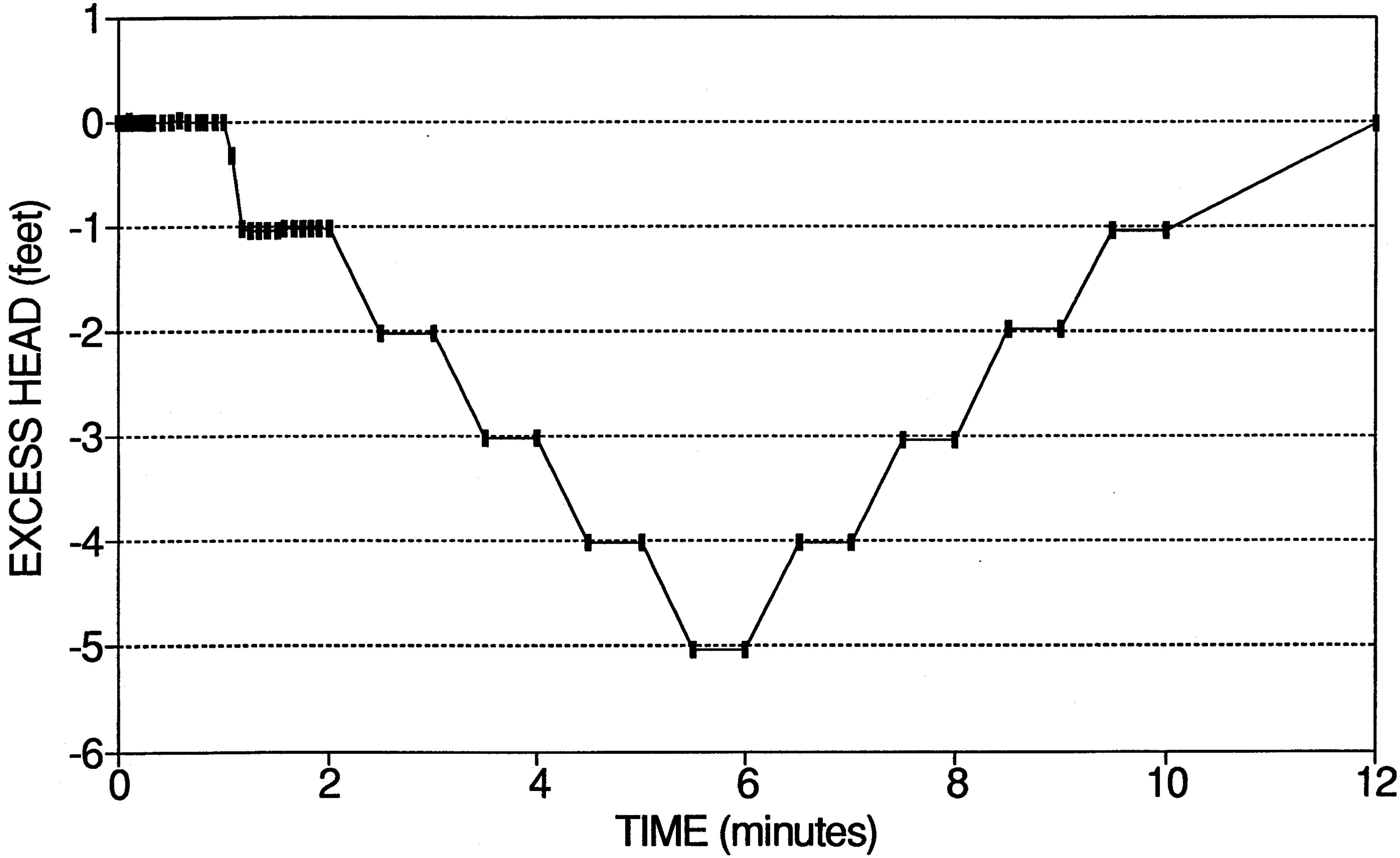
Footnotes:
A = TOWC = top of well casing
b = WD = depth to water from MP
c = MTD = measured total depth from MP
d = Probe End = length beyond measuring point on probe
e = TD = total depth of well from MP

Notes:
- All measurements are relative to Mark Point (MP) = north side of TOWC
- QC review by supervisor is a check of reasonableness
- Measurements 1 and 2 must be within .01 ft of a 3rd measurement must be taken

(4011-600-0022) (GW1-FORM.1A) (09-18-91) (4:18pm)

TEN MINUTE CALIBRATION TEST

39291 - PZ01



SLUG TEST DATA FORM

Location OU1
Borehole No. 39292 PZ01
Test Date 121591
Measuring Point TOC
Type of Test slug + withdrawal
Transductor Probe Serial No. 1759DD
Datalogger Test Run No. 0, 1
(include time and date for Hermit # 180 identification purposes)
PZ01-1a.TST
PZ01-1b.TST
PZ01-1C.TST

Name J. Uhlinger
Groundwater Elevation Before Test 32.10
Total Casing Depth 47.75
Borehole Diameter 7"
Casing Diameter ID 2.07"
Screened Interval 35.8' - 45.8'
Sand Pack Interval 45.8 - 33.5
Lithology Tested clayey silt

Actual Time	Elapsed Time	Depth-to Water from Top of Casing (ft)	H Excess Head (ft)	H/HO

SEE DATA PRINTOUT

SLUG INJECTION TEST DATA FORM 39291 - PZ01

FILE: PZ01_1B.WQ2
TEST DATE: 12/15/91
START TIME: 09:18:19 AM

H0: 1.479 FT
REFERENCE: 32.10 FT

ELAPSED TIME (min)	DEPTH TO H20 FROM TOC (ft)	EXCESS HEAD (ft)	H/H0
0	30.147	1.953	1.32
0.0083	30.305	1.795	1.21
0.0166	30.39	1.71	1.16
0.025	29.694	2.406	1.63
0.0333	30.878	1.222	0.83
0.0416	30.542	1.558	1.05
0.05	30.169	1.931	1.31
0.0583	30.194	1.906	1.29
0.0666	30.39	1.71	1.16
0.075	30.447	1.653	1.12
0.0833	30.365	1.735	1.17
0.1	30.343	1.757	1.19
0.1166	30.397	1.703	1.15
0.1333	30.374	1.726	1.17
0.15	30.4	1.7	1.15
0.1666	30.4	1.7	1.15
0.1833	30.409	1.691	1.14
0.2	30.416	1.684	1.14
0.2166	30.422	1.678	1.13
0.2333	30.435	1.665	1.13
0.25	30.438	1.662	1.12
0.2666	30.447	1.653	1.12
0.2833	30.454	1.646	1.11
0.3	30.507	1.593	1.08
0.3166	30.441	1.659	1.12
0.3333	30.463	1.637	1.11
0.4166	30.482	1.618	1.09
0.5	30.53	1.57	1.06
0.5833	30.549	1.551	1.05
0.6666	30.539	1.561	1.06
0.75	30.587	1.513	1.02
0.8333	30.602	1.498	1.01
0.9166	30.621	1.479	1.00
1	30.637	1.463	0.99
1.0833	30.653	1.447	0.98
1.1666	30.666	1.434	0.97
1.25	30.678	1.422	0.96
1.3333	30.694	1.406	0.95
1.4166	30.704	1.396	0.94
1.5	30.719	1.381	0.93
1.5833	30.732	1.368	0.92
1.6666	30.742	1.358	0.92
1.75	30.754	1.346	0.91
1.8333	30.761	1.339	0.91
1.9166	30.77	1.33	0.90

SLUG INJECTION TEST DATA FORM 39291 - PZ01

ELAPSED TIME (min)	DEPTH TO H20 FROM TOC (ft)	EXCESS HEAD (ft)	H/H0
2	30.776	1.324	0.90
2.5	30.843	1.257	0.85
3	30.887	1.213	0.82
3.5	30.932	1.168	0.79
4	30.966	1.134	0.77
4.5	31.017	1.083	0.73
5	31.052	1.048	0.71
5.5	31.083	1.017	0.69
6	31.102	0.998	0.67
6.5	31.134	0.966	0.65
7	31.163	0.937	0.63
7.5	31.194	0.906	0.61
8	31.216	0.884	0.60
8.5	31.239	0.861	0.58
9	31.264	0.836	0.57
9.5	31.283	0.817	0.55
10	31.315	0.785	0.53
12	31.359	0.741	0.50
14	31.438	0.662	0.45
16	31.479	0.621	0.42
18	31.539	0.561	0.38
20	31.574	0.526	0.36
22	31.618	0.482	0.33
24	31.653	0.447	0.30
26	31.685	0.415	0.28
28	31.71	0.39	0.26
30	31.758	0.342	0.23
32	31.77	0.33	0.22
34	31.789	0.311	0.21
36	31.824	0.276	0.19
38	31.837	0.263	0.18
40	31.853	0.247	0.17
42	31.878	0.222	0.15
44	31.891	0.209	0.14
46	31.903	0.197	0.13
48	31.929	0.171	0.12
50	31.944	0.156	0.11

SLUG WITHDRAWAL TEST DATA FORM 39291 - PZ01

FILE: PZ01_1C.WQ2
TEST DATE: 12/15/91
START TIME: 10:09:13 AM

H0: -1.303 FT
REFERENCE: 32.10 FT

ELAPSED TIME (min)	DEPTH TO H20 FROM TOC (ft)	EXCES HEAD (ft)	H/H0
0	33.758	-1.658	1.27
0.0083	33.748	-1.648	1.26
0.0166	33.758	-1.658	1.27
0.025	33.755	-1.655	1.27
0.0333	33.745	-1.645	1.26
0.0416	33.748	-1.648	1.26
0.05	33.745	-1.645	1.26
0.0583	33.723	-1.623	1.25
0.0666	33.73	-1.63	1.25
0.075	33.72	-1.62	1.24
0.0833	33.726	-1.626	1.25
0.1	33.714	-1.614	1.24
0.1166	33.698	-1.598	1.23
0.1333	33.695	-1.595	1.22
0.15	33.692	-1.592	1.22
0.1666	33.679	-1.579	1.21
0.1833	33.679	-1.579	1.21
0.2	33.673	-1.573	1.21
0.2166	33.657	-1.557	1.19
0.2333	33.65	-1.55	1.19
0.25	33.647	-1.547	1.19
0.2666	33.647	-1.547	1.19
0.2833	33.657	-1.557	1.19
0.3	33.688	-1.588	1.22
0.3166	33.676	-1.576	1.21
0.3333	33.609	-1.509	1.16
0.4166	33.568	-1.468	1.13
0.5	33.565	-1.465	1.12
0.5833	33.527	-1.427	1.10
0.6666	33.783	-1.683	1.29
0.75	33.489	-1.389	1.07
0.8333	33.479	-1.379	1.06
0.9166	33.464	-1.364	1.05
1	33.454	-1.354	1.04
1.0833	33.47	-1.37	1.05
1.1666	33.448	-1.348	1.03
1.25	33.419	-1.319	1.01
1.3333	33.407	-1.307	1.00
1.4166	33.394	-1.294	0.99
1.5	33.385	-1.285	0.99
1.5833	33.378	-1.278	0.98
1.6666	33.369	-1.269	0.97
1.75	33.359	-1.259	0.97
1.8333	33.35	-1.25	0.96
1.9166	33.343	-1.243	0.95

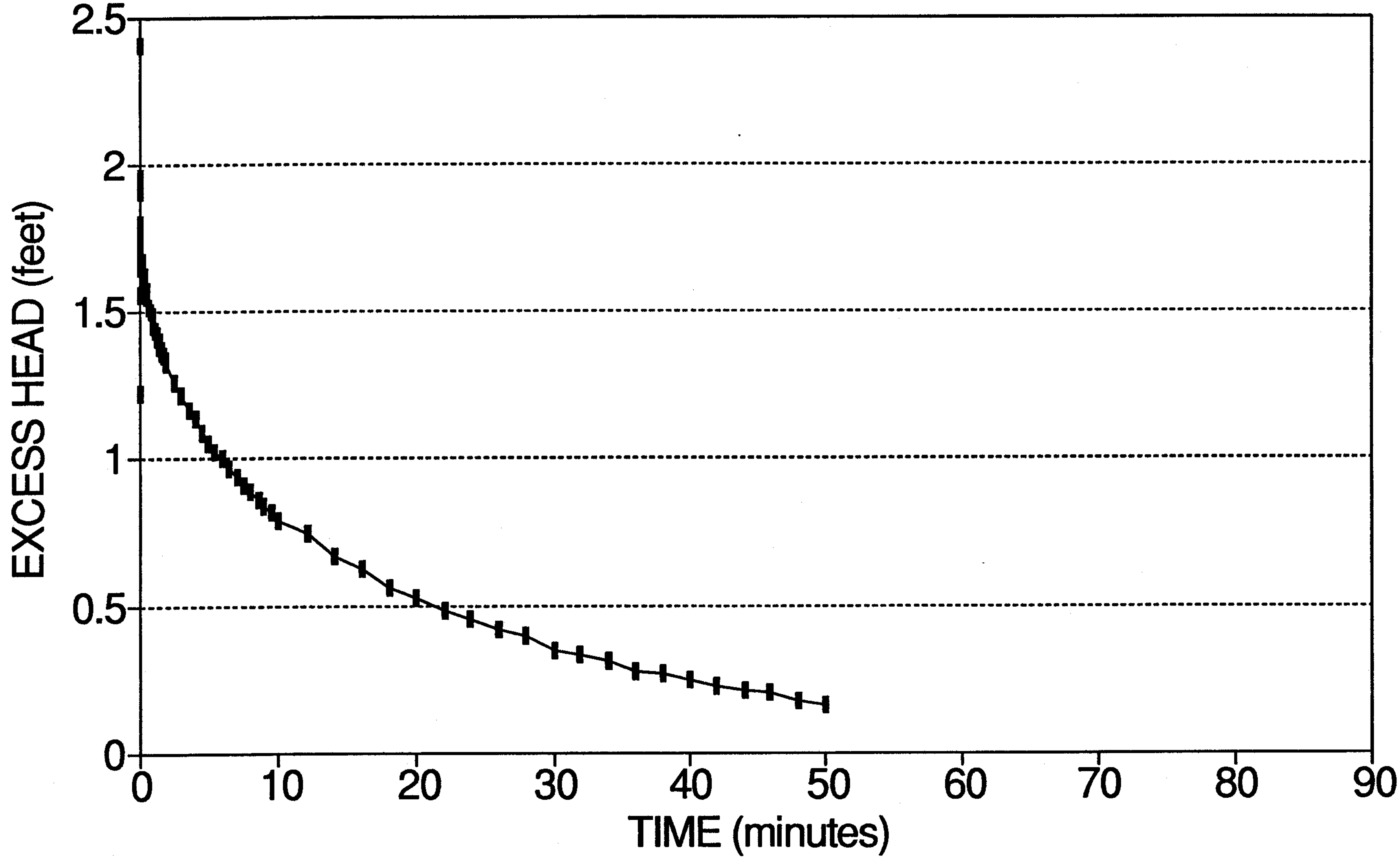
SLUG WITHDRAWAL TEST DATA FORM 39291 - PZ01

ELAPSED TIME (min)	DEPTH TO H20 FROM TOC (ft)	EXCES HEAD (ft)	H/H0
2	33.334	-1.234	0.95
2.5	33.267	-1.167	0.90
3	33.226	-1.126	0.86
3.5	33.188	-1.088	0.83
4	33.157	-1.057	0.81
4.5	33.125	-1.025	0.79
5	33.097	-0.997	0.77
5.5	33.068	-0.968	0.74
6	33.04	-0.94	0.72
6.5	33.014	-0.914	0.70
7	32.998	-0.898	0.69
7.5	32.954	-0.854	0.66
8	32.935	-0.835	0.64
8.5	32.913	-0.813	0.62
9	32.891	-0.791	0.61
9.5	32.872	-0.772	0.59
10	32.846	-0.746	0.57
12	32.783	-0.683	0.52
14	32.72	-0.62	0.48
16	32.663	-0.563	0.43
18	32.612	-0.512	0.39
20	32.568	-0.468	0.36
22	32.53	-0.43	0.33
24	32.498	-0.398	0.31
26	32.463	-0.363	0.28
28	32.432	-0.332	0.25
30	32.41	-0.31	0.24
32	32.384	-0.284	0.22
34	32.362	-0.262	0.20
36	32.343	-0.243	0.19
38	32.327	-0.227	0.17
40	32.308	-0.208	0.16
42	32.296	-0.196	0.15
44	32.283	-0.183	0.14
46	32.27	-0.17	0.13
48	32.261	-0.161	0.12
50	32.248	-0.148	0.11
52	32.239	-0.139	0.11
54	32.229	-0.129	0.10
56	32.22	-0.12	0.09
58	32.217	-0.117	0.09
60	32.207	-0.107	0.08
62	32.201	-0.101	0.08
64	32.198	-0.098	0.08
66	32.194	-0.094	0.07

ELAPSED TIME (min)	DEPTH TO H20 FROM TOC (ft)	EXCES HEAD (ft)	H/H0
68	32.188	-0.088	0.07
70	32.185	-0.085	0.07
72	32.179	-0.079	0.06
74	32.175	-0.075	0.06
76	32.175	-0.075	0.06
78	32.172	-0.072	0.06
80	32.169	-0.069	0.05
82	32.163	-0.063	0.05

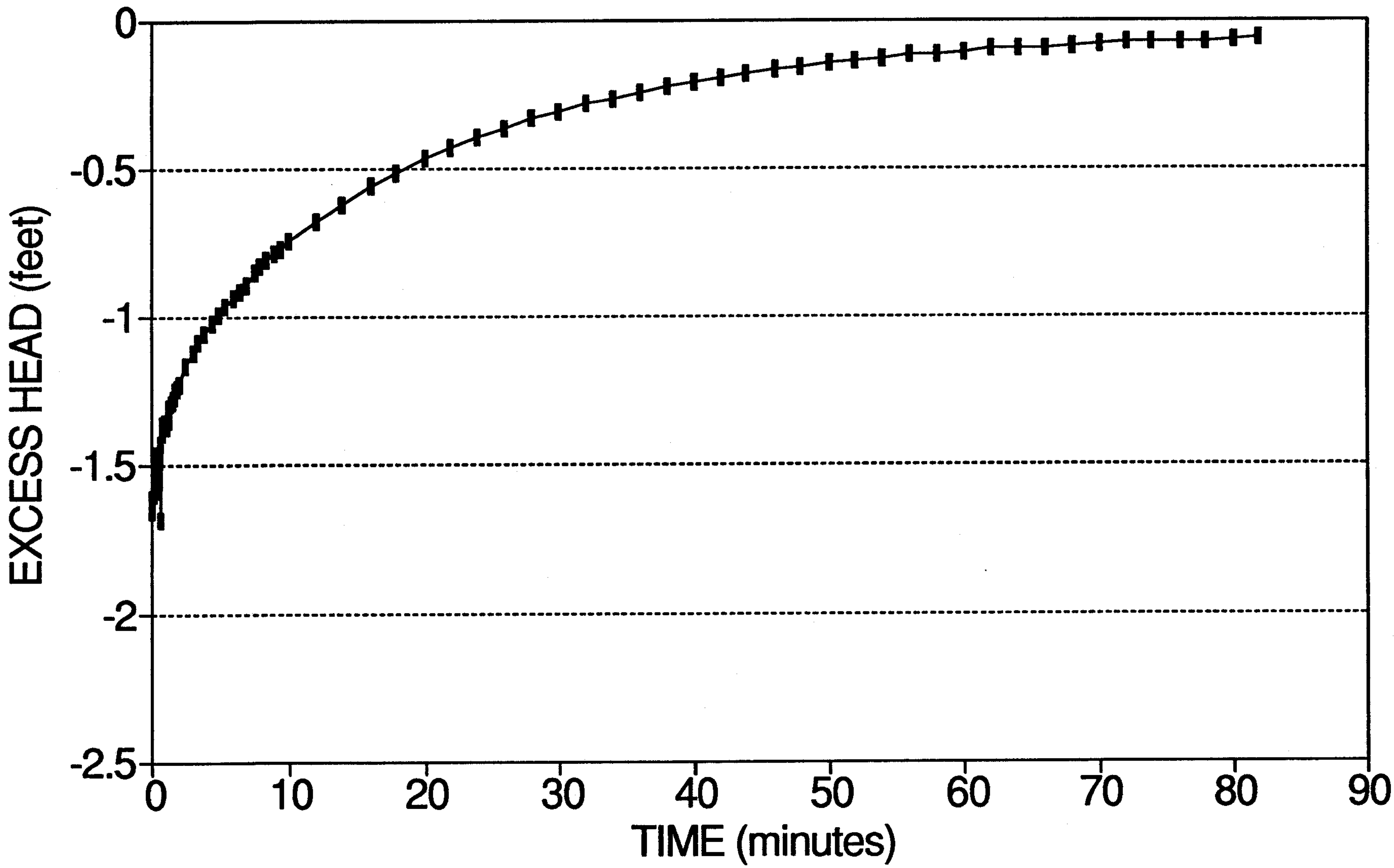
SLUG INJECTION TEST

39291 - PZ01



SLUG WITHDRAWAL TEST

39291 - PZ01



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                     A Q T E S O L V   R E S U L T S
                              Version  1.10

05/08/92                                                            11:35:01

================================================================================
                              TEST DESCRIPTION

Data set........... PZ01INJ.DAT
Data set title..... SLUG INJECTION TEST 39291 - PZ01
Project............ OPERABLE UNIT 1
Client............. EG&G ROCKY FLATS
Location........... 881 HILLSIDE
Test date.......... 12/15/91

Knowns and Constants:
   No. of data points.................. 81
   Radius of well casing............... 0.0863
   Radius of well...................... 0.292
   Aquifer saturated thickness......... 15.4
   Well screen length.................. 9.6
   Static height of water in well...... 13.5
   Log(Re/Rw).......................... 2.581
   A, B, C.............................  2.534,  0.413,  0.000

================================================================================
                              ANALYTICAL METHOD

Bouwer-Rice (Unconfined Aquifer Slug Test)

================================================================================
                     RESULTS FROM VISUAL CURVE MATCHING

VISUAL MATCH PARAMETER ESTIMATES

           Estimate
   K  =   6.6394E-005
   y0 =   1.4950E+000

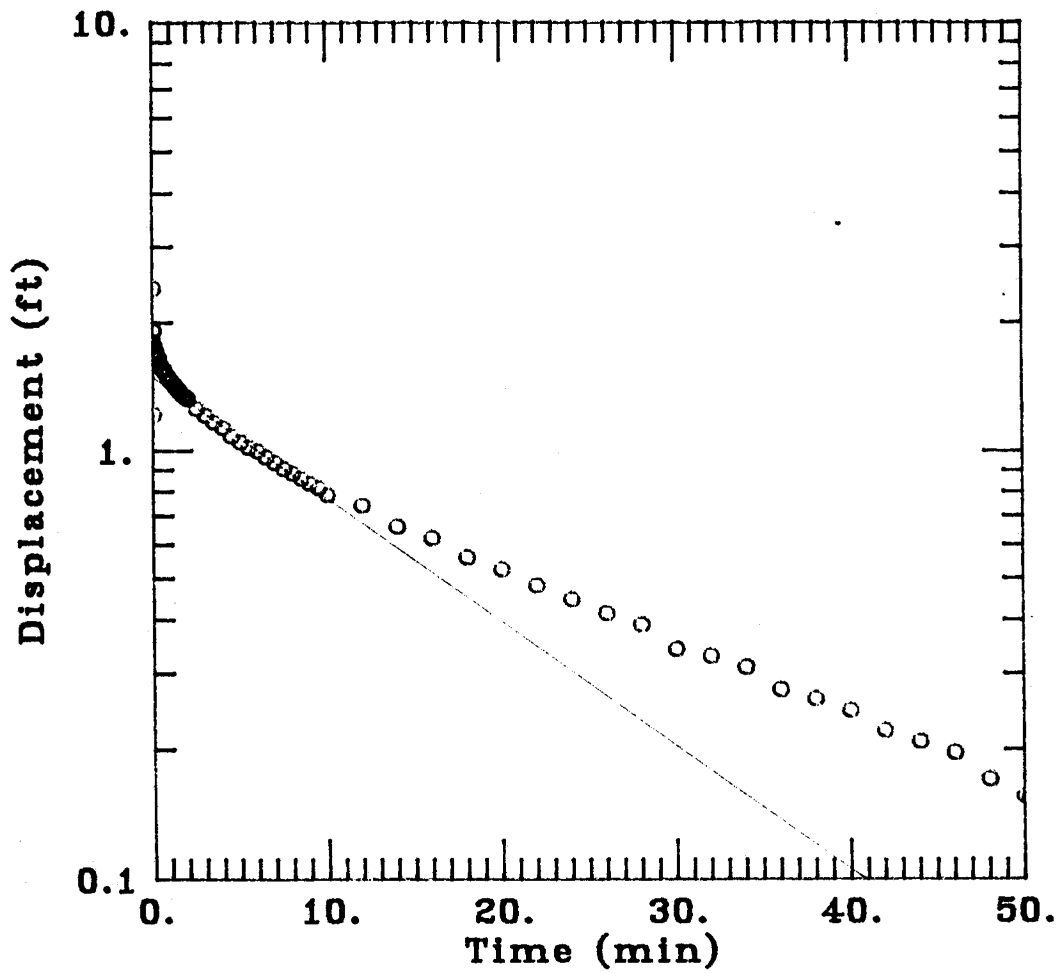
<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>
```

Client: **EG&G ROCKY FLATS**

Project No.: **OPERABLE UNIT 1**

Location: **881 HILLSIDE**

SLUG INJECTION TEST 39291 – PZ01



DATA SET:
PZ01INJ.DAT
05/08/92

AQUIFER TYPE:
Unconfined

SOLUTION METHOD:
Bouwer-Rice

TEST DATE:
12/15/91

ESTIMATED PARAMETERS:
K = 6.6394E-05 ft/min
y0 = 1.495 ft

TEST DATA:

rc = 0.0863 ft
rw = 0.292 ft
L = 9.6 ft
b = 15.4 ft
H = 13.5 ft

A Q T E S O L V   R E S U L T S
Version 1.10

05/08/92 12:35:01

TEST DESCRIPTION

Data set........... PZ01WD.DAT
Data set title..... SLUG WITHDRAWAL TEST 39291 - PZ01
Project............ OPERABLE UNIT 1
Client............. EG&G ROCKY FLATS
Location........... 881 HILLSIDE
Test date.......... 12/15/91

Knowns and Constants:
No. of data points.................. 97
Radius of well casing............... 0.0863
Radius of well...................... 0.292
Aquifer saturated thickness......... 15.4
Well screen length.................. 9.6
Static height of water in well...... 13.5
Log(Re/Rw).......................... 2.581
A, B, C............................. 2.534, 0.413, 0.000

ANALYTICAL METHOD

Bouwer-Rice (Unconfined Aquifer Slug Test)

RESULTS FROM VISUAL CURVE MATCHING

VISUAL MATCH PARAMETER ESTIMATES

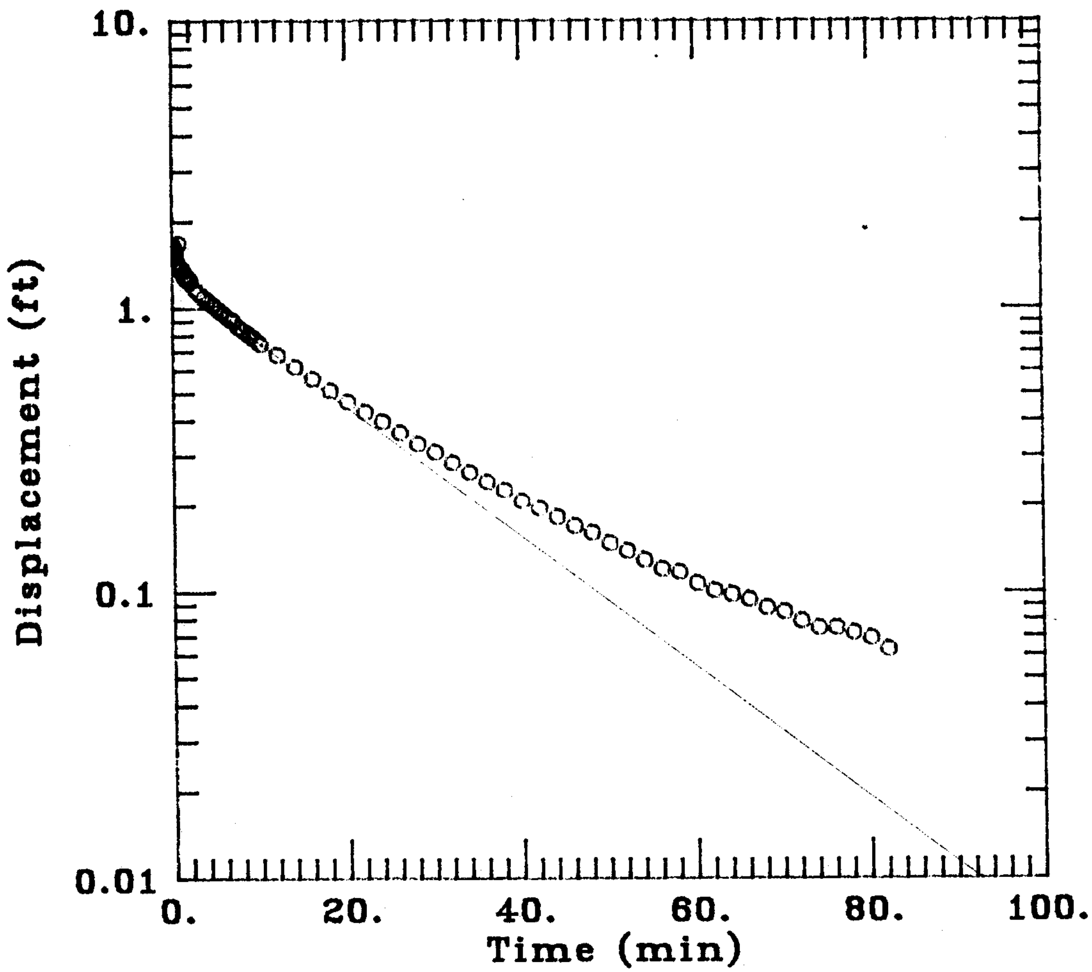
	Estimate
K =	5.2402E-005
y0 =	1.2698E+000

<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<>>

Client: **EG&G ROCKY FLATS**

Project No.: **OPERABLE UNIT 1** | Location: **881 HILLSIDE**

SLUG WITHDRAWAL TEST 39291 – PZ01



DATA SET:
PZ01WD.DAT
05/08/92

AQUIFER TYPE:
Unconfined

SOLUTION METHOD:
Bouwer-Rice

TEST DATE:
12/15/91

ESTIMATED PARAMETERS:
K = 5.2402E-05 ft/min
y0 = 1.27 ft

TEST DATA:

rc = 0.0863 ft
rw = 0.292 ft
L = 9.6 ft
b = 15.4 ft
H = 13.5 ft

Single Well Test Analysis

Date of Test:	12/15/91	Project:	OU1 PHASE III RI
Piezometer	39291	Client:	EG&G ROCKY FLATS
Screen Interval:	34.2-43.8	Location:	881 Hillside
Filter Interval:	31.7-45.95	Type of Test:	Slug Injection
Water Level:	30.25		

Hvorslev Analysis Method:
(after Fetter, 1988)

$$K = \frac{(r \text{ squared})}{2\,(L)\,(To)} \ln (L/R)$$

For L/R>8

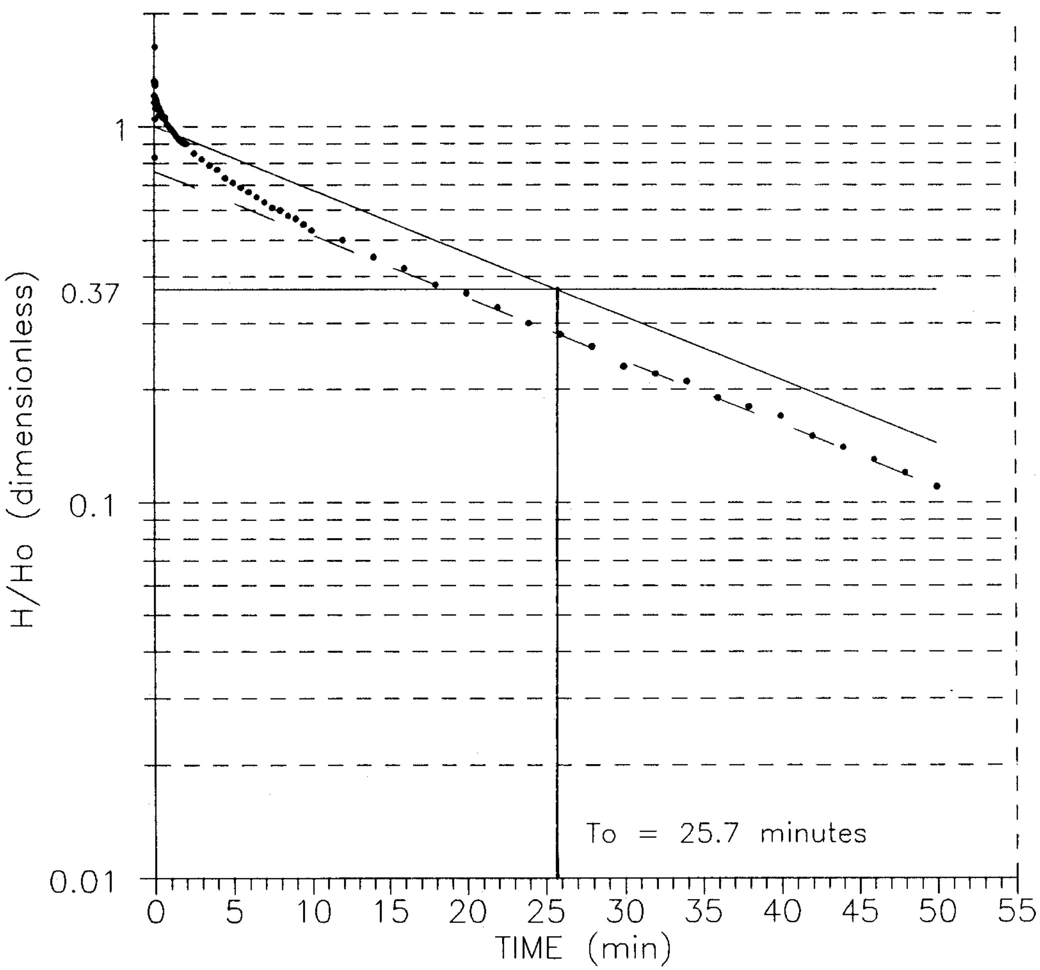
L = length of the well screen:	9.600	feet
r = radius of the well casing:	0.0863	feet
R = radius of the well screen:	0.292	feet
To = time to recover 37%:	25.7	minutes
L/R = validity check	32.88	

K = 5.3E-05 ft/min x 0.508 cm-min/sec-ft

K = 2.7E-05 cm/sec

HVORSLEV ANALYSIS

39291 – PZ01
SLUG INJECTION TEST
To = 25.7 minutes



Single Well Test Analysis

Date of Test:	12/15/91	Project:	OU1 PHASE III RI
Piezometer	39291	Client:	EG&G ROCKY FLATS
Screen Interval:	34.2-43.8	Location:	881 Hillside
Filter Interval:	31.7-45.95	Type of Test:	Slug Withdrawal
Water Level:	30.25		

Hvorslev Analysis Method:
(after Fetter, 1988)

$$K = \frac{(r \text{ squared})}{2\,(L)\,(To)} \ln (L/R)$$

For L/R>8

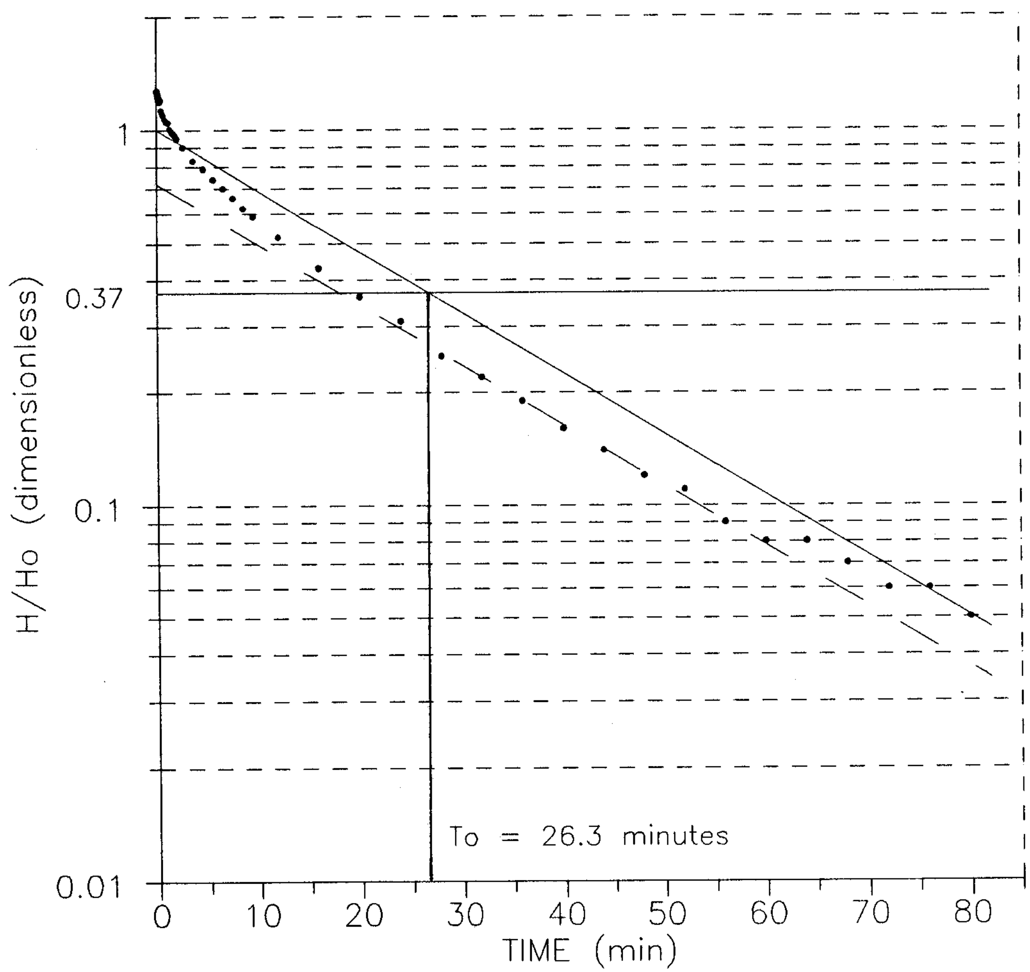
L = length of the well screen:	9.600	feet
r = radius of the well casing:	0.0863	feet
R = radius of the well screen:	0.292	feet
To = time to recover 37%:	26.3	minutes
L/R = validity check	32.88	

K = 5.2E-05 ft/min x 0.508 cm-min/sec-ft

K = 2.6E-05 cm/sec

HVORSLEV ANALYSIS

39291 - PZ01
SLUG WITHDRAWAL TEST
To = 26.3 minutes



Appendix B2 · Text

Multiple-Well Test Data

Phase III
RFI/RI Report

U1 OU1 OU
881 Hillside
OU1 OU1 O
Hillside 881
1 OU1 OU1
side 881 Hill
U1 OU1 OU
881 Hillside
OU1 OU1 O
Hillside 881

B2 MULTIPLE-WELL TEST DATA

B2.1 INTRODUCTION

Multiple-well pumping and tracer tests were performed in the Woman Creek alluvium as part of the Operable Unit No. 1 (OU1) Phase III Resource Conservation and Recovery Act (RCRA) Facility Investigation/Remedial Investigation (RFI/RI) at Rocky Flats Plant (RFP). The multiple-well pumping and tracer tests used an array of 15 wellpoints arranged in a three- by five-well array to further evaluate the hydraulic and contaminant transport characteristics of the Woman Creek valley fill alluvium that lies immediately downgradient of OU1. The multiple-well pumping test was directed toward estimating transmissivity and specific yield, while the tracer test was conducted to estimate effective porosity, linear dispersion, and average linear ground water velocity in the alluvium.

Three multiple-well pumping and tracer tests were originally planned along Woman Creek between 881 Hillside and Indiana Street in areas expected to have the greatest amount of saturated alluvium (EG&G 1991a). Due to the absence of saturated conditions at two of the planned sites (Sites 2 and 3), the testing program was modified to a single multiple-well pumping and tracer test (Site 1) (Figure B2-1). Saturated conditions sufficient for the test were ultimately found on the third exploratory boring in the Site 1 vicinity.

The multiple-well pumping and tracer tests were performed in general accordance with the following documents:

- Final Phase III RFI/RI Work Plan for OU1 (EG&G 1991a)
- Environmental Management Department (EMD) Standard Operating Procedures (SOPs) especially Groundwater SOPs GW.08 Aquifer Pumping Tests and GW 2.07 Tracer Tests (EG&G 1991b)
- OU1 Technical Memorandum 3, Multiple-Well Pumping Test Plan (DOE 1991a)
- OU1 Technical Memorandum 4, Multiple-Well Tracer Test Plan (DOE 1991b)

Due to field conditions encountered some modifications were made to the described guidelines. These modifications are described below in the appropriate sections of this appendix. This appendix and accompanying attachments describe the design and configuration of the tests, the analytical methods, and the test results.

Prior to performing the pumping tests, a simple analytical model, WELFLO, was used to simulate aquifer conditions in the Woman Creek alluvium (Walton 1989). Inputs for the model included various aquifer and test parameters such as transmissivity, specific yield, pumping rate and duration, well radius, grid spacing, and number of pumping and observations wells. In order to simulate drawdown in the multiple-well array under different aquifer conditions, several model runs were performed using various pumping rates, test durations, and conservative estimates of aquifer transmissivity and specific yield obtained from the Phase III RFI/RI Work Plan for OU1 (EG&G 1991a) and other pertinent site-specific information.

Prior to installing the multiple-wellpoint array, a single wellpoint, located approximately downgradient of the proposed multiple-wellpoint array, was installed. This wellpoint was used to conduct a step-drawdown pumping test as well as tracer evaluation tests. The step-drawdown test was conducted to determine the optimum pumping rate for the multiple-well pumping test. The tracer evaluation tests were conducted to select the most appropriate (i.e., sufficiently conservative and/or detectable) of the three proposed tracers for the multiple-well tracer test. The two tracers evaluated and selected were distilled water and potassium bromide-spiked formation water. Plans to test rhodamine-WT dye were canceled because satisfactory results were obtained with bromide.

Following the step-drawdown and tracer evaluation tests, the multiple-well pumping test was conducted using the center well of the array as the pumped well. Changes in the water levels in each of the 15 wellpoints were recorded during the pumping and recovery portions of the test. An estimate of the optimum pumping rate for the multiple-well pumping test was determined from the results of the single-well step-drawdown test using analytical techniques from Kruseman and de Ridder (1989). Estimates of aquifer transmissivity and specific yield using the multiple-well pumping test data were determined using analytical techniques presented by Neuman (1975), Cooper and Jacob (1946), and Theis (1935) aided by the computer program AQTESOLV (Geraghty and Miller, Inc. 1989, updated 1991) and a distance-drawdown method presented in Driscoll (1986).

Since the natural ground water flow velocity at the test site was suspected to be quite low in the Woman Creek area, a controlled artificial gradient was induced in the three- by five-well array to establish a steady linear flow system for the multiple-well tracer test. Once linear flow had been established, tracer solution was supplied to the five injection wells. The tracer concentrations in ground water at five extraction wells and the middle well of the array were monitored regularly for tracer breakthrough and concentration increases. Average linear ground water velocity and linear dispersion were estimated from the tracer test by matching time-concentration data with theoretically derived time-concentration curves. Effective porosity was then calculated using the hydraulic conductivity values determined from the multiple-well pump test data as well as the average linear ground water velocity and linear dispersion results.

Field activities for the pump and tracer tests were conducted from November 1991 through January 1992. Field activities during the winter months required special measures to protect the test equipment and workers from cold weather, precipitation, and high winds. After the temporary wells had been installed, a 10- by 10-foot canvas tent was erected over the single-well area, and a 16- by 27-foot canvas tent was erected over the multiple-well array area. Two propane space heaters were used in the tents during colder weather. The ambient temperature in the tents during field work was generally between 5 degrees Celsius (°C) and 15°C.

The multiple-well constant-rate pumping test, both single-well tracer evaluation tests, and the multiple-well tracer test were lengthy tests and continued into or throughout several nights. Two pairs of fluorescent lights were hung in the small tent and four pairs of fluorescent lights were hung in the large tent. Electrical power was supplied for the lights and test equipment using a

5-kilowatt (kW) gasoline-powered generator with an equivalent backup generator. High wind conditions posed a particular problem during the multiple-well tracer test, and operations had to be halted several times for safety reasons. All field activities were conducted in accordance with health and safety guidelines. Two-person teams were used for most field activities, although for several tests, one or more extra persons were required.

In spite of the challenging weather and field conditions, the greatest difficulty affecting field operations was that preliminary estimates of hydrologic parameters from the Phase III RFI/RI Work Plan for OU1 (EG&G 1991a) were substantially different from the parameters actually encountered in the field. For example, pumping rates for the multiple-well test had to be increased to more than ten times the preliminary estimates. Consequently, field operations were delayed on several occasions while test design and equipment selection were revised and more appropriate equipment procured. A chronologic summary of field activities is included as Attachment B2-1.

B2.2 PUMPING TESTS

B2.2.1 Single-Well Step-Drawdown Tests

Field equipment and test procedures for the single-well step-drawdown test and the analytical methods used to determine the optimum pumping rate for the multiple-well test are presented below.

2.2.1.1 Well Installation

A single temporary wellpoint (wellpoint 39891) was installed 29.3 feet east (approximately downgradient) of the exploratory boring (pilot hole 1/borehole 39091) in the Woman Creek valley fill alluvium at Site 1 (Figure B2-1). The wellpoint was installed on November 27, 1991, using a B-57 Mobile Drill with hollow stem augers (3.25-inch inside diameter [I.D.]) and the other equipment listed in Attachment B2-2. The wellpoint was installed in general accordance with Technical Memorandum 3 (Multiple-Well Pumping Test Plan, DOE 1991a). However, due to boulders and cobbles encountered during several installation attempts, it was necessary to auger to a depth of 5 feet before the wellpoint could be successfully driven to the top of the claystone bedrock (approximately 6 feet in this area) without damaging the integrity of the wellpoint. One wellpoint was destroyed during initial attempts to drive it through the boulders and cobbles. The wellpoint was installed so that the well screen fully penetrated the saturated alluvial thickness (approximately 3.9 feet) and extended approximately 1 foot above the water table. The wellpoint was installed based on site-specific hydrogeologic conditions determined from the exploratory boring. In this area, the depth to the base of saturated alluvial material (top of bedrock) was determined from the exploratory boring to be 6 feet, and the depth to water was approximately 2.6 feet.

The wellpoint was constructed of 1.7-inch-I.D. stainless steel with a screen length of 5 feet and a slot size of 0.010 inch. For completion of the wellpoint a 1.5-inch-I.D. carbon steel extension was attached to the top of the well screen with the use of a bell reducer for an approximate stickup of 1 foot above the ground surface (see Figure B2-2 for general wellpoint construction). A 1.7-inch-I.D. wellpoint was used for the test, instead of the 1.5-inch-I.D. wellpoint specified in Technical Memorandum 3 (DOE 1991a). The slightly larger wellpoint was chosen in order to more easily accommodate the downhole pumping and tracer test equipment and to avoid time delays associated with custom manufacturing 1.5-inch wellpoints, which are not a commonly available size. Natural formation materials filled the annular space around the wellpoint upon auger retrieval. Table B2-1 provides a summary of the well installation specifications, and Attachment B2-3 is a compendium of the field data sheets for the single wellpoint installation.

Well screen length and slot size were based on site-specific hydrogeologic information obtained from visual logging and a sieve analysis performed on the saturated core material from the exploratory boring as well as visual logging of a nearby well (well 30991) and borehole (borehole 30091). The visual logging and sieve analyses were performed according to Geotechnical SOP GT.01 (Logging of Alluvial and Bedrock Material, EG&G 1991b). The screen slot size was chosen more conservatively (i.e., smaller) than the sieve analyses alone indicated in order to avoid lengthy well development times and associated test delays. In addition, the visual logging had indicated that a substantial amount of fine material was present.

B2.2.1.2 Well Development and Sampling

The single wellpoint was developed on December 2 and 3, 1991, using the equipment listed in Attachment B2-2. The methods were in general accordance with the criteria described in Groundwater SOP GW.08 (Aquifer Pumping Tests, EG&G 1991b) with additional guidance from Section 5.2.1 of Groundwater SOP GW.02 (Well Development, EG&G 1991b). A 1.25-inch-outside-diameter (O.D.) bottom-filling bailer was used to remove well casing volumes. A well casing volume (approximately 0.50 gallon) was calculated using water level and total depth measurements. These parameters were measured according to Groundwater SOP GW.01 (Water Level Measurements in Wells and Piezometers, EG&G 1991b) and Section 5.2.1.1 of Groundwater SOP GW.02 (EG&G 1991b). Specific conductance, pH, and temperature measurements were collected at regular intervals during the removal of well casing volumes. A graduated container was used to measure the volume of water removed. The pH and conductivity meters were calibrated prior to collecting measurements using manufacturer's instructions and guidance from Groundwater SOP GW.05 (Field Measurement of Ground Water Field Parameters, EG&G 1991b).

Well development continued over a 2-day period until a total of ten well casing volumes (5 gallons) were removed from the wellpoint and pH, temperature, and conductivity readings had stabilized within the last four consecutive measurements (i.e., pH readings within 0.2 units, temperature within 1°C, and conductivity readings within 10 percent of each other). In addition, this wellpoint was further developed through the pumping action of the peristaltic pump during the first step-drawdown test attempt on December 3, 1991 (Section B2.2.1.3). This development involved the removal of approximately 5 additional gallons of ground water. Table B2-2 summarizes well development activities.

A water quality sample (BH01010EBU1) was collected immediately after the wellpoint was developed in general accordance with Technical Memorandum 4 (Multiple-Well Tracer Test Plan, DOE 1991b) and Groundwater SOP GW.06 (Ground Water Sampling, EG&G 1991b). This sample was obtained in order to provide general background chemistry for the multiple-well tracer test. The water quality sample was collected using a peristaltic pump. The samples were then stored in a sample cooler with the appropriate preservatives. The sample was analyzed for common ion chemistry (sodium, calcium, iron, silicon, aluminum, potassium, magnesium, manganese bicarbonate, nitrate, sulfate, fluoride, chloride, and bromide), total organic carbon, and total dissolved solids. The results of these analyses are presented in Table B2-3, and where applicable site-wide background ground water quality values for the uppermost aquifer are presented. On the basis of this representative analysis, no special considerations had to be taken into account for the tracer test evaluation. Attachment B2-3 is a collection of the well development and sampling field data sheets.

B2.2.1.3 Test Procedures

Two step-drawdown tests were performed on the single wellpoint according to the criteria in Technical Memorandum 3 (Multiple-Well Pumping Test Plan, DOE 1991a) and Groundwater SOP GW.08 (Aquifer Pumping Tests, EG&G 1991b) using the equipment listed in Attachment B2-2. A diagram of the step-drawdown test setup is presented in Figure B2-3. These tests were performed to determine the optimum pumping rate to be used during the subsequent multiple-well constant-rate discharge test. The step-drawdown tests were performed on a single wellpoint outside of the array prior to installing the multiple-well array. These tests were conducted in order to determine if a multiple-well pumping test would be feasible due to the small amount of saturated alluvial thickness encountered while drilling the exploratory boring. The downgradient single wellpoint was also used for the tracer evaluation tests and ensured that the step-drawdown and tracer evaluations tests would not influence the hydraulic conditions of the multiple-well test area.

Either a 5-pound per square inch (psi) pressure transducer, with an accuracy of ± 0.14 inch, or a 10-psi pressure transducer, with an accuracy of ± 0.28 inch, was placed at the bottom of the wellpoint at different times. The different pressure transducers were used on different dates of the step-drawdown test to compare their sensitivities. The transducers were connected to the Hermit SE 2000 data logger for data collection. The transducer cable was secured to the well casing to avoid any potential outside interference (e.g., wind) to transducer operation. The intake line for the peristaltic pump was placed approximately 6 inches above the transducer. A portable computer was used to download the time-drawdown data from the data logger. A water level meter was used to collect manual drawdown measurements for quality control purposes. Flow measurements were collected using an in-line flow meter within the pump discharge line, a stopwatch, and a graduated flask. Water from the test was collected and temporarily stored in lined 55-gallon drums for decanting and subsequent use in the single-well tracer test.

The step-drawdown tests were conducted on December 3 and December 6, 1991. Prior to the start of the tests, static water levels and total depths were measured. The first step-drawdown test (December 3) was performed after it was confirmed that the water level had stabilized sufficiently following completion of development activities. The static water level was entered into the data logger as the reference level for the pressure transducer. Thus, the transducers measured drawdown relative to static water level. The transducer parameters including linearity, scale factor, and offset were also programmed into the data logger to convert the transducer output to an intermediate pressure, and then to a head value. The data logger was programmed to collect time-drawdown measurements logarithmically according to the schedule in Table B2-4.

Manual time-drawdown measurements were also collected at approximately 5-minute intervals during the test, except for the first 5 minutes of the test in which they were measured more frequently. Manually collected time-drawdown measurements are included in Attachment B2-3. Manual time-drawdown measurements were collected less frequently than Groundwater SOP GW.08 (EG&G 1991b) outlines because of the combined effect of the low pumping rate and the drawdown measurement accuracy required for the test. It was determined that inserting the water level probe could influence the water level measurements collected simultaneously by the data logger at the required level of accuracy because of the very small expected drawdowns. To compensate, the data logger was programmed to collect measurements at more frequent intervals than the SOP directs.

The step-drawdown test conducted on December 3, 1991 consisted of two steps. The first step was conducted for 60 minutes at an average pumping rate of 0.067 gallons per minute (gpm). A pumping rate of 0.080 gpm was used for the second step. Five minutes into the second step, however, the wellpoint began to be pumped dry. As a result the test was discontinued after an elapsed time of 74 minutes. Attachment B2-4, Table 1 presents the time-drawdown measurements collected by the data logger. The specified pumping rates in Technical Memorandum 3 (Multiple-Well Pumping Test Plan, DOE 1991a) were used as initial setup guidance but were later modified due to limitations in adjusting the pumping rate of the peristaltic pump.

The second step-drawdown test conducted on December 6, 1991 consisted of eight steps ranging from 0.034 to 0.11 gpm during time periods of 80 to 15 minutes, respectively. Based on the results of the first test, the early steps of the second test were selected at lower pumping rates. These eight steps were comprised of the following average pumping rates and time periods: 0.034 gpm (80 minutes), 0.046 gpm (80 minutes), 0.057 gpm (30 minutes), 0.065 gpm (40 minutes), 0.083 gpm (50 minutes), 0.096 gpm (30 minutes), 0.10 gpm (30 minutes), and 0.11 gpm (15 minutes). Attachment B2-3 is a collection of the field data sheets and Attachment B2-4, Table 2 presents time-drawdown measurements.

B2.2.1.4 Analysis of Test Data

The results of the initial single-well pumping test conducted at wellpoint 39891 on December 3 are presented in Figure B2-4. The step-drawdown test was unsuccessful because the lowest discharge rate of the pump was too high to produce the desired results. The water level in the well was drawn down to the intake of the pump after approximately 65 minutes of pumping.

The results of the follow-up single-well pumping test conducted at wellpoint 39891 on December 6, 1991, are presented in Figure B2-5. The data were analyzed using the Hantush-Bierschenk method (Kruseman and de Ridder 1989), which computes well loss coefficients. Once the well loss coefficients are determined, the drawdown in the well can be predicted for any realistic discharge at a specified time. The Hantush-Bierschenk method is applicable to confined, leaky, or unconfined aquifers and makes the following assumptions:

- The aquifer is of seemingly infinite areal extent, homogeneous, isotropic, and of uniform thickness over the area influenced by the test
- Prior to pumping, the piezometric surface is horizontal (or nearly so) over the area that will be influenced by the test
- The aquifer is pumped stepwise at increased discharge rates
- The pumping well penetrates the entire thickness of the aquifer and receives water only through horizontal flow

The first element of the Hantush-Bierschenk method is to determine the increments of drawdown for each step over a fixed time interval. Examination of the drawdown versus time plot indicates that most of the drawdown for each time step occurred within the first 30 minutes. Therefore, the fixed time interval used in this analysis was 30 minutes. The next element requires determining total drawdown in the well during the n-th step by summing the drawdown increments. Finally, after matching measured discharge rates to each step, the ratio of total drawdown to discharge can be computed for each step. The results of this data analysis are listed below:

Step (n)	$\Delta s_{w(n)}$ (feet)	$s_{w(n)}$ (feet)	Q_n (gpm)	$s_{w(n)}/Q_n$ (ft/gpm)
1	0.045	0.045	0.032	1.369
2	0.038	0.083	0.037	2.253
3	0.034	0.117	0.057	2.053
4	0.031	0.148	0.065	2.287
5	0.233	0.381	0.082	4.614
6	0.254	0.635	0.096	6.626
7	0.133	0.768	0.102	7.554

($\Delta s_{w(n)}$ determined for 30-minute fixed time interval. $\Delta s_{w(n)}$ not determined for n=8 because the 8th time step is less than 30 minutes long.)

where:

$\Delta s_{w(n)}$ = Incremental drawdown in the well during the n-th step

$s_{w(n)}$ = Total drawdown in the well during the n-th step

Q_n = Discharge

The values of $s_{w(n)}/Q_n$ versus the corresponding values of Q_n are plotted and presented in Figure B2-6. The procedure requires that a straight line be fitted to the data, and Figure B2-6 shows a line fit to the data using linear regression analysis. The slope of the line $\Delta(s_{w(n)}/Q_n)/\Delta Q_n$ is the value for the nonlinear well loss coefficient, C, which is 84.14. The y-intercept of the line is the value for the linear well/aquifer loss coefficient, B, which is -1.845.

The results of this analysis can be used to determine the drawdown in the well for a given discharge rate using the following equation:

$$s_w = (84.14)Q^2 - (1.845)Q \quad \text{(for } t = 30 \text{ minutes)}$$

The following are tabulated drawdowns for various discharge rates calculated using the above equation as well as the corresponding percent drawdown in the well given the saturated thickness of 3.9 feet (determined prior to the start of the test):

Discharge (Q) (gpm)	Drawdown (s_w) (feet)	Percent of Saturated Thickness
0.03	0.020	0.5
0.04	0.061	1.6
0.05	0.118	3.0
0.06	0.192	4.9
0.07	0.283	7.3
0.08	0.391	10.0
0.09	0.515	13.2
0.10	0.657	16.8
0.11	0.815	20.9
0.12	0.990	25.4

The maximum desirable drawdown for the pumping test should be about 10 percent of the saturated thickness and should not exceed 20 percent in accordance with SOP GW.08 (EG&G 1991b). Drawdowns beyond 10 to 20 percent exceed the validity of some analysis methods, such as the Cooper-Jacob method. The above table indicates that the maximum drawdown for the multiple pumping test should be reached at a pumping rate of 0.08 gpm and the pumping rate should not exceed 0.11 gpm. The recovery data were also collected for the step-drawdown test of December 6, 1991, and are shown in Figure B2-5. These data were not evaluated since the analysis methods for recovery data only apply to constant-head pumping tests (Driscoll 1986).

B2.2.2 Multiple-Well Tests

Field equipment and test procedures for the multiple-well pumping test and the analytical methods used to estimate transmissivity and specific yield of the Woman Creek valley fill alluvium are presented in the following sections.

B2.2.2.1 Well Installation

Fifteen temporary wellpoints were installed on December 7 and 8, 1991, for the multiple-well pumping and tracer tests in the Woman Creek valley fill alluvium at Site 1 using the equipment listed in Attachment B2-5. The wellpoints were designated I1 to I5 for the injection wells, O1 to O5 for the observation wells, and E1 to E5 for the extraction wells for the multiple-well tracer test (Figure B2-1). The wellpoints were installed in a three- by five-well array so that the rows of five wells were oriented perpendicular to the estimated direction of ground water flow on approximately 2.5-foot centers within the array. The wellpoint spacing was enlarged from the proposed 2 feet due to difficult drilling conditions encountered in the field. The wellpoint array was centrally located between the exploratory boring (borehole 39091) and the single wellpoint (wellpoint 39891) (Figure B2-1). The wellpoints were installed and constructed using the same procedures employed for the single wellpoint installation (Section B2.2.1.1) in accordance with Technical Memorandum 3 (Multiple-Well Pumping Test Plan, DOE 1991a) (Figure B2-2 illustrates general wellpoint construction). Similar to the single wellpoint installation, the presence of boulders and cobbles made it necessary to auger the drive holes for the wellpoints to minimize damage to the wellpoints. Small diameter solid stem augers (4.0-inch O.D.) were used for the multiple-wellpoint installation. Despite precautions, however, two wellpoints were destroyed during installation due to the presence of numerous boulders and cobbles.

Based on site-specific hydrogeologic information gathered from the exploratory boring, the wellpoints were installed to the top of bedrock, at a depth of approximately 6 feet, with the screens fully penetrating the saturated thickness of the alluvium and extending approximately 1 foot above the water table. Table B2-1 summarizes individual well installation specifications, and Attachment B2-6 presents the field data sheets for the multiple-well installation.

B2.2.2.2 Well Development

The wellpoints were developed on December 9, 14, 15, and 16, 1991 in accordance with the criteria described in Groundwater SOP GW.08 (Aquifer Pumping Tests, EG&G 1991b) with additional guidance from Section 5.2.1 of Groundwater SOP GW.02 (Well Development, EG&G 1991b) using the equipment listed in Attachment B2-5. Development of the wellpoints in the multiple-well array was not conducted during the single-well tracer evaluation tests (conducted December 10-13, 1991) to ensure that the single-well tracer test area hydrostatic conditions were not influenced by development activities.

The wellpoints were developed using procedures consistent with those for the single wellpoint (Section B2.2.1.2). Specific conductance, temperature, and pH measurements were collected after every one-half of a well casing volume was removed. In addition to the procedures described in Section B2.2.1.2, it was necessary to use more energetic development methods on a few of the wellpoints that were not recovering satisfactorily after attempts to develop them with a bailer. Decanted well development water was added back into four of the wellpoints that were not recovering satisfactorily (wellpoints O2, O3, E2, and E5) and bailed out again in an attempt to aid the development process. This method was only effective with wellpoint O2. A surge block (consisting of a 1.5-inch O.D., 3-foot-long stainless steel slug) was used on four of the wellpoints (wellpoints E1, E2, E4, and E5) in the easternmost row of well array and on the center wellpoint of the array (wellpoint O3). Wellpoint O3 was used as the pumped well during the multiple-well pumping test. The surge block technique was successful in developing the five previously poorly recovering wellpoints. After all of the wellpoints had been developed according to the criteria in Groundwater SOPs GW.08 and GW.02 (EG&G 1991b), each well in the array was pumped an average of 25 minutes with a peristaltic pump to remove the silt until the purged water appeared relatively clear. The criteria from Groundwater SOPs GW.08 and GW.02 (EG&G 1991b) required that a minimum of five well casing volumes be removed, that pH measurements had stabilized to within 0.2 units, that temperature had stabilized to within 1°C, and that conductivity had stabilized to within 10 percent for three consecutive volumes. After pumping the wellpoints, a final round of pH, conductivity and temperature readings were collected from each wellpoint. Table B2-2 provides a summary of well development activities, and Attachment B2-6 presents the well development field data sheets.

B2.2.2.3 Test Procedures

A multiple-well constant rate pumping test was conducted on December 18 and 19, 1991, using the three- by five-wellpoint array installed at Site 1 (Figure B2-1). The pumping test was conducted in accordance with the criteria in Technical Memorandum 3 (Multiple-Well Pumping Test Plan, DOE 1991a), and Groundwater SOP GW.08 (Aquifer Pumping Tests, EG&G 1991b) using the equipment listed in Attachment B2-5. Refer to Figure B2-7 for a diagram of the test setup. The test was performed to further characterize the transmissivity and specific yield of the Woman Creek valley fill alluvium.

Pumping began on December 18 at 12:46 and continued for 8 hours (480 minutes) at an average rate of 1.51 gpm (0.2019 cubic foot per minute [ft^3/min]). The pump was shut off at 20:46 after the drawdown in the pumped well equaled approximately 20 percent of the saturated thickness of the alluvium. This was done in accordance with Groundwater SOP GW.08 (EG&G 1991b). Aquifer recovery was monitored immediately after pumping ceased until 11:36 on December 19 for a total of 14 hours and 50 minutes (890 minutes). The recovery was monitored until it was determined that the maximum recovery was reached (i.e., 87 percent of drawdown in the pumped well) and that water levels were generally decreasing after that point.

Fifteen pressure transducers were used for the test including three 5 psi transducers (accuracy of ± 0.14 inch) and twelve 10 psi transducers (accuracy of ± 0.28 inch). A transducer was placed in each of the wellpoints slightly above the wellpoint bottom. The more sensitive 5 psi pressure transducers were placed in wellpoints I1, I5, and E5. These wellpoints were located at the corners of the pump test grid where the least amount of drawdown was expected. The majority of the pressure transducers was the 10 psi type due to unavailability of the 5 psi pressure transducers originally specified for the test in Technical Memorandum 3 (DOE 1991a). After comparing results obtained during the step-drawdown tests using the two types of pressure transducers and operating information provided by the equipment vendors, it was determined that using a majority of 10 psi transducers with strategically placed 5 psi units would provide the required level of accuracy for the test.

Each of the 15 pressure transducers was connected to one of two 8 channel Hermit SE 2000 data loggers to collect time-drawdown measurements. The transducer cables were secured to the well casings to avoid any potential outside interference to transducer operation (e.g., wind). The Hermit data loggers were programmed to collect time-drawdown at the logarithmic intervals presented in Table B2-4. Prior to the start of the test, static water levels were measured in each of the wellpoints and then programmed into the data loggers as reference levels for each transducer. Thus, the transducers measured drawdown relative to the static water levels. Properties of the transducers, including linearity, scale factor, and offset specific to each transducer were also programmed into the data loggers to convert the transducer output to the desired units.

A diaphragm pump was used in the pumped well, wellpoint O3. The intake line for the diaphragm pump was placed approximately 6 inches above the transducer. Pumping rates ranged from 1.43 to 1.60 gpm during the test with an average pumping rate of 1.51 gpm (0.2019 ft^3/min). Water level meters were used to collect manual time-drawdown measurements during the test. These measurements were collected continuously in the 15 wellpoints by two-person teams as often as possible during the first 20 minutes of the test. Measurements were then collected at approximately 10-minute intervals up to an elapsed time of 95 minutes. After this time, measurements were collected every 30 minutes for the rest of the 8-hour period. Attachment B2-6 presents the manual time-drawdown measurements.

Similar to the step-drawdown test, manual time-drawdown measurements were collected less frequently than the guidelines in Groundwater SOP GW.08 (EG&G 1991b) suggest. This was due to the physical limitations of collecting numerous measurements in 15 wells simultaneously. More importantly, the water level probe could have potentially influenced the water level measurements collected simultaneously by the data logger at the required level of accuracy because of the low expected drawdowns. To compensate, the data logger was programmed to collect measurements at more frequent intervals than the SOP recommended.

Prior to the successful implementation of the pumping test on December 18, several unsuccessful attempts to start the test were made on December 17 using the pumping rate predicted from the single-well step-drawdown test conducted on December 6. The pumping rate was gradually increased from the predicted rate of 0.08 to approximately 0.50 gpm with minimal measured drawdown. At 0.50 gpm, the capacity of the peristaltic pump was exceeded and the decision was made to try a larger capacity diaphragm pump. The test on December 18 was performed after it was confirmed that the water levels had stabilized from the pumping test activities conducted the previous day.

Due to the increased average pumping rate of 1.51 gpm used in the multiple-well test compared to the 0.08 gpm rate predicted by the single step-drawdown test, flow measurements obtained during the test were made with a graduated container and a stop-watch. This method was used instead of the flow meter originally planned for the test because the pumping rates exceeded the flow meter capacity. Water from the test (approximately 725 gallons) was stored for decanting and later use in the multiple-well tracer test. A portable computer was used to transfer time-drawdown data from the data loggers both during and after the test. While the test was in progress, the time-drawdown data was periodically downloaded and plotted to monitor the drawdown in the pumped and observation wells over time. Attachment B2-7 (Tables 1 and 2) presents the data logger files for the pumping and recovery portions of the test.

B2.2.2.4 Analysis of Test Data

Aquifer hydraulic parameters including transmissivity and specific yield were estimated from the multiple-well pumping and recovery test conducted on December 18 and 19, 1991. The pumping test data were analyzed using methods presented by Neuman (1975), Cooper and Jacob (1946), and a distance-drawdown method presented in Driscoll (1986). Time-drawdown and recovery data, along with the associated graphs, are presented in Attachment B2-7. Data from the recovery phase of the test were analyzed using the Theis Recovery method (1935). The Cooper-Jacob and Theis Recovery methods are both straight-line analysis techniques, while the Neuman method is a curve-matching technique. All three are graphical methods for pumping test data analysis; the data analysis was completed using the AQTESOLV software package (Geraghty and Miller 1989, updated 1991). The distance-drawdown method was completed to compare the results from the former three methods.

Methods and Assumptions

The Cooper-Jacob method is a modification of the Theis drawdown formula, that fits a straight line to plots of well drawdown versus time on a semilogarithmic scale. As recommended by Kruseman and deRidder (1989), the value for the dimensionless argument for the well function, u, in the Theis equation was selected at 0.05 (i.e., $u \leq 0.05$ for valid application).

The Neuman curve-matching method uses the concept of a delayed water table response, where water levels in observation wells near the pumping well may decline at a slower rate than the rate determined by the Theis equation. Time-drawdown curves are plotted on a log-log scale and typically show an S-shape. The stages of this S-shaped curve are described as follows:

- The early-time segment is relatively steep and reflects the initial pumping period (i.e., generally the first few minutes of pumping). This is due to instantaneous water release from storage, similar to a confined aquifer.

- A flat segment from the intermediate period of the test is generated as the aquifer pores become dewatered as the water table falls.

- Another steep segment occurs at the later stages of the test due to aquifer flow again becoming horizontal, thus causing the time-drawdown curve to appear similar to the Theis drawdown curve.

The Theis Recovery method can be used for late-time recovery data after the effects of elastic storage have dissipated. As a result, residual drawdown data fall on a straight line when plotted on a semilogarithmic scale, and can be evaluated using the Theis Recovery equation. The distance-drawdown method generates a plot of drawdown versus distance from the pumped well on a semilogarithmic scale. Transmissivity can then be calculated using a relationship between transmissivity, measured discharge, and the slope of the distance-drawdown graph plotted from the data. A total of five observation wells (wellpoints I1, O1, O5, E3, E4) were used to plot the distance-drawdown graph.

The assumptions for the Cooper and Jacob and Theis Recovery methods for unconfined aquifers include the following:

- The aquifer has seemingly infinite areal extent
- The aquifer is homogeneous, isotropic, and of uniform thickness over the area influenced by the test
- Prior to pumping, the water table is horizontal over the area influenced by the pumping test
- The aquifer is pumped at a constant discharge rate
- The pumping well penetrates the entire aquifer and therefore receives water from the entire saturated thickness of the aquifer
- The flow to the well is in an unsteady state
- The diameter of the pumping well is small, so storage in the well can be neglected
- Water is released instantaneously from storage with the decline of hydraulic head
- Flow to the pumping well is horizontal and uniform in a vertical section through the axis of the well
- Flow velocity is proportional to the tangent of the hydraulic gradient instead of its sine (which is actually the case)
- Values of u are small (i.e., radial distance from the pumping well to the observation well, r, is small and time since pumping began, t, is large)
- There is no delayed yield in the aquifer

The assumptions for the Neuman method for unconfined aquifers include the following:

- The aquifer has seemingly infinite areal extent
- The aquifer is homogeneous and of uniform thickness over the area influenced by the test
- Prior to pumping, the water table is horizontal over the area influenced by the test
- The aquifer is pumped at a constant discharge rate
- The flow to the well is in an unsteady state
- The diameter of the pumping well is small, so storage in the well can be neglected
- The aquifer is isotropic or anisotropic

The assumptions for the distance-drawdown method include the following:

- More than three observation wells are used to construct the plot
- Only valid for u<0.05 (i.e., r is small and t is large)

The time-drawdown data have been corrected to account for the fact that the pump used did not have proper suction for 2 minutes and 40 seconds, into the test. Thus, this amount of time was subtracted from the total elapsed time for each pumping data point collected by the data logger. The elapsed recovery time for one of the data loggers (wellpoints I1 to O3) was also adjusted by 3 seconds to account for a delayed start. All drawdown and recovery curves are plotted using the corrected data. Table B2-5 presents a summary of the time-drawdown and recovery analyses including the initial saturated thickness, distance from the pumping well, and calculated values of transmissivity, hydraulic conductivity, and the specific yield for each well for each of the three analytical techniques. The table also presents the mean, standard deviation, and range values for each parameter. Table B2-6 presents the data generated from the distance-drawdown analysis, and Table B2-7 provides a comparison of the values from this pumping test with values from previous drawdown/recovery tests conducted in the Woman Creek alluvium. It should be noted that wellpoint O3 was the pumping well, and a valid value for specific yield can not be determined.

Cooper-Jacob Drawdown Analysis

The Cooper-Jacob straight-line analysis was performed on the late time data for all the wellpoints. The minimum time for which the analysis is valid given a $u < 0.05$ was determined for each wellpoint using the following formula:

$$t=\frac{r^2S}{4Tu}$$

where:

r = distance from the pumping wellpoint to the observation wellpoint

S = coefficient of storage = 0.1

T = transmissivity

The minimal time for which the Cooper-Jacob analysis is valid varied from approximately 20 to 117 minutes depending on the distance of the observation wellpoint from the pumping wellpoint. The results are valid for all the straight line matches presented in this report.

The results of the Cooper-Jacob analysis included hydraulic conductivity values ranging from 1.8×10^{-2} to 2.2×10^{-2} cm/sec with an arithmetic mean of 1.9×10^{-2} cm/sec. The analysis did not produce valid values for specific yield. The values calculated ranged from 0.31 to 2.2 with a mean of 0.81. A normal value for the specific yield of an unconfined aquifer is 0.1.

Neuman Drawdown Analysis

The Neuman curve matching method was also conducted on the drawdown data. The curve matching provided poor matches of the early time drawdown data except for wellpoint O3.

The results of the Neuman analysis included hydraulic conductivity values ranging from 1.5×10^{-2} to 2.2×10^{-2} cm/sec with an arithmetic mean of 1.9×10^{-2} cm/sec. The analysis did not produce valid values for specific yield. The values calculated ranged from 0.30 to 2.2 with a mean of 0.76. A normal value for the specific yield of an unconfined aquifer is 0.1.

Theis Recovery Analysis

The water levels were measured in the wellpoints for approximately 890 minutes after the pump was turned off. At about 700 minutes, the water levels ceased rising though they had not regained prepumping levels and exhibited a residual drawdown ranging from 0.07 to 0.09 feet. The transducers indicated decreasing water levels in wellpoints I1, I2, I4, I5, O1, O3, O5, E1, E3, and E5 from about 700 minutes until the transducers were removed. The rate of water level decrease measured by the transducers averaged 0.12 ft/day. Water levels were measured periodically in all the wellpoints from after the pump test until the tracer test was conducted in January. These measurements showed that the water table declined 0.7 foot from December 19 until January 3, a rate of approximately 0.05 ft/day. From January 3 to January 22, the water table remained fairly constant, fluctuating about 0.1 ft overall.

The water level data collected at the end of the pump test and thereafter appears to indicate that the water table began dropping during the test. This trend was removed from the recovery data prior to analysis by assuming that the trend is linear. The rate of decline was determined by fitting a line to the decreasing data trend that occurred after 700 minutes using linear regression techniques and deriving an equation for the line. The equation was used to predict the natural water table decline at each wellpoint and subtracting the natural water table decline from the data. Attachment B2-7 contains graphs showing the measured recovery in each well and the adjusted recovery data. Data from wellpoints E2 and O4 are not included as the transducers malfunctioned. The graphs show that the adjusted data contains very little residual drawdown. The adjusted data were used in the Theis recovery analysis.

The results of the Theis Recovery analysis included transmissivity values ranging from 0.1298 to 0.1951 ft^2/min with an arithmetic mean of 0.1569 ft^2/min and hydraulic conductivity values ranging from 1.90×10^{-2} to 2.69×10^{-2} cm/sec with an arithmetic mean of 2.24×10^{-2} cm/sec.

Specific yields were not determined but the ratio of storage during pumping to storage during recovery (S') was determined for each wellpoint. This value ranged from 1.473 to 1.810 with an arithmetic mean of 1.663.

Analysis of the Theis Recovery data are considered to be more reliable than analysis of drawdown data due to the fact that recovery rates are constant (i.e., not affected by external perturbations of the aquifer) as compared to drawdown, which is affected by the well discharge rate. However, transmissivity calculated using the recovery method may give slightly higher values for unconfined aquifers (Kruseman and de Ridder 1989).

Distance-Drawdown Analysis

Hydraulic conductivity values were calculated from the distance-drawdown transmissivity values using the relationship with saturated thickness. The geometric mean hydraulic conductivity value for this method was approximately 3.6×10^{-2} cm/sec. The geometric mean storativity was 0.15. The wellpoints used for the distance drawdown calculations were O1, O5, I1, E3, and E4. Hydraulic conductivity and storativity were calculated for times after pumping started of 60, 100, 200, 300, 400, and 480 minutes. The u value for 60 minutes exceeded 0.05 and the data are not included in this report. The u values calculated for the remaining times were all below 0.05.

Summary of Results

As shown in Table B2-7, the geometric mean of the hydraulic conductivity values determined by each analytical method ranged from 1.9×10^{-2} to 3.6×10^{-2} centimeters per second (cm/sec). The previous hydraulic conductivity values were determined for the Woman Creek alluvium by drawdown/recovery tests; values ranged from 3×10^{-3} to 3×10^{-4} cm/sec (EG&G 1991a). Mean values for specific yield for the Cooper-Jacob and Neuman methods were 0.64 and 0.63, respectively. However, both of these methods, values for specific yield exceeded unity, with calculated values of 2.2 and 2.0, respectively. The Theis Recovery method had a specific yield range from 0.50 to 0.84, and a mean of 0.65.

Deviations from Ideal Conditions

The plots of drawdown to log time for each wellpoint show a deviation from ideal conditions. Ideal conditions would yield plots of drawdown to log time that fall on a straight line. The plots of data from this pump test show the data deflecting upwards approximately 8 minutes after pumping began. After approximately 110 minutes, the data again falls on a straight line with a different slope than the early data. This deflection could indicate several different aquifer conditions: the presence of an impermeable boundary, a change in transmissivity in the vicinity of the wellpoints, or the effects of delayed yield.

An impermeable boundary in the vicinity of the wells is possible given the spotty nature of the alluvial aquifer. Boreholes drilled upvalley and downvalley of the test site were dry or did not produce enough water for a test. The drawdown to log time plots can be used to determine the distance to an impermeable barrier or the point at which transmissivity changes using image well theory (Dawson and Istok 1991). The distance to the barrier can be determined using the equation:

$$r_i = r_r \sqrt{\frac{t_i}{t_r}}$$

where:

r_i = distance from the image well to the observation well

r_r = distance from the pumping well to the observation well

t_i = total time of pumping which produces predicted drawdown at the observation well due to the image well

t_r = total time of pumping which produces drawdown at the observation well due to the pumping well

The resulting distance to the image well is divided by two to determine the distance to the barrier. This analysis was conducted on wellpoints E1, I1, I5, and O5. The results indicate that a barrier or change in transmissivity exists between 8 and 16 feet distance from these wellpoints. The actual results are 14.8 ft from E1, 8.5 ft from I1, 16 ft from I5, and 14.8 ft from O5. Though an impermeable barrier is possible, it is unlikely at the distances calculated by this method. Water levels measured in well 6486 located approximately 125 ft east of the wellpoints indicate similar thickness of saturated alluvium, while well 30991, located approximately 195 ft northwest of the wellpoints, was dry. Well 6486 is approximately 20 feet topographically lower than the wellpoints and well 30911 is approximately 30 ft higher than the wellpoints. The exploratory boring (39091) drilled for this site is located approximately 12 ft west of the wellpoints and the single wellpoint (39891) is located approximately 12 ft east of the wellpoints. The exploratory boring and single wellpoint both had thicknesses of saturated alluvium similar to the multiple wellpoints.

The deviations could indicate a change in transmissivity. The inflections shown on the plots would indicate that the transmissivity of the aquifer is higher in the vicinity of the wellpoints and lower further away from the wellpoints. The development of the wellpoints removed a considerable volume of fine material. This could locally increase the transmissivity of the aquifer around the wellpoints. However, the aquifer would probably not be affected more than 10 ft from the wellpoints. If this is the case, the transmissivities determined from the late-time data would be more representative of natural conditions.

The deviations could also be due to the effects of delayed yield from the aquifer. The data for wellpoint O3 fit the Neuman type curve very well, though the Neuman type curves do not fit the data from the other wellpoints very well.

The preceeding analysis indicates that the deviation seen in the data from the ideal conditions is most probably due to change in transmissivity or delayed yield effects and that analysis of the early time will not provide an accurate characterization of the aquifer hydrologic parameters.

The wellpoints used for the distance drawdown calculations were O1, OS, I1, E3, and E4. Hydraulic conductivity and storativity were calculated for times after pumping started of 60, 100, 200, 300, 400, and 480 minutes. The u value for 60 minutes exceeded 0.05 and this data is not included in this report. The u values calculated for the remaining times were all below 0.05.

B2.3 TRACER TESTS

B2.3.1 Single-Well Tracer Tests

Test procedures for the single-well tracer evaluation tests are presented below. Field equipment and procedures for installation, development, and sampling of the single wellpoint are presented in Sections B2.2.1.1 and B2.2.1.2. The tracer evaluation tests were conducted to select a sufficiently conservative and detectable tracer for the multiple-well tracer test.

B2.3.1.1 Test Procedures

The single-well tracer evaluation tests for distilled water and potassium bromide were conducted on December 10-11 and 13-14, 1991, respectively. A complete list of equipment used for each test is included in Attachment B2-2. The test setups are shown in Figures B2-8 and B2-9.

Tubing, fittings, and containers in direct contact with the ground water or tracer were composed of inert materials, such as polyethylene, nylon, polypropylene, vinyl, polyvinyl chloride (PVC), silicone, and stainless steel. The tracer solutions were prepared and stored in a 30-gallon plastic tank.

The distilled water tracer consisted of six 5-gallon containers of distilled water. For the bromide tracer evaluation test, a bromide concentration of 500 milligrams per liter (mg/l) was selected, based on the characteristics of natural ground water and the performance characteristics of the bromide ion selective electrode (ISE) used for analyses in the field. The practical analytical range of the bromide ISE used was between approximately 0.2 and 1,000 mg/l (see Attachment B2-8 for details). Outside of that range, the electrode response in terms of millivolts becomes nonlinear, requiring more complicated analytical procedures.

A second consideration in the instrumentation was the possibility of analytical interference from other ions present in the ground water. For the bromide ISE used, the most important interference ion to consider is chloride. According to directions provided by the ISE manufacturer, Orion Research Inc., the concentration of chloride may be as great as 400 times the concentration of bromide (in terms of molarity) before interference becomes a problem. At the time that the bromide tracer concentration was selected, a laboratory-determined chloride concentration value for the Woman Creek ground water was not available. Instead, chloride concentration was estimated from the specific conductance (SC) of the ground water (approximately 960 micromhos per centimeter [μmhos/cm]). Assuming that the sole contributor to SC was sodium chloride, the chloride concentration of the ground water would be about 350 mg/l. Table B2-3 presents the results of the laboratory analyses. Using the recommended maximum ratio of 400 to 1 (molarity), the minimum practical detection limit for bromide due to chloride interference would be about 2 mg/l chloride. Considering the bromide ISE linear response range, the effect of chloride ion interference, and uncertainties resulting from temperature effects (see Attachment B2-8), the minimum practical quantification limit was estimated to be between 1 and 2 mg/l. Background levels of bromide in the ground water were below that practical quantification limit.

The bromide solution was prepared by dissolving 84.56 grams of reagent grade potassium bromide in a small quantity of distilled water, and then mixing that solution in 30 gallons of water extracted during the previous test. The extracted water consisted of a mixture of the distilled water tracer and natural ground water. To prevent stratification in the 30-gallon tank, a propeller mixer was used throughout the injection stage of the bromide test.

The tracer fluid was delivered to the single-well using a peristaltic pump with 1/8-inch-I.D. pumphead tubing. During the tests, a variable area flow meter with a 0- to 0.071-gpm range was placed downstream of the pump to estimate the injection and extraction rates. Those estimates were used to adjust the pumphead speed of the peristaltic pump. Actual injection and extraction rates were calculated using the volumes of produced or injected fluid and elapsed time. The variable area flow meter was checked prior to beginning the single-well tests by pumping a known volume of water through the system and recording elapsed time. The flow rate with the flow meter in situ was very similar to the calibration chart provided by the manufacturer.

To help distribute the tracer fluid over the entire water column height, a perforated, semirigid tube was inserted in the well. All connections were made with vinyl tubing. The first tracer evaluation test was conducted 4 days after completing the step-drawdown test allowing ample time for complete water table recovery.

During the tests, water levels were recorded with a Hermit data logger and pressure transducer. Measurements for the early portion of the distilled water evaluation test were taken with an electronic water level meter. Injection and extraction rates as well as tubing sizes were estimated using the results of the single-well step-drawdown pump tests. A rate of 0.07 gpm was selected. During both the injection and extraction modes of the test, the ground water level was monitored regularly by checking the Hermit data logger. In accordance with Technical Memorandum 4 (Multiple-Well Tracer Test Plan, DOE 1991b), the water column height was not allowed to rise or drop more than 10 percent of the static water column height. During the injection stage of both tracer evaluation tests, the water column height increased by approximately 3 percent. During the extraction mode, however, the water column height dropped by approximately 10 percent and the extraction rate had to be reduced slightly by lowering the pumphead speed. The test parameters are summarized in more detail in Attachment B2-9, Table 1.

For the distilled water tracer evaluation test, the concentration of tracer in the extracted ground water was determined using two specific conductivity meters. A YSI model 3446 flow-through conductivity cell (30 milliliters [ml] volume) was placed downstream of the pump and flow meter and specific conductivity was read from a YSI model 35 conductance meter and recorded regularly. As an independent check, an Orion model 122 conductivity/temperature meter and temperature-compensated probe-type specific conductivity electrode were used. The electrode was placed in a 100-ml beaker along with the discharge line. The beaker/electrode assembly was suspended above the discharge-water storage tank so that the fluid in the beaker was continually refreshed. The Orion model 122 conductivity/temperature meter automatically compensates for sample temperature using a temperature coefficient of 2.1 percent per °C, and corrects readings to 25°C. Temperature and temperature-compensated SC measured at the discharge point were recorded regularly.

Temperature was measured using the temperature modes of the Orion model 122 conductivity/temperature meter and the Orion model 250 pH meter. Accuracy was checked against a glass thermometer. During the extraction mode of the distilled water test, the temperature of the extracted ground water ranged from 5.4°C to 7.8°C. Specific conductivity measurements recorded from the flow-through cell were manually corrected for temperature using 2.1 percent per degree centigrade, which is appropriate for most natural ground waters. Flow-through cell measurements were corrected to 25°C using the following equation from the instrument operations manual:

$$SC_{25^\circ C} = \frac{SC_T}{1 + (T - 25^\circ C)\,K}$$

where:

SC_T	=	specific conductivity measured under field conditions
$SC_{25^\circ C}$	=	specific conductivity measured at 25°C
T	=	the temperature of the measured fluid
K	=	the correction factor (0.021/°C)

Both SC instruments were checked before use with a 1000 µmhos/cm calibration standard. A typical calibration check for the Orion model 122 conductivity/temperature meter (with automatic temperature compensation) was 1056 µmhos/cm at 6.3°C (5 percent error). A typical calibration check for the YSI model 35 conductivity meter was 701 µmhos/cm at 6.3°C, which, when manually corrected to 25°C, yields 976 µmhos/cm (2 percent error). Temperature-corrected data is compiled in Attachment B2-9, Table 2. A total of 66 recordings were made using the flow-through cell.

Routine pH measurements were made with an Orion model 250 pH meter with automatic temperature compensation. The meter was calibrated using commercially prepared pH 4.01, pH 7.00, and pH 10.00 buffer solutions.

For the extraction cycle of the bromide tracer test, a fluid sampling valve was installed downflow of the peristaltic pump and flow meter. Samples were collected in 50-ml plastic beakers at regular intervals and immediately analyzed for bromide concentration. Temperature, pH, and specific conductivity were periodically measured also. A detailed description of analytical methods for bromide is included in Attachment B2-8. Bromide concentration readings in millivolts were converted to bromide concentrations in mg/l using a calibration curve made with 7.7°C standards. Bromide tracer test results are compiled in Attachment B2-9, Table 3. A total of 69 samples were collected and analyzed in the field for bromide.

B2.3.1.2 Analysis of Test Data

Results of the single-well distilled water and bromide tracer evaluation tests are tabulated in Attachment B2-9, Tables 2 and 3.

The use of distilled water as a tracer is somewhat unique in that the measured parameter specific conductance is less concentrated in the tracer than in the ground water. To evaluate the performance of the two tracers on an equivalent basis, breakthrough curves were prepared in which normalized concentration is plotted against time. For the bromide tracer, the concentrations of bromide measured in the extracted fluid (C) were normalized to the initial value of bromide in the tracer solution (C_o = 500 mg/l). For the distilled water tracer, the measured specific conductivity was normalized to the specific conductivity of the ground water (960 μmhos/cm, measured with the flow-through cell, and corrected to 25°C), and then subtracted from one. This is equivalent to the following:

$$1 - K \frac{C}{C_o}$$

where:

$$K = \frac{C_o}{C_f}$$

and where:

C_o = Specific conductivity of the distilled water at 25°C (approximately 17 μmhos/cm)

C_f = Specific conductivity of the ground water at 25°C (960 μmhos/cm measured with flow-through cell)

C = Specific conductivity of the extracted fluid at 25°C

The normalized concentrations of the distilled water and the bromide tracer solutions are plotted against volume extracted in Figure B2-10. The average extraction rates were slightly different for the two tracer evaluation tests and so the more conventional graphs of normalized concentration against time could not be directly correlated.

The change in tracer concentration during the test followed a predictable trend. The initial samples, collected immediately after beginning the extraction stage of the tracer evaluation tests, had concentrations very similar to the tracer solutions. After only a small volume of fluid had been extracted, the composition of the extracted fluid had substantially changed. The 50 percent concentration point was reached after 2.0 gallons had been removed during the distilled water test and after 3.7 gallons had been removed during the bromide test. Most of the change in concentration of the extracted fluid occurred during the first third of the test (first 10 gallons).

The 80 percent concentration point (relative to undisturbed ground water) was reached after about 6.7 gallons had been removed during the distilled water test and 12.5 gallons had been removed during the bromide test. Thereafter, the concentration asymptotically approached that of the undisturbed ground water.

In summary, the apparent recovery was much quicker during the distilled water test then during the bromide test. Bromide is considered a relatively conservative tracer, in that bromide is generally not affected by sorptive processes (Davis et al. 1985). In comparison, however, distilled water is probably quite reactive with aquifer constituents even in shallow sediments comprising the aquifer at this test site. The quicker recovery seen with the distilled water is probably the result of mobilizing sorbed ions or dissolving very small masses of minerals in the sediment into the distilled water tracer.

On the basis of these results, bromide was selected as the most appropriate tracer to use for the multiple-well tracer test. The 500 mg/l bromide concentration was chosen as the most appropriate concentration.

B2.3.2 Multiple-Well Tests

Multiple-well test procedures, test data analysis, and procedures for well abandonment and equipment decontamination are presented below. Equipment and field procedures to install and develop the multiple-well array are presented in Sections B2.2.2.1 and B2.2.2.2.

B2.3.2.1 Test Procedures

The multiple-well tracer test was conducted on January 27 and 28, 1992, after sufficient time had passed to analyze data, redesign tests, and procure equipment again following the constant-rate pumping tests. Although run on January 27, the tracer test was discontinued due to high winds on two separate occasions after stable gradients had been achieved. The water levels were than allowed to re-equilibrate to static conditions prior to restarting the test on each later attempt. A complete list of the equipment used is included in Attachment B2-5, and Figures B2-11 and B2-12 demonstrate the test setup.

The test was performed using the three- by five-well array that had been used for the multiple-well pump test. For the tracer test, the row of five wells on the west side of the grid were used as injection wells, and the five on the east side were used as extraction wells. The center row of wells was used mainly for water level observation. A pressure transducer was placed in each of the 15 wells and connected to one of two Hermit data loggers. The same pressure transducers used in the multiple-well pumping test were placed in each wellpoint except for one. The transducer for wellpoint E2 was replaced due to an apparent malfunction indicated by pumping test results. The pressure transducers and data loggers were programmed to read water column height.

To induce a gradient during the test, water levels in the injection and extraction wells were controlled using ten solid-state liquid-level-control relays coupled with ten diaphragm pumps. For each of the injection and extraction wells, two electrodes were positioned at the desired water level height and fastened to a perforated polyethylene tube using vinyl tape. A ground wire was attached near the bottom of each tube. Each "pump on" electrode was mounted approximately 3/8 inch from the "pump off" electrode. That distance was selected to be long enough to eliminate continuous switching due to water splashing in the wells and short enough to minimize hysteresis. A reference mark was made near the top of each tube corresponding to the desired depth that the tubes should be inserted into the wells. By comparing the position of the reference mark relative to the top of the casing for each well, the electrodes could be positioned easily and with accuracy.

For the injection wells, the liquid-level-control relays were wired in the inverse mode, and each "pump off" electrode was placed above the "pump on" electrode. With that configuration, each pump ran independently until the water level reached the upper electrode, when the pump would be switched off. When the water level dropped just below the lower electrode, each pump was automatically switched on, and the cycle was repeated.

For the extraction wells, the liquid-level-control relays were wired in the direct mode, and each "pump off" electrode was placed below the "pump on" electrode. With that configuration, each pump ran independently until the water level dropped to the lower electrode, when the pump would be switched off. When the water level rose to just above the upper electrode, each pump was automatically switched on, and the cycle was repeated.

To help organize the injection, extraction, and sampling systems, a 4- by 8-foot platform was constructed on saw horses and placed above the multiple-well grid. For each of the five injection wells and the five extraction wells, a control relay box, diaphragm pump, and flow accumulator were mounted on the platform. To simplify construction, minimize back pressure, and reduce the possibility for leaks, a separate length of discharge tubing was used for each extraction well and a separate length of intake tubing was used for each injection well. All connections were made with 1/2-inch-I.D. vinyl tubing. Fittings were composed of nylon, polypropylene, or PVC.

Digital flow accumulators were used for each of the five injection wells and five extraction wells. Flow accumulators were capable of responding to flow rates between 0.3 and 3.0 gpm. Before installation, all ten flow accumulators were connected with 1-foot lengths of 1/2-inch-I.D. tubing and distilled water was pumped through at approximately 1.5 gpm. Accumulators were simultaneously calibrated according to the user's manual. Once calibrated, 30 gallons of distilled water were pumped through the accumulators and the readings recorded. This process was repeated several times and empirical correction factors were generated for each accumulator from the average of the readings. The correction factors were quite small. The largest factor was 2 percent, and the remaining nine values were less than 1 percent. Correction factors are listed in Attachment B2-10, Table 1.

For the injection wells, the ends of the intake tubing were taped together with a weight and placed at the bottom of the 200-gallon or 375-gallon tank or 55-gallon drum. The intake tubing was connected to diaphragm pumps, then to flow accumulators, and finally to the perforated polyethylene tubing inserted into the well casing of each of the five injection wells. The perforated polyethylene tubing inserted into each of the five extraction wells was connected to diaphragm pumps, then to flow accumulators, then to a sampling valve, and finally to discharge tubing. The ends of the discharge tubing were taped together with a weight, and also placed in a tank or drum.

Sampling equipment was also constructed for the middle injection wellpoint (I3) and the middle observation wellpoint (O3). For each of those wells, a 3/16-inch-I.D. perforated polyethylene tube was used to extract water from the wells. The polyethylene tube was connected to a peristaltic pump, which was connected to a sampling valve, and the discharge was returned to the respective well. All connections were made with 1/4-inch-I.D. vinyl tubing.

All sampling valves were mounted at the west end of the 4- by 8-foot platform to facilitate efficient sampling. The first stage of the multiple-well test consisted of establishing a uniform gradient between the row of injection and row of extraction wells (i.e., an east-west gradient). Prior to starting the liquid-level-control relays and pumps, an initial measurement was taken with the Hermit SE2000 data loggers. This was important, because the water levels fluctuated daily on the order of tenths of feet. The initial measurements were used to make small adjustments on the positioning of the perforated tubing/electrode assemblies. Once positioned, the assemblies were fastened at the top of the well casing with vinyl tape.

After preliminary adjustments were made, the liquid-level-control relays were energized and left on until the test was completed. The system was allowed to run for several hours before making adjustments. During that time, the intake and discharge tubing clusters were placed in the 200-gallon tank that had been filled with ground water during the pump test. While establishing the gradient, the injection and extraction rates were similar, so the net production or loss of fluid was nearly zero.

After an hour or more, a number of readings were taken from each channel of the Hermit data loggers. Averaged readings were compared to the initial (static) water column heights in each well. If necessary, minor adjustments were made in the positioning of the perforated tubing/electrode assemblies. Generally, adjustments were on the order of several hundredths to a few tenths of a foot. Once the water column heights seemed to be satisfactory, a 30-minute recorded run was made with the Hermit data loggers recording at 1 minute intervals to evaluate whether the gradient had stabilized. Stabilization was indicated by a relatively constant water column height in each of the five observation wells for the 30-minute period, as well as the appropriate water column heights in the extraction or injection wells. Generally, minor adjustments had to be made in the position of several of the perforated tubing/electrode assemblies, and a second 30-minute test was conducted for confirmation.

A stable gradient was actually established on three occasions on January 23, 24, and 27, 1992. Tracer injection activities for the first and second occasions were canceled, however, after Health and Safety personnel issued directives to halt operations due to high wind conditions. For each of the three occasions, between 6 and 8 hours were required to induce a satisfactory stable gradient. The third and final attempt was initially hampered by frozen water in many of the intake and discharge tubing clusters, which had to be thawed. Also small air leaks had developed in some of the intake tubing connections of some of the pumps, which inhibited their self-priming capability. Nevertheless, a satisfactory gradient was established after about 8 hours on the third test attempt, and the full tracer injection and recovery procedure was completed.

The following rearrangement of Darcy's Law was used to estimate the desired head relative to the initial water column heights:

where:

$$\Delta h = \frac{n_e(\Delta l)^2}{\Delta t\ K}$$

Δh = desired head

n_e = effective porosity

Δl = travel distance

Δt = average travel time

K = hydraulic conductivity

Assuming an effective porosity of 20 percent, a travel distance of 5 feet, an average travel time of approximately 4 hours, and a hydraulic conductivity of 2.8 x 10^{-2} cm/sec, the desired head is estimated at 0.4 foot:

$$\Delta h = \frac{.20\ (5\ ft)^2}{(240\ \text{min})\ (0.0551\ feet/minute)} = 0.4\ foot$$

Based on observed well efficiencies during the first two preliminary gradient tests, it was decided to distribute the head difference asymmetrically relative to the initial (static) water column height. About 65 percent (0.25 foot) was appropriated to the injection wells and about 35 percent (0.15 foot) was appropriated to the extraction wells. This was done to balance the injection and extraction rates. The wells were generally more efficient in the extraction mode than in the injection mode. Balancing the rates was important because of the relatively high pumping rates and the limited storage capacity available.

The bromide tracer solution was prepared in a 375-gallon tank by mixing 846 grams reagent grade potassium bromide with approximately 300 gallons of ground water extracted and decanted during the multiple-well pump test. A triple-beam balance was used to measure the potassium bromide, which was mixed with a small quantity of water before mixing in the large tank. A gasoline-powered pump (approximately 20 gpm capacity) was used to recirculate (and thereby mix) the bromide solution by placing the pump intake hose near the top of the tank and the pump discharge hose near the top of the tank. A propane-powered space heater was placed facing the tank during mixing to raise the average water temperature from 1.7°C to 4.5°C to match that of the in situ ground water. Pumping was continued for approximately 1 hour.

Additional bromide tracer solution was prepared in four lined 55-gallon drums. Ground water produced during the multiple-well pump test was mixed with 155 gram aliquots of potassium bromide in each drum. The bromide tracer solution that was prepared in the four drums was transferred to the 375-gallon tank 220 minutes after the tracer test was started.

The tracer test portion of the multiple-well tracer test was started at 15:00 on January 27, 1992. Initially, a two-person team continually collected samples from the five extraction well sampling valves and the sampling valves for the middle injection and observation wells. A third person concentrated on bromide ISE measurements, and a fourth person took readings from the flow accumulators and the Hermit data loggers and checked the pumps and other equipment. The sampling frequency was gradually reduced during the first 3 hours of the tracer test, and only two persons were required for the remaining 6 hours. A total of 271 samples were collected and analyzed in the field for bromide concentration and temperature. Eighty-seven of these samples were collected from extraction wells E1 and E5 to supplement sampling specified in the test guideline documents. The time of collection, the temperature, and the bromide ISE response in millivolts were recorded for each sample. Temperature was measured with an Orion model 122 conductivity/temperature meter and temperature-compensated probe-type specific conductivity electrode. Attachment B2-8 describes analytical methodology for bromide. The tracer-test portion of the multiple-well tracer test was run for a total of 9 hours. The test was stopped when bromide concentrations in the extraction wells and middle observation wells had stabilized.

The corrected flow accumulator readings are included in Attachment B2-10, Table 1. The corrected flow accumulator readings, converted to incremental pumping rates (Δvolume/Δt), are listed in Attachment B2-10, Table 2 and plotted in Attachment B2-10, Figure 1.

According to the flow accumulator measurements, a total of 545 gallons of bromide tracer solution was injected and a total of 860 gallons of fluid was extracted. The volume injected as recorded with the flow accumulators, 545 gallons, matches well with the estimated total volume of tracer solution that was mixed (~300 gallons + 4 x 55 gallons = 520 gallons). Despite distributing the Δh difference asymmetrically between the injection and extraction wells (65 percent increase for injection wells and 35 percent decrease for extraction wells), approximately 60 percent more fluid was extracted than was injected. That difference must be considered when interpreting the profiles of the breakthrough curves.

In addition to the disparity in total injected and extracted fluid volumes, there was a large disparity in fluid volumes pumped into and out of individual injection and extraction wells. Wells I1 through I5 were injected with 21, 3, 7, 1, and 68 percent, respectively, of the proportion of total tracer volume used. The volumes extracted from wells E1 through E5 were 43, 7, 6, 31, and 14 percent, respectively, of the proportion of total fluid volume produced. Wells I5, E1, and E4 were clearly more productive than neighboring wells. Fortunately, the more productive wells were generally adjacent to less productive wells, providing a compensating effect. In addition, the most productive wells were generally located at the ends of the row of injection and extraction wells. That was expected, because those wells were not affected by two neighboring wells as were the interior wells of each line. Furthermore, the end wells supplied or removed fluid located laterally outside of the multiple-well array in addition to upgradient or downgradient fluid. Differences in well productivity were also attributed to inhomogeneities in the sediment. The variability in injection and extraction well efficiencies were taken into account during data analysis, and the effect on the tracer test interpretation is discussed below in Section B2.3.2.2.

The pressure transducer data are compiled in Attachment B2-10, Table 3. The data are expressed relative to the initial water column heights measured on January 27, 1992 at 08:00, prior to beginning any activities affecting ground water that day. The pressure transducer data are plotted in Attachment B2-10, Figures 2 through 6 to better display trends, and are then summarized in Attachment B2-10, Table 4. The oscillation shown in the plots of all of the injection well and extraction well water levels was due to the pumps switching on and off. The amplitude in the oscillation was equal to the spacing between electrodes plus a minor component attributed to hysteresis. The average highs and lows were estimated from Attachment B2-10, Figures 2 through 6 and summarized in Attachment B2-10, Table 4. The estimated average amplitude of the oscillation ranged between 0.04 and 0.07 foot, and averaged about 0.05 foot, which is equivalent to 5/8 inch. That value is well within the acceptable range specified in the Final Phase III RFI/RI Work Plan for OU1 (EG&G 1991a). The average distance between the relative water levels of the injection well/extraction well pair defined the hydraulic head for each well pair, and are compiled in Attachment B2-10, Table 4. The mean hydraulic head for the five injection well/extraction well pairs was 0.39 foot, which was distributed with a 0.24-foot mean increase in the injection wells and a 0.15-foot mean decrease in the extraction wells. Results were very close to the intended values. The relative water level increase for injection well I5 was purposely reduced (mean level was 0.17 foot) because the productivity of that well was disproportionately high.

Several of the anomalies observed on the relative water level profiles in Attachment B2-10, Figures 2 through 6, are attributable to equipment adjustments made during the tracer test. The water mound in injection well I4 at 220 minutes resulted from manually running the well pump for a brief period to reprime the I4 intake tubing (Attachment B2-10, Figure 5). Note that it required more than 30 minutes to recover, because of the extremely low efficiency of the well. The spikes between 400 and 430 minutes for injection well I5 were also due to pump adjustments (Attachment B2-10, Figure 6). In contrast to the response for well I4, the water level in well I5 recovered quickly because of well I5's higher efficiency.

The relative water levels for the observation wells were more similar to the relative water levels for the extraction wells than for the injection wells (Attachment B2-10, Figures 2 through 6). This response can be explained because the extraction rate was about 60 percent greater than the injection rate, and the radii of influence from the extraction wells would be expected to be larger. An explanation for the apparent water mounding in observation well O4 is not clear (Attachment

B2-10, Figure 5). It may be due to a faulty pressure transducer, although the transducer showed no other signs of malfunction. It should be noted that a similar, but less extreme, pattern was recorded for observation well O5 (Attachment B2-10, Figure 6). A more plausible explanation may be that well O4 reflects neighboring well effects such as the low productivity of nearby injection well I4, and the disproportionately high productivity of nearby injection well I5. The small scale oscillation in observation well O3 may result from periodically removing samples with a peristaltic pump for bromide analysis.

The analytical results for the multiple-well tracer test are compiled in Attachment B2-10, Table 5. Bromide measurements recorded as electrode potential in millivolts were converted to concentrations in mg/l using a calibration curve made with standards at 4.6°C (Attachment B2-8). The mean temperature of the samples from the five extraction wells was 4.3 ± 0.2°C. Refer to Attachment B2-6 for field data sheets for the tracer test.

B2.3.2.2 Analysis of Test Data

In this section, results from the multiple-well tracer test are used to determine longitudinal dispersion and average linear velocity. Coupled with hydraulic conductivity data obtained during the multiple-well constant-rate pumping test results, the tracer test results are also used to determine effective porosity.

The general approach used to interpret the time-concentration data is described in Ogata (1970) and summarized in Freeze and Cherry (1979) and Davis et al. (1985). Calculations were made on a well-by-well basis, in which the three- by five-well multiple-well array was divided into five columns oriented parallel to the induced linear gradient and the natural gradient in the Woman Creek area. By examining five data sets, a general notion of variability was obtained. Refer to Freeze and Cherry (1979, p. 70-76) and Davis et al. (1985, Appendix B) for a discussion of dispersion and velocity.

Time-concentration data are tabulated in Attachment B2-10, Table 5 and plotted in Figure B2-13 for each of the five injection well/extraction well pairs. The time-concentration data from the five extraction wells show some similar features. There was generally a steady increase in bromide concentration for 150 minutes, when a plateau was reached. There was another rise in concentration at approximately 260 minutes, followed by a drop at approximately 300 minutes and another rise at approximately 400 minutes. The trends may be the result of unintended changes in the bromide concentration of the tracer solution (see Attachment B2-10, Table 5). The frequency of the fluctuations may be due to lag time in tracer travel between the injection wells and the extraction wells. The plateau at about 150 minutes may be the time at which equilibrium was reached between the influx of tracer solution contributing to each extraction well and the influx of ground water from outside (downgradient and laterally located) the multiple-well array. Such a scenario is probable because the extraction rates exceeded the injection rates by an average of approximately 60 percent.

The gross profile of time-concentration data from extraction wells E1 and E2 are similar. Extraction well E5 is also similar, but had an unexplainable decrease in concentration after 200 minutes. The profiles from extraction wells E3 and E4 are substantially steeper than the others. Only the samples collected from those two wells approached the initial concentration of the tracer, 500 mg/l. The times required to reach one half of the initial tracer concentration were also quite variable, ranging from about 25 minutes for extraction well E4 to more than 500 minutes for extraction well E1. These results are reformatted and discussed in more detail below.

Theory

To solve for longitudinal dispersion and average linear velocity, a curve-matching approach was applied using type curves generated by Ogata's (1970) solution for the one-dimensional form of the advection-dispersion equation (see Freeze and Cherry 1979, p. 389) for a step-function input of tracer solution into a semi-infinite saturated granular (porous) medium in a unidirectional flow field. The particular form of the solution selected is appropriate for the conditions under which the multiple-well tracer test was conducted.

The assumption made for that solution is that a constant-concentration plane is maintained throughout the test and the following boundary conditions exist:

- The initial concentration everywhere downgradient from the plane formed by the row of injection wells is zero
- The concentration of tracer solution at the plane formed by the row of injection wells is maintained at a constant concentration during the test
- The concentration of tracer at some distance upgradient, downgradient, and laterally from the plane formed by the row of injection wells is zero

Described mathematically, those boundary conditions are:

$$C\ (L, 0) = 0,\ L \geq 0$$

$$C\ (0, t) = C_o,\ t \geq 0$$

$$C\ (\infty, t) = 0,\ t \geq 0$$

where:

C = concentration of bromide

L = distance from the measuring point to the plane formed by the row of injection wells

t = time

The solution for those boundary conditions is:

$$C/C_o = \frac{1}{2}\ erfc\left(\frac{L - \bar{v}t}{2\ (D_l t)^{1/2}}\right) + \frac{1}{2}\ \exp\left(\frac{\bar{v}L}{D_l}\right)\ efrc\left(\frac{L + \bar{v}t}{2\ (D_l t)^{1/2}}\right)$$

where:

$\bar{v}$ = average linear velocity

D_l = longitudinal dispersion

erfc = the complimentary error function

Ogata (1970, Figure 5) solved the equation above for a family of different velocity-dispersion-distance conditions and plotted them on log-probability paper. By plotting C/C_0 versus $\bar{v}t/L$, which are dimensionless values, he produced a plot that is applicable for any tracer test configuration satisfying the boundary conditions. However, it is somewhat difficult to intuitively visualize the correlation between conventional breakthrough curve profiles and the universal curves. Consequently, the equation above was solved for specific conditions relevant to the multiple-well tracer test described herein.

For convenience, solutions to the equation were initially determined for the 50 percent breakthrough point (i.e., the time at which $C/C_0 = 0.5$). The time required for 50 percent breakthrough was determined by manually fitting a curve to plots of normalized concentration versus time on normal graph paper, and estimating the time reading to the nearest minute at which C/C_0 was 50 percent. Distance was determined using the well coordinates listed in Attachment B2-11 for each injection well/extraction well pair. With those variables defined, remaining unknown parameters are average linear velocity and longitudinal dispersion. Dispersion was then determined iteratively for a given velocity value. Using those self-consistent velocity and dispersion values, a theoretical breakthrough curve was then produced by calculating C/C_0 at 2- to 10-minute intervals between zero (actually just above zero) and 540 minutes (the length of the test).

The complimentary error function (erfc) was solved using the following close approximation from Press et al. (1989):

$$\mathbf{erfc(X) = T\ exp(-X^2+A+T(B+T(C+T(D+T(E+T(F+T(G+T(H+T(I+T(J))))))))))}$$

$$\mathbf{if\ (X < 0)\ then\ erfc(X) = 2 - erfc(X)}$$

where:

T = 1/(1 + abs(X)/2)

A = -1.26551223

B = 1.00002368

C = 0.37409196

D = 0.09678418

E = -0.18628806

F = 0.27886807

G = -1.13520398

H = 1.48851587

I = -0.82215223

J = 0.17087277

To help visualize the relationship between average linear velocity, longitudinal dispersion, and time for 50 percent breakthrough, sets of curves were made for four different velocity values for different 50 percent breakthrough times. Figures B2-14 through B2-17 are plots for average linear velocities of 0.1, 0.05, 0.01, and 0.001 foot per minute, respectively, for a distance value of 5 feet. Longitudinal dispersion values range from about 0.02 to 2.5 square feet per minute (ft^2/min). The range of velocity values and breakthrough times used to construct Figures B2-14 through B2-17 bracket the range of values for the multiple-well tracer test. It is useful to become acquainted with the profiles to interpret the multiple-well test.

As can be seen in Figures B2-14 through B2-17, as longitudinal dispersion approaches zero, the fluid moves through the system like a plug, and the front arrives almost instantaneously (see in particular the curve constructed for a "t @ C/C_o = 0.5" value of 50 minutes in Figure B2-14). For large longitudinal dispersion values, the initial arrival of tracer occurs relatively early, but the time required to reach 100 percent becomes great.

Data Analysis

Two sets of normalized concentration versus time breakthrough curves were prepared for each of the five injection well/extraction well pairs. In Figures B2-18 through B2-22, the measured bromide concentration values were normalized to 500 mg/l, which was the intended concentration of bromide in the injected tracer solution. In Figures B2-23 through B2-27, the measured bromide concentration values were normalized to the average maximum measured bromide concentration, which ranged between 210 and 460 mg/l. The rationale for that procedure is discussed below.

The match between any of the type curves (Figures B2-14 through B2-17) with the breakthrough curves constructed using 500 mg/l for C_o (Figures B2-18 through B2-22) is generally quite poor. Only the breakthrough curve produced from the middle injection well/extraction well pair (wells I3 through E3) was successfully fitted (Figure B2-20). For the remaining well pairs the early results and the late results can be fitted with moderate success, but the entire breakthrough curve cannot be matched well. Even attempts at fitting type curves calculated with unreasonably high longitudinal dispersion values did not produce satisfactory fits.

Closer examination of the test parameters for the multiple-well test reveals several contributing factors for the deviation from the theoretical breakthrough behavior. The most significant factor affecting the results is the disparity between the actual injection and extraction rates. Despite attempts to match those rates, the total volume extracted exceeded the total volume injected by approximately 60 percent (Attachment B2-10, Table 1). Consequently, the bromide concentration in the extracted fluid would never have reached that of the tracer solution, because the extraction wells were extracting non-tracer bearing water from downgradient or lateral sources, as well as the injected tracer solution. The middle extraction well (E3) would be least affected by dilution from ground water outside the system and it showed the best curve fit as discussed above. Nevertheless, the breakthrough curve shown in Figure B2-20 for the middle extraction well does not appear that it would reach 100 percent.

Secondly, there was an unintended increase in bromide concentration in the tracer solution during the test (Attachment B2-10, Table 5), possibly as a result of stratification in the 375-gallon tank used to contain the tracer solution. Stratification in the tank may have resulted from substantial freezing of the formation water in the tank prior to the test despite efforts to thoroughly mix and heat the tracer solution during the test.

The effect of the concentration increase may explain the slow steady increase in C/C_o after approximately 180 minutes in injection well/extraction well pairs 1, 2, 3, and 4. In other words, the system may have been close to equilibrium at that time. The explanation for the decrease in C/C_o in well pair 5 after 180 minutes is not clear.

The problems discussed above complicate the interpretation of the test results but are not insurmountable. The fact that the tracer concentration measured in the extracted fluid does not reach the initial concentration is not unusual for tracer tests (see Davis et al. 1985, p. 54-56).

To overcome the data problems discussed above, a second set of breakthrough curves was constructed using the average maximum bromide concentration determined from each extraction well as C_o. For each breakthrough curve, a family of type curves was generated using the specific well spacing and breakthrough times and plotted along with the breakthrough curve (Figures B2-23 through B2-27).

The match between certain type curves and the breakthrough curves is very good. A summary of the parameters for the closest matching curve for each well pair is included in Table B2-8. The most reliable results are from well pair 3. That well pair was located at the center of the linear gradient field and also had fairly well matched injection and extraction rates (refer to Attachment B2-10, Figure 1). The least reliable results are probably from well pairs 1 and 5, which were located at each end of the extraction well row and were most likely to have been extracting downgradient and lateral to gradient ground water.

In the following discussion, the average linear velocity values determined above are used with hydraulic conductivity values calculated from the multiple-well constant-rate pumping test to determine effective porosity. By combining Darcy's Law and an equation expressing the conservation of mass of water, effective porosity can be calculated directly.

$$Q = KA \frac{\Delta h}{\Delta L} \ (\textit{Darcy's Law})$$

$$Q = \bar{v}\, n_e A$$

where:

Q	=	volumetric flux (ft^3/min)
K	=	hydraulic conductivity (ft/min)
A	=	cross-sectional area (ft^2)
h	=	hydraulic head (feet)
L	=	distance (feet)
$\Delta h/\Delta L$	=	hydraulic gradient (dimensionless)
$\bar{v}$	=	average linear velocity (ft/min)
n_e	=	effective porosity (dimensionless)

Combining the equations and rearranging the variables produces the following equation:

$$n_e = \frac{K\ \Delta h/\Delta L}{\bar{v}}$$

Effective porosity values were calculated for each of the five injection well/extraction well pairs. Results range from a low of 2 percent to a high of 12 percent and are summarized in Table B2-9.

Interpretation of Results

The most reliable values for average linear velocity, longitudinal dispersion, and effective porosity are probably those determined from analysis of well pair 3. The bromide time-concentration data from that well pair produced a profile closest to the anticipated results. This is easily explained because well pair 3 was in the center of the linear gradient system. Furthermore, anomalies in matching injection and extraction rates were least severe near the central area of the multiple-well array. Results from the well pairs at the ends of the rows (well pairs 1 and 5) should be disregarded because of disproportionate pumping rates in several of those wells and their locations on the fringe of the linear gradient system. The longitudinal dispersion value calculated for well pair 4 was unusually high, and should probably be disregarded. There is a favorable comparison between results from well pair 3 calculated from curves using a C_o value of 461 mg/l (Figure B2-25, Tables B2-8 and B2-9) and the results calculated from curves using a C_o value of 500 mg/l in which early data and late data were matched separately (Figure B2-20, Tables B2-8 and B2-9). In fact, the later results bracket the former results. The most reliable approximate results are as follows:

- Average linear velocity was 0.07 ± 0.02 foot per minute
- Longitudinal dispersion was 0.2 ± 0.1 ft^2 per minute
- Effective porosity was 5 to 10 percent

Longitudinal dispersion can be more readily compared to published values by dividing it by average linear velocity to yield a value for longitudinal dispersivity:

$$\alpha L = \frac{D_l}{\bar{v}}$$

where:

αL = longitudinal dispersivity (feet)

D_l = longitudinal dispersion (ft^2/min; or coefficient of dispersion in direction of L)

v = average linear velocity (ft/min)

Using the values above, longitudinal dispersivity is approximately 3 feet. Longitudinal dispersivity is highly scale dependent and must be considered in context with the fluid transport distance (Davis et al. 1985; Neuman 1990).

The most significant factors affecting the accuracy and precision of the tracer test results stem from unanticipated sediment heterogeneity, particularly the cobble and pebble content of the sediment that affected wellpoint placement, and variability of hydrologic parameters. The multiple-well tracer test had been designed with the expectation of substantially lower pumping rates and longer travel times. In retrospect, considering the high observed pumping rates, the multiple-well tracer test would have benefitted from a larger well spacing. However, it is recognized there were also severe constraints upon test site locations because of the lack of saturated conditions.

During installation of the multiple-well array, several problems were encountered associated with sediment heterogeneity. Several wellpoint locations had to be shifted slightly because of obstructions (boulders or cobbles) encountered during drilling. Furthermore, pilot holes were drilled through a majority of the screened interval because the wellpoints could not be driven through the screened interval to total depth. The net effect of the installation problems was that the distance of undisturbed sediment between the wellpoints was reduced, possibly resulting in an increase in the measured average linear velocity values already exacerbated by in-homogeneous conditions.

Further problems included the necessity of developing several wellpoints by repeated surging to improve their production characteristics. Initially, some of the wellpoints would not produce any fluid. Despite taking great care in development, the production characteristics of the wells were not uniform and in fact were quite unpredictable. However, there was no correlation between pumping rates (see Attachment B2-10, Figure 1) and whether a particular well had been developed by surging. Inspection of the well screens after they had been removed indicated that variabilities in well production rates were not due to screen collapse during installation although several did show distorted shapes. Problems associated with well development and sediment heterogeneity may account for the variability in average linear velocity, longitudinal dispersion, and effective porosity determined for each of the five well pairs.

Considering the nature of the Woman Creek alluvial sediments and complications associated with the installation and development of the wells, the calculated average linear velocities seem to be somewhat high and the effective porosities seem to be too low. Those variables are inversely related (see equation above), and it is best to consider them jointly for analysis. Doubling the effective porosity reduces the velocity by a factor of two, and yields more realistic values. Comparison of the calculated longitudinal dispersivity value with values determined by other workers over an approximately 1.5-meter distance suggests that the value determined herein is somewhat high (see Davis et al. 1985, Table B.1, and Neuman 1990, Figures 1-3).

B2.3.2.3 Well Abandonment and Decontamination

The wellpoints for the single-well and multiple-well tests were withdrawn from the ground on January 29, 1992, following the completion of the multiple-well tracer test. The remaining boreholes were grouted according to Geotechnical SOP GT.05 (EG&G 1991b) using the equipment listed in Attachment B2-5. Attachment B2-6 presents the borehole abandonment forms.

Although the Site 1 area is not classified as a potentially contaminated area, nor was the presence of contamination indicated during environmental field monitoring conducted during drilling for the test site, the decontamination procedures for equipment established in the Field Operations SOPs (i.e., FO.03, FO.04, FO.12, EG&G 1991b) were followed as general practice. Equipment used at the site was decontaminated both prior to and after its use at the site whether it was being stored at RFP or was removed from the plant.

B2.4 SUMMARY OF RESULTS AND CONCLUSIONS

Estimates of aquifer transmissivity, specific yield, effective porosity, linear dispersion, and average linear ground water velocity for the Woman Creek alluvium were determined from the pumping and tracer tests and are summarized below.

B2.4.1 Pumping Tests

The Neuman, Cooper-Jacob, and Theis Recovery methods all produced similar estimates of aquifer hydraulic conductivity and are presented below:

Analysis Method	Hydraulic Conductivity Range (cm/sec)	Hydraulic Conductivity Geometric Mean (cm/sec)	Specific Yield Range	Specific Yield Geometric Mean
Cooper-Jacob	1.8×10^{-2} to 2.5×10^{-2}	2.0×10^{-2}	0.31 to 2.2	0.64
Neuman	1.5×10^{-2} to 2.4×10^{-2}	1.9×10^{-2}	0.30 to 2.0	0.63
Theis Recovery	1.9×10^{-2} to 2.7×10^{-2}	2.2×10^{-2}	-	-
Distance - Drawdown	3.0×10^{-2} to 4.5×10^{-2}	3.6×10^{-2}	0.11 to 0.18	0.15

The values determined by the distance-drawdown method were also in good agreement. The mean hydraulic conductivity of 2.0×10^{-2} cm/sec determined from the Cooper-Jacob method probably is the best estimate of the hydraulic conductivity of the alluvial aquifer. Figure 2B-28 is a bar graph that shows by wellpoint the hydraulic conductivities determined using each analysis method. As the figure indicates, the Theis Recovery method estimated the highest hydraulic conductivity of any method for every wellpoint except wellpoint O5. (Note: data from wellpoints E2 and O4 which were not analyzed using the Theis Recovery method). These estimates may be higher than the actual hydraulic conductivity as analysis of recovery data for pumping tests conducted in unconfined aquifers may give a slightly high value of hydraulic conductivity (Water and Power Resources Service 1981). The Neuman analysis provided the same mean estimate of hydraulic conductivity as the Cooper-Jacob. However, the Neuman method provided less reliable results than the other methods given the poor Neuman curve matches of early time data. The geometric mean hydraulic conductivity estimated from the distance-drawdown analysis is higher than determined from the other analysis and is probably less representative of the aquifer. The analysis required more extrapolation of data because the observation wells were located in close proximity to each other. The estimated values of hydraulic conductivity for the Woman Creek alluvium fall within the typical range of values for sands and gravels 10 to 10^{-3} cm/sec (Nielsen 1991). Gravels were commonly noted during the installation of the pilot hole and wellpoints in the area. The hydraulic conductivity values obtained from the multiple-well test for the Woman Creek alluvium are believed to be more reasonable than the previously reported single-well drawdown/recovery test values. Also, well bore storage and well construction problems are less likely to influence multiple-well tests compared to single-well tests.

Estimates of specific yield values obtained for the test are unreasonably high, since values for sands and gravels normally range from 0.10 to 0.30 (Nielsen 1991). Many of the estimated specific yields exceeded unity, thus these analyses are invalid. The specific yield data does show a distinct trend when plotted against the distance of the observation wellpoints from the pumping wellpoint as shown in Figure 2B-29. The closer the observation wellpoint is to the pumping wellpoint, the higher the specific yield. Unity is exceeded when the wellpoint is less than 3 feet from the pumping wellpoint and unrealistic values of specific yield are estimated when this distance is less than 5 feet. The specific yields estimated from wellpoints over 5 feet from the pumping well are in the range of 0.30 to 0.35, with one exception, wellpoint I1 with a specific yield of 0.46 from Cooper-Jacob analysis. The results of this test indicate that for future tests observation wells should be located a distance greater than 5 feet from the pumping well to obtain realistic estimates of specific yield.

The distance-drawdown analysis provided some consistent estimates for the specific yield ranging from 0.11 to 0.18 with a geometric mean of 0.15. This estimate is within a valid range for this aquifer.

The results of the pumping test are appropriate for the geologic materials present in the area. The drill logs for the pilot borehole and nearby wells indicate that the alluvial material is silty, clayey, gravel. Boulders are apparent in the nearby stream bed and were encountered when the wellpoints were installed causing problems with wellpoint placement. In addition, considerable silt was removed from the aquifer when the wells were developed.

Doty and Associates reported pump test analysis results for data from some of the wellpoints in a January 1992 report. The January report presented results of a Cooper-Jacob straight line analysis for data from wellpoints O3, O2, O1, and I1 using both the early time and late time drawdown data and unadjusted recovery data. The January report presented geometric means of 2.7×10^{-1} cm/sec for early drawdown data, 1.8×10^{-2} cm/sec for late drawdown data, 5.3×10^{-1} cm/sec for early recovery data, and 3.1×10^{-2} cm/sec for late recovery data. The January report presented results of a distance-drawdown analysis using wellpoints O2, I2, O1, and I1 that estimated a geometric mean hydraulic conductivity of 1×10^{-1} cm/sec. The January report presented data from wellpoints O2, I2, O1, and I1 analyzed using Boulton's method for delayed yield that estimated geometric mean hydraulic conductivities of 2.7×10^{-2} cm/sec for early data and 1.2×10^{-2} cm/s for late data. The January report also presented storage coefficient estimates from the Boulton's method with arithmetic means of 0.7 for early data and 1.44 for late data. The January report concluded that the hydraulic conductivity is 1.8×10^{-2} cm/sec and the storage coefficient is 1.0.

The January report results are similar to the results presented in this report. The hydraulic conductivities estimated using the Cooper-Jacob method for late time data were nearly identical in both reports. The recovery late time data hydraulic conductivities are lower in this report then in the January report because the analysis presented here included an adjustment of the data to remove a trend of decreasing water levels not caused by the pumping test.

The January report presented used the Boulton method of analysis to examine the affects of delayed yield whereas the Neuman method was used in this report. The Boulton method is a curve matching procedure that provides two separate match points, one for early time data and one for late time data that are used to estimate early and late time aquifer properties. The

Neuman method matches a curve to the entire data set and estimates one set of hydraulic parameters. The Neuman method was used here instead of the Boulton method because Boulton requires the definition of an empirical constant, known as the Boulton's delay index, which is not clearly related to any physical phenomenon (Kruseman and de Ridder 1989). Though most of the data did not provide good early time Neuman curve matches, data from wellpoints O3 and O4 were good matches for the entire data set.

Early time drawdown data was not analyzed in this report using the Cooper-Jacob method because most of the early time data exceeded the Cooper-Jacob criteria ($u < 0.05$) and early time results would reflect the effects of delayed yield and the alterations to the natural aquifer caused by well installation and development. Early time recovery data was not analyzed using the Theis Recovery method because early time data reflect the impacts of elastic storage which set in after pumping stops (Kruseman and de Ridder 1989).

In conclusion, the hydraulic conductivity of the alluvial aquifer in the vicinity of Woman Creek is estimated as 1.8×10^{-2} to 2.0×10^{-2} cm/sec and the specific yield is estimated as 0.15 to 0.2. If an accurate estimate of specific yield is desired, another pumping test should be conducted with a minimum of one observation well located a distance greater than 5 feet from the pumping well.

B2.4.2 <u>Tracer Tests</u>

Results from the multiple-well tracer test were used to determine average linear velocity, longitudinal dispersion, and effective porosity. Sets of values were determined for each of the five injection well/extraction well pairs. The most reliable values were obtained from the middle well pair. Approximate values were as follows:

- Average linear velocity was 0.07 ± 0.02 ft/min
- Longitudinal dispersion was 0.2 ± 0.1 ft^2/min
- Effective porosity was 5 to 10 percent

Judging from the physical appearance of the Woman Creek alluvium, this calculated average linear velocity may be too high and the effective porosity may be somewhat low. Comparison of the longitudinal dispersivity determined herein with values determined by other workers over similar distances suggests that the value determined from this test is somewhat large. Probable deviations are attributed to unexpected textural characteristics of the Woman Creek alluvium and complications associated with installation and development of the wells. Extrapolation of the results determined from this study to a regional scale or to materials with differing characteristics should be made with caution. One should consider regional changes in sediment textural properties as well as the scale dependency of dispersion.

Appendix B2 · Tables

Multiple-Well Test Data

Phase III
RFI/RI Report

Table B2-1. Wellpoint Installation Summary

Wellpoint	Date Installed	Diameter (inch)	Depth Augered (feet)	Depth to Bottom of Screen (feet)	Stickup (feet)
SINGLE WELL					
39891	11/27/91	1.7	5.0	5.8	0.95
MULTIPLE-WELL ARRAY					
I1	12/08/91	1.7	6.5	6.2	0.82
I2	12/08/91	1.7	6.5	6.0	0.92
I3	12/08/91	1.7	5.5	6.0	1.05
I4	12/08/91	1.7	4.5	6.1	1.06
I5	12/08/91	1.7	5.0	6.2	1.03
O1	12/07/91	1.7	6.0	6.2	0.80
O2	12/07/91	1.7	6.0	6.1	0.80
O3	12/07/91	1.7	5.0	6.0	0.97
O4	12/07/91	1.7	5.5	6.0	1.00
O5	12/08/91	1.7	5.0	6.0	0.90
E1	12/07/91	1.7	4.7	5.9	1.10
E2	12/07/91	1.7	5.0	5.9	1.00
E3	12/07/91	1.7	5.5	6.1	0.90
E4	12/07/91	1.7	5.5	6.0	0.99
E5	12/07/91	1.7	5.5	6.1	0.75

Notes: Measurements are from ground surface. Depth to bottom of screen was measured during development of well points. Survey coordinates for the well points are included in Attachment B2-11. Well screen length is 5 feet.

Table B2-2. Wellpoint Development Summary

Wellpoint	Dates Developed	Development Method: Bail	Development Method: Pump	Development Method: Add Decanted Development Water and Bail	Development Method: Surge Block	Final Parameters: pH	Final Parameters: SC (µmhos/cm)	Final Parameters: T(°C)
SINGLE-WELL								
39891	12/02, 12/03/91	X				7.73	960	5.1
MULTIPLE-WELL ARRAY								
I1	12/09, 12/15, 12/16/91	X	X			7.06	868	4.8
I2	12/09, 12/15, 12/16/91	X	X			7.00	1002	5.1
I3	12/09, 12/15, 12/16/91	X	X			6.99	1012	5.3
I4	12/09, 12/15, 12/16/91	X	X			7.00	1016	5.3
I5	12/09, 12/15, 12/16/91	X	X			7.02	1015	5.4
O1	12/09, 12/16/91	X	X			7.01	996	5.4
O2	12/14, 12/15, 12/16/91	X	X	X		7.01	988	5.5
O3	12/14, 12/15, 12/16/91	X	X	X	X	7.02	986	5.6
O4	12/14, 12/16/91	X	X			7.02	973	6.0
O5	12/09, 12/16/91	X	X			7.03	964	5.5
E1	12/09, 12/14, 12/15, 12/16/91	X	X		X	7.06	973	5.4
E2	12/14, 12/15, 12/16/91	X	X	X	X	7.18	960	5.5
E3	12/14, 12/16/91	X	X			7.00	956	5.6
E4	12/14, 12/15, 12/16/91	X	X		X	7.02	956	5.6
E5	12/09, 12/14, 12/15, 12/16/91	X	X	X	X	7.02	945	5.5

T = Temperature
SC = Specific Conductance

Table B2-3. Water Quality Sample Results

Chemical	Results (mg/l)	*Background Upper Tolerance Limit (mg/l)
Aluminum	4.03	
Antimony	0.025 B	
Arsenic	0.002 U	
Barium	0.133 B	
Beryllium	0.001 U	
Cadmium	0.006	
Calcium	77.9	
Chromium	0.017	
Cobalt	0.003 U	
Copper	0.016 B	
Iron	4.51	
Lead	0.003	
Magnesium	31.8	
Manganese	0.197	
Mercury	0.0002 U	
Nickel	0.068	
Potassium	1.64 B	
Selenium	0.004 B	
Silver	0.002 U	
Sodium	88.1	
Thallium	0.001 U	
Vanadium	0.015 B	
Zinc	0.088 E	
Cesium	0.051 U	
Lithium	0.054 BE	

Upper limit of tolerance interval reported in the 1990 Background Geochemical Characterization Report (DOE 1990)

* Background values not presented for metals because values in 1990 Geochemical Characterization Report represent dissolved metals concentrations whereas the results presented in this table represent total metals concentrations

B Indicates the compound was found in the blank and in the sample
E Concentration exceeds calibration range of the instrument
U Indicates compound was analyzed for, but not detected

Table B2-3. Water Quality Sample Results

Chemical	Results (mg/l)	*Background Upper Tolerance Limit (mg/l)
Molybdenum	0.008 B	
Stontium	0.738	
Tin	0.017 U	
Bicarbonate as $CaCO_3$	310.0	249.35
Bromide	2.00 U	
Chloride	76.00	21.98
Fluoride	1.50	
Nitrate/Nitrite	0.08	3.43
Sulfate	120.00	67.08
Total Dissolved Solids	620.00	388.76
Total Organic Carbon	9.00	

Upper limit of tolerance interval reported in the 1990 Background Geochemical Characterization Report (DOE 1990)

* Background values not presented for metals because values in 1990 Geochemical Characterization Report represent dissolved metals concentrations whereas the results presented in this table represent total metals concentrations

B Indicates the compound was found in the blank and in the sample
E Concentration exceeds calibration range of the instrument
U Indicates compound was analyzed for, but not detected

Table B2-4. Data Logger Standard Log Schedule

Log Cycle	Elapsed Time	Sample Interval
1	0 - 5 seconds	0.5 second
2	5 - 20 seconds	1 second
3	20 - 120 seconds	5 seconds
4	2 - 10 minutes	0.5 minute
5*	10 - 100 minutes	1 minute
6	100 - 1,000 minutes	10 minutes
7	1,000 - 10,000 minutes	100 minutes
8	> 10,000 minutes	500 minutes

*Note: Sample interval is 2 minutes for the multiple-well pumping test for an elapsed time of 10 to 100 minutes.

Table B2-5. Multiple-Well Pumping Test Analysis - Cooper- Jacob, Neuman, and Theis Recovery Methods

			ANALYSIS METHOD: Cooper-Jacob				Neuman				Theis Recovery			
Well	b (ft)	r (ft)	T (ft^2/min)	K (ft/min)	K (cm/sec)	S	T (ft^2/min)	K (ft/min)	K (cm/sec)	S	T (ft^2/min)	K (ft/min)	K (cm/sec)	S'
I1	3.68	5.15	0.1338	0.0364	0.0185	0.4650	0.1398	0.0380	0.0193	0.3075	0.1951	0.0530	0.0269	1.717
I2	3.47	3.05	0.1497	0.0431	0.0219	1.1450	0.1494	0.0431	0.0219	1.139	0.1560	0.0450	0.0228	1.621
I3	3.51	2.42	0.1372	0.0391	0.0199	1.5740	0.1292	0.0368	0.0187	1.5800	0.1564	0.0446	0.0226	1.721
I4	3.54	3.24	0.1217	0.0344	0.0175	0.9527	0.1145	0.0323	0.0164	0.9020	0.1625	0.0459	0.0233	1.81
I5	3.56	5.38	0.1391	0.0391	0.0198	0.3137	0.1353	0.0380	0.0193	0.3036	0.1460	0.0410	0.0208	1.692
O1	3.72	4.51	0.1325	0.0356	0.0181	0.5508	0.1382	0.0372	0.0189	0.4883	0.1694	0.0455	0.0231	1.736
O2	3.65	2.25	0.1338	0.0367	0.0186	2.1720	0.1344	0.0368	0.0187	2.0170	0.1633	0.0447	0.0227	1.627
O3	3.37	0.071	0.1298	0.0385	0.0196	NC	0.1191	0.0353	0.0180	181.9	0.1425	0.0423	0.0215	1.609
O4	3.56	2.53	0.1723	0.0484	0.0246	0.6971	0.1273	0.0358	0.0182	1.162	NC	NC	NC	NC
O5	3.47	4.99	0.1321	0.0381	0.0193	0.5036	0.1264	0.0364	0.0185	0.5547	0.1298	0.0374	0.0190	1.599
E1	3.73	5.33	0.1418	0.0380	0.0193	0.3550	0.1476	0.0396	0.0201	0.3241	0.1581	0.0424	0.0215	1.62
E2	3.83	3.47	0.1873	0.0489	0.0248	0.3498	0.1837	0.0480	0.0244	0.3363	NC	NC	NC	NC
E3	3.71	3.44	0.1315	0.0354	0.0180	0.7463	0.1103	0.0297	0.0151	0.8121	0.1556	0.0419	0.0213	1.719
E4	3.56	3.84	0.1345	0.0378	0.0192	0.5952	0.1491	0.0419	0.0213	0.4998	0.1565	0.0440	0.0223	1.473
E5	3.27	5.51	0.1292	0.0395	0.0201	0.3450	0.1171	0.0358	0.0182	.3394	0.1482	0.0453	0.0230	1.673

Cooper-Jacob and Neuman analyses methods were completed for manual time-drawdown measurements for Wells 04 and E2 due to apparent transducer malfunctions.

Specific yield cannot be determined for the pumped well (Well 03) and therefore is not presented.

b = Initial saturated thickness
r = Distance from pumping well
NC = Not calculated
T = Transmissivity
K = Hydraulic conductivity
S = Specific yield
S' = Ratio of pumping storativity to recovery storativity

Table B2-5. Multiple-Well Pumping Test Analysis - Cooper- Jacob, Neuman, and Theis Recovery Methods

			ANALYSIS METHOD: Cooper-Jacob				Neuman				Theis Recovery			
Well	b (ft)	r (ft)	T (ft^2/min)	K (ft/min)	K (cm/sec)	S	T (ft^2/min)	K (ft/min)	K (cm/sec)	S	T (ft^2/min)	K (ft/min)	K (cm/sec)	S'
Geometric Mean			0.1395	0.0391	0.0198	0.6416	0.1337	0.0374	0.0190	0.6268	0.1562	0.0439	0.0223	1.661
Arithmetic Mean			0.1404	0.0393	0.0199	0.7689	0.1348	0.0376	0.0191	0.7690	0.1569	0.0441	0.0224	1.663
Standard Deviation			0.0168	0.0042	0.0021	0.5191	0.0178	0.0042	0.0021	0.5157	0.0148	0.0034	0.0017	0.081
High			0.1873	0.0489	0.0248	2.1720	0.1837	0.0480	0.0244	2.0170	0.1951	0.0530	0.0269	1.810
Low			0.1217	0.0344	0.0175	0.3137	0.1103	0.0297	0.0151	0.3036	0.1298	0.0374	0.0190	1.473

Cooper-Jacob and Neuman analyses methods were completed for manual time-drawdown measurements for Wells 04 and E2 due to apparent transducer malfunctions.

Specific yield cannot be determined for the pumped well (Well 03) and therefore is not presented.

b = Initial saturated thickness
r = Distance from pumping well
NC = Not calculated
T = Transmissivity
K = Hydraulic conductivity
S = Specific yield
S' = Ratio of pumping storativity to recovery storativity

Table B2-6. Distance-Drawdown Method

Corrected Time (min)	T (ft^2/min)	K (ft/min)	K (cm/s)	S
100	0.323	0.089	0.045	0.18
200	0.270	0.074	0.038	0.18
300	0.242	0.067	0.034	0.14
400	0.247	0.068	0.035	0.11
480	0.211	0.058	0.030	0.16
Geometric Mean	0.256	0.071	0.036	0.15
Arithmetic Mean	0.259	0.071	0.036	0.15
Standard Deviation	0.037	0.010	0.005	0.03
High	0.323	0.089	0.045	0.18
Low	0.211	0.058	0.030	0.11

Distance-drawdown analysis conducted on Wellpoints I1, O1, O5, E3, and E4.
T = Transmissivity
K = Hydraulic conductivity

Table B2-7. Summary of Multiple-Well Pumping Test Analyses

	RFI/RI Phase III Pumping Test Analysis Method				Woman Creek Previous Results
	Cooper-Jacob	Neuman	Theis Recovery	Distance-Drawdown	Drawdown/Recovery
Transmissivity:					
Range (ft^2/min)	1.2×10^{-1} to 1.9×10^{-1}	1.1×10^{-1} to 1.8×10^{-1}	1.3×10^{-1} to 2.0×10^{-1}	2.1×10^{-1} to 3.2×10^{-1}	
Geometric Mean (ft^2/min)	1.4×10^{-1}	1.3×10^{-1}	1.6×10^{-1}	2.6×10^{-1}	
Hydraulic Conductivity:					
Range (ft/min)	3.4×10^{-2} to 4.9×10^{-2}	3.0×10^{-2} to 4.8×10^{-2}	3.7×10^{-2} to 5.3×10^{-2}	5.8×10^{-2} to 8.9×10^{-2}	
Geometric Mean (ft/min)	3.9×10^{-2}	3.7×10^{-2}	4.4×10^{-2}	7.1×10^{-2}	
Range (cm/sec)	1.8×10^{-2} to 2.5×10^{-2}	1.5×10^{-2} to 2.4×10^{-2}	1.9×10^{-2} to 2.7×10^{-2}	3.0×10^{-2} to 4.5×10^{-2}	3×10^{-4} to 3×10^{-3}
Geometric Mean (cm/sec)	2.0×10^{-2}	1.9×10^{-2}	2.2×10^{-2}	3.6×10^{-2}	
Specific Yield:					
Range	0.31 to 2.2	0.30 to 2.0	Not calculated	0.11 to 0.18	
Geometric Mean	0.64	0.63		0.15	

Table B2-8. Summary of Average Linear Velocity and Longitudinal Dispersion Values

Well Pair	L (ft)	C_o (mg/l)	t @ C_{max} (min)	t @ $C/C_o = 0.5$ (min)	$\bar{v}$ (ft/min)	D_l (ft^2/min)
I1-E1	4.78	213	464	95	0.035	0.076
I2-E2	5.04	300	443	91	0.040	0.081
I3-E3	5.85	461	462	47	0.090	0.21
I4-E4	5.05	388	461	16	0.10*	1.2*
I5-E5	4.75	313	118	18	0.18*	0.42*
I3-E3**(early)	5.85	500	-	49	0.050	0.43
I3-E3***(late)	5.85	500	-	49	0.10	0.12

Notes:

Results correspond to breakthrough curves plotted in Figures B2-23 to B2-27 except as noted below.

L = distance between the injection and extraction wells (data in Attachment B2-11 and calculations in Attachment B2-10, Table 4).

C_o = either 500 mg/l, the intended tracer concentration, or was defined as the average maximum estimated from the bromide concentration data.

t @ C_{max} = the time at which the average maximum bromide concentration was defined.

t @ $C/C_o = 0.5$ is the time at which 50 percent breakthrough had occurred, estimated from each breakthrough curve.

$\bar{v}$ = average linear velocity for the type curve that most closely matches the observed breakthrough curve (Figures B2-23 to B2-25).

D_l = longitudinal dispersion for the type curve that most closely matches the observed breakthrough curve (Figures B2-23 to B2-25).

* $\bar{v}$ and D_l were determined by interpolating between two type curves that bracketed the observed breakthrough curves (Figures B2-23 to B2-25).

** Results correspond to the breakthrough curve plotted in Figure B2-20 (C_o = 500 mg/l), with early data matched.

***Results correspond to the breakthrough curve plotted in Figure B2-20 (C_o = 500 mg/l), with late data matched.

Table B2-9. Summary of Effective Porosity Values

Well Pair	K (ft/min)	Δh (ft)	ΔL (ft)	$\Delta h/\Delta L$	$\bar{v}$ (ft/min)	n_e (%)
I1-E1	0.047	0.42	4.78	0.088	0.035	12
I2-E2	0.045	0.40	5.04	0.078	0.040	9
I3-E3	0.043	0.41	5.85	0.071	0.090	3
I4-E4	0.045	0.42	5.05	0.083	0.10	4
I5-E5	0.041	0.32	4.75	0.067	0.18	2
I3-E3**(early)	0.043	0.41	5.85	0.071	0.050	6
I3-E3***(late)	0.043	0.41	5.85	0.071	0.10	3

Notes:

Results correspond to breakthrough curves plotted in Figures B2-23 to B2-27 except as noted below.

K = hydraulic conductivity calculated using the Theis Recovery method. Values listed are averaged values from the injection, observation, and extraction wells, except for sets 2 and 4, for which no conductivity values were available for the extraction well (E2) and observation well (O4), respectively, due to pressure transducer malfunctions.

Δh = hydraulic head (Attachment B2-10, Table 4).

ΔL = distance between the injection well and extraction well (data in Attachment B2-11, Table 1 and calculations in Attachment B2-10, Table 4).

$\Delta h/\Delta L$ = hydraulic gradient.

$\bar{v}$ = average linear velocity (Table B2-8).

n_e = calculated effective porosity (see text).

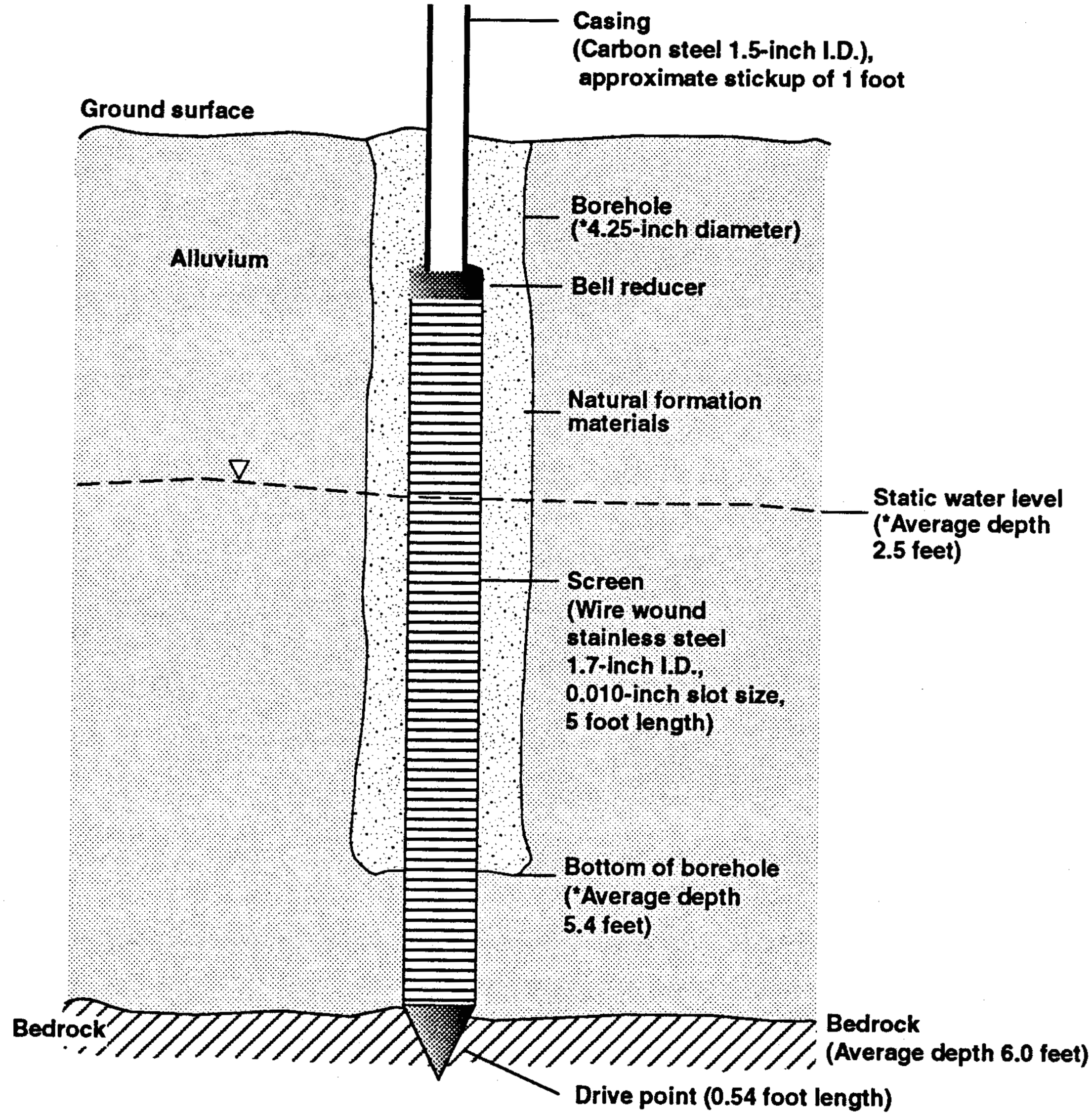
** Results correspond to the breakthrough curve plotted in Figure B2-20 (C_o = 500 mg/l), with early data matched.

***Results correspond to the breakthrough curve plotted in Figure B2-20 (C_o = 500 mg/l), with late data matched.

Appendix B2 · Figures

Multiple-Well Test Data

Phase III
RFI/RI Report



* For single well point 39891:

Borehole diameter	6 inches
Static water level	2 feet
Bottom of borehole	5 feet

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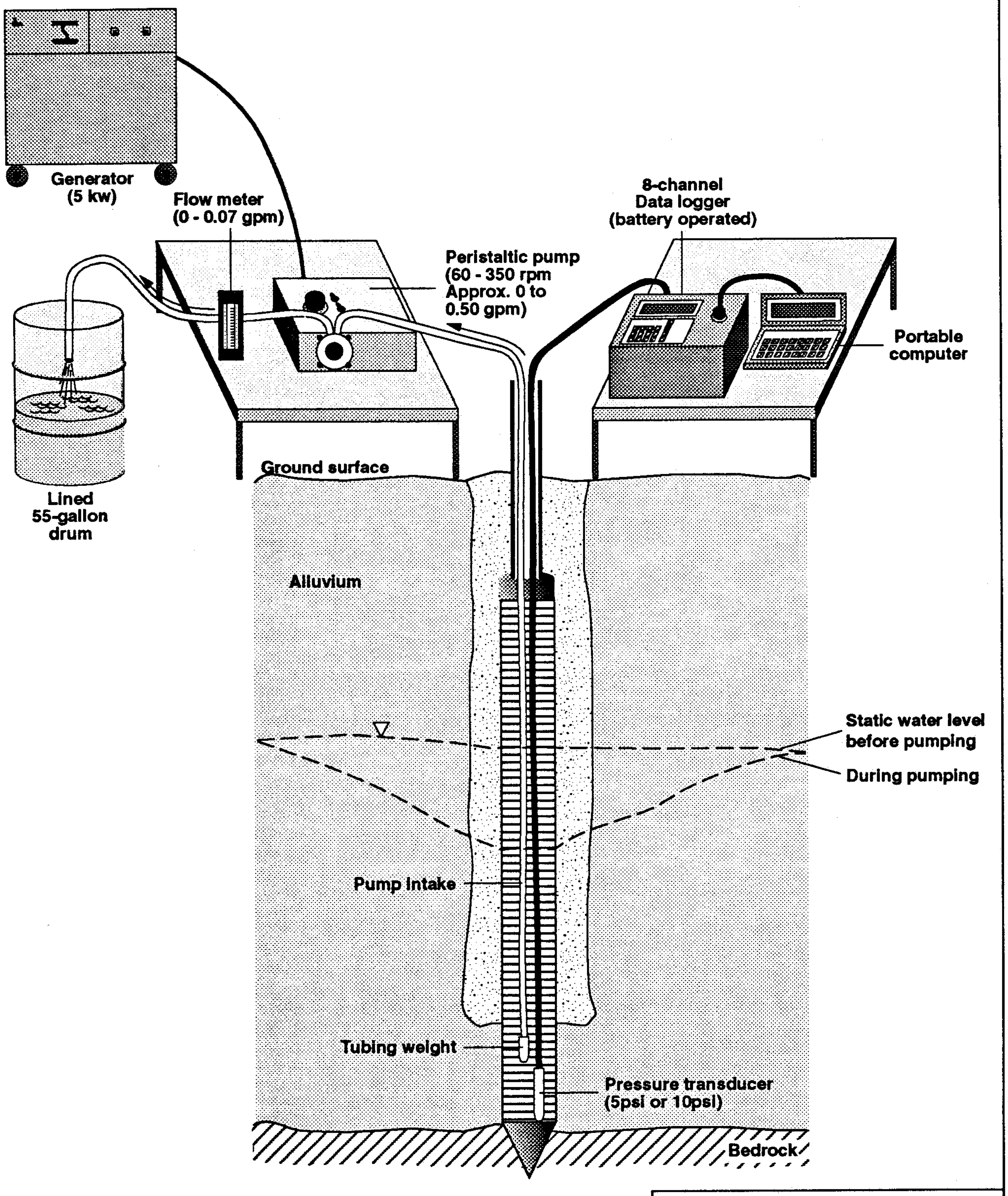
Phase III RFI/RI Report

General Wellpoint Construction

Figure B2-2 June 1992



Drawing not to scale.

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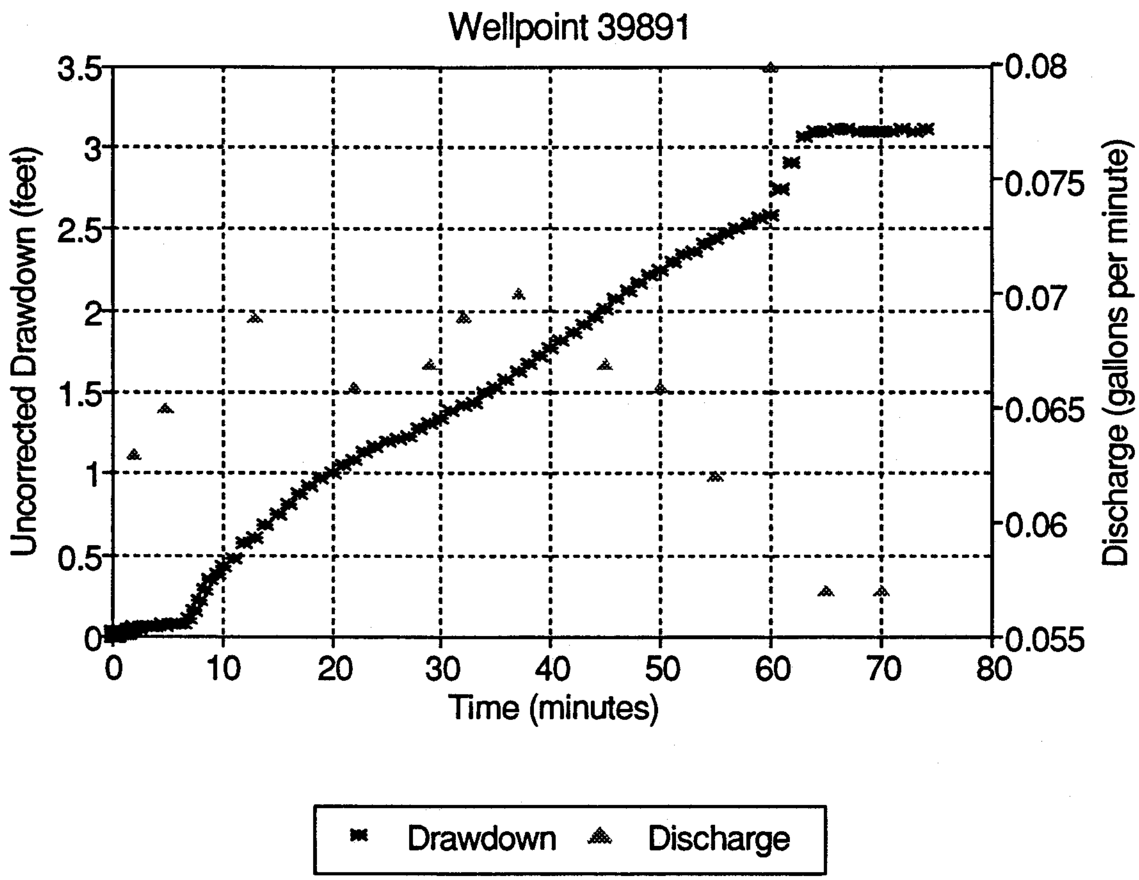
Single-Well Step-Drawdown Test Setup

Figure B2-3 June 1992



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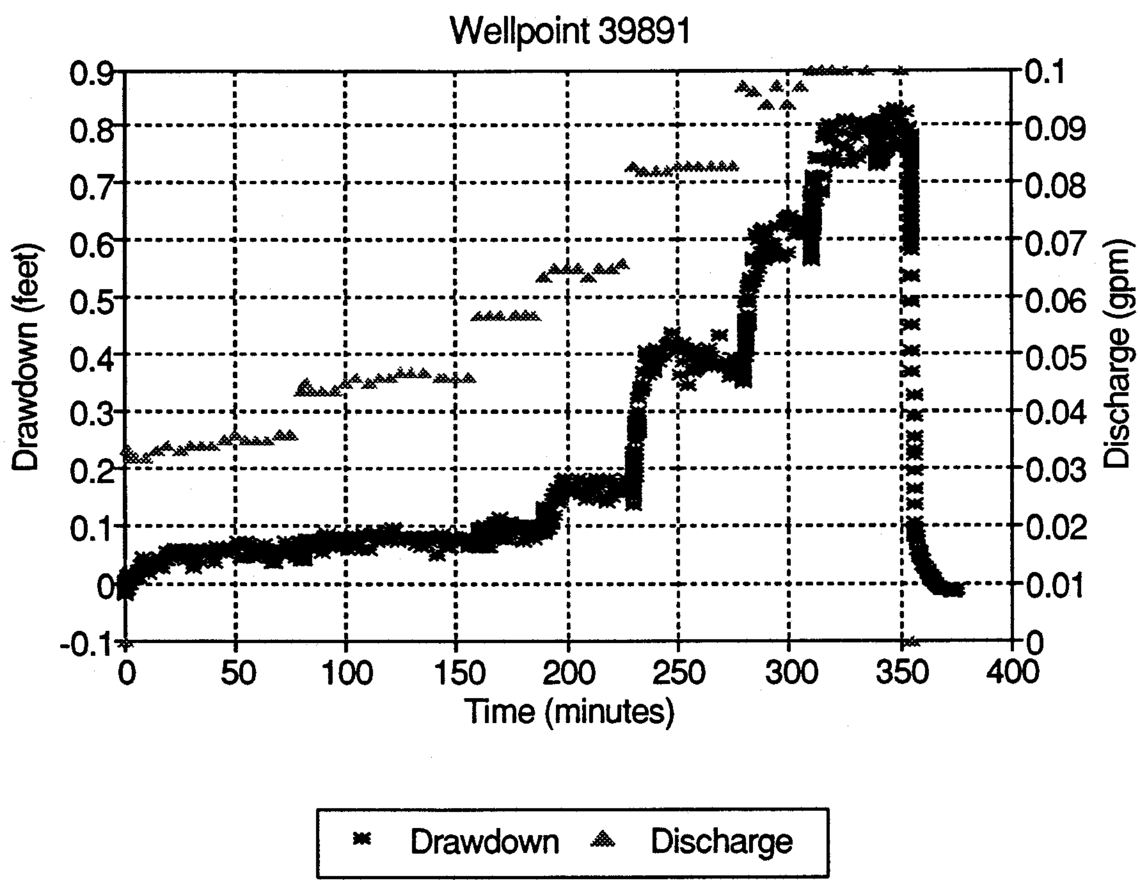
PHASE III RFI/RI REPORT

December 3, 1991
Step-Drawdown Test Results
Figure B2-4

JUNE 1992



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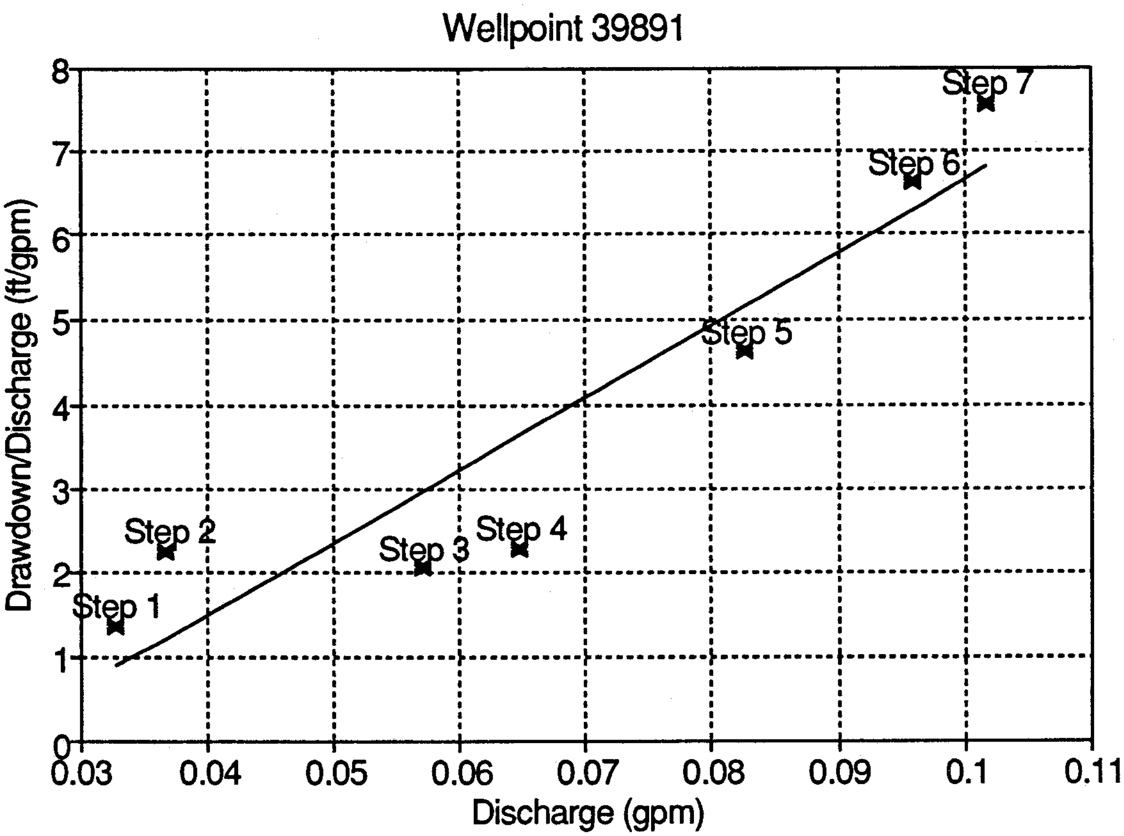
December 6, 1991
Step-Drawdown Test Results
Figure B2-5

JUNE 1992



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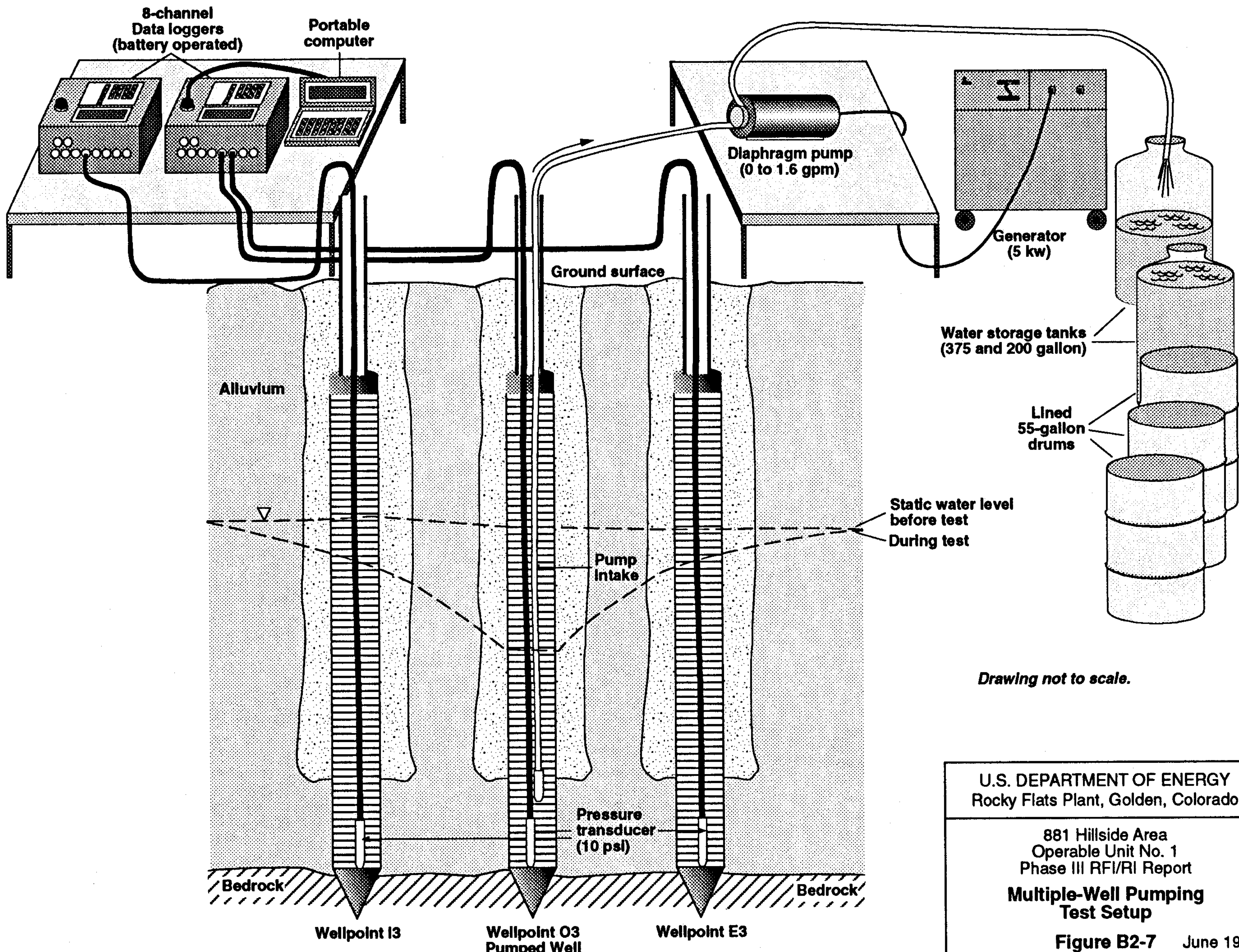
PHASE III RFI/RI REPORT

December 6, 1991
Step-Drawdown Test Results
Hantush-Bierschenk Analysis
Figure B2-6

JUNE 1992



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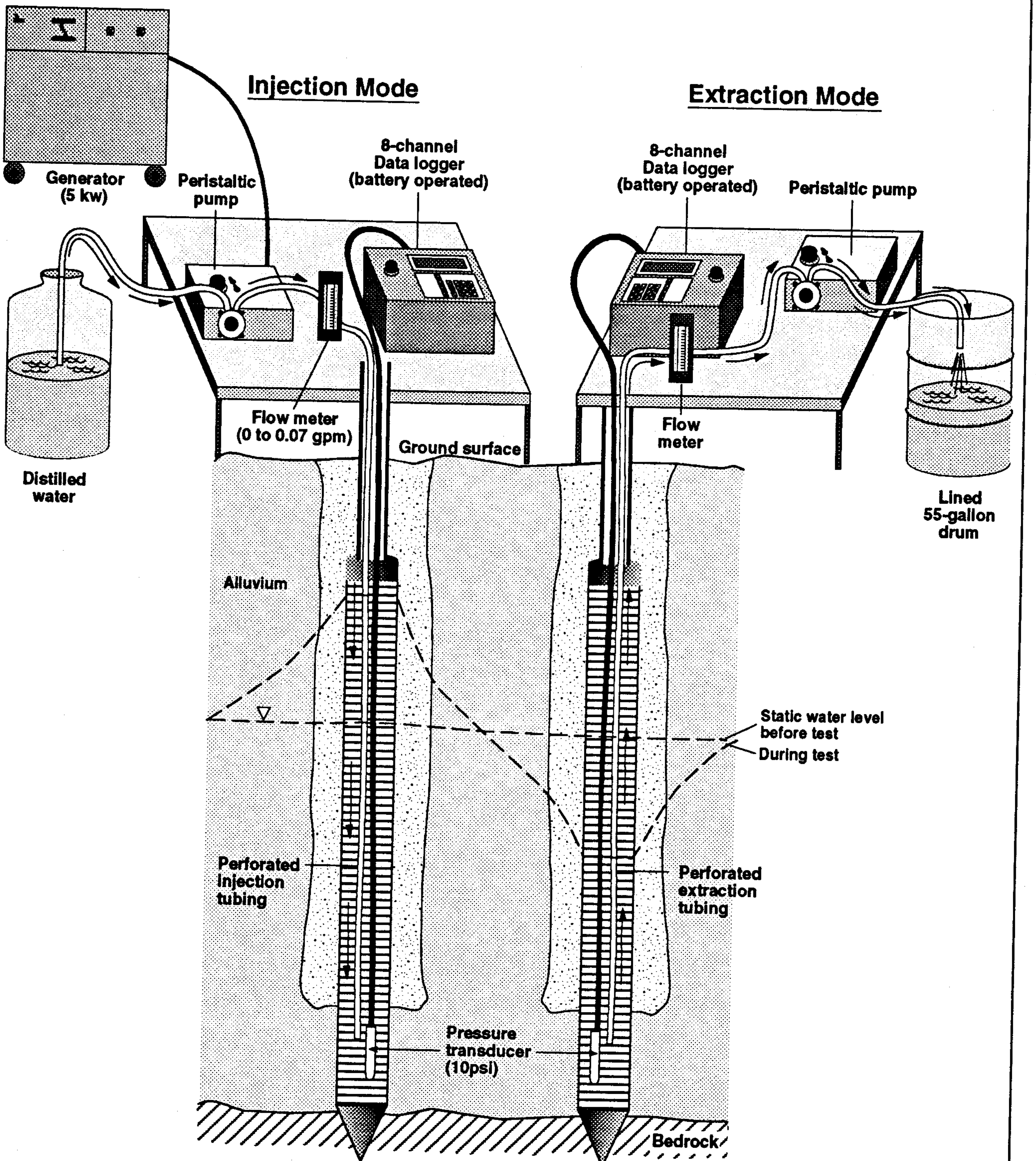
Operable Unit No. 1
Phase III RFI/RI Report

Multiple-Well Pumping Test Setup

Figure B2-7 June 1992



Drawing not to scale.

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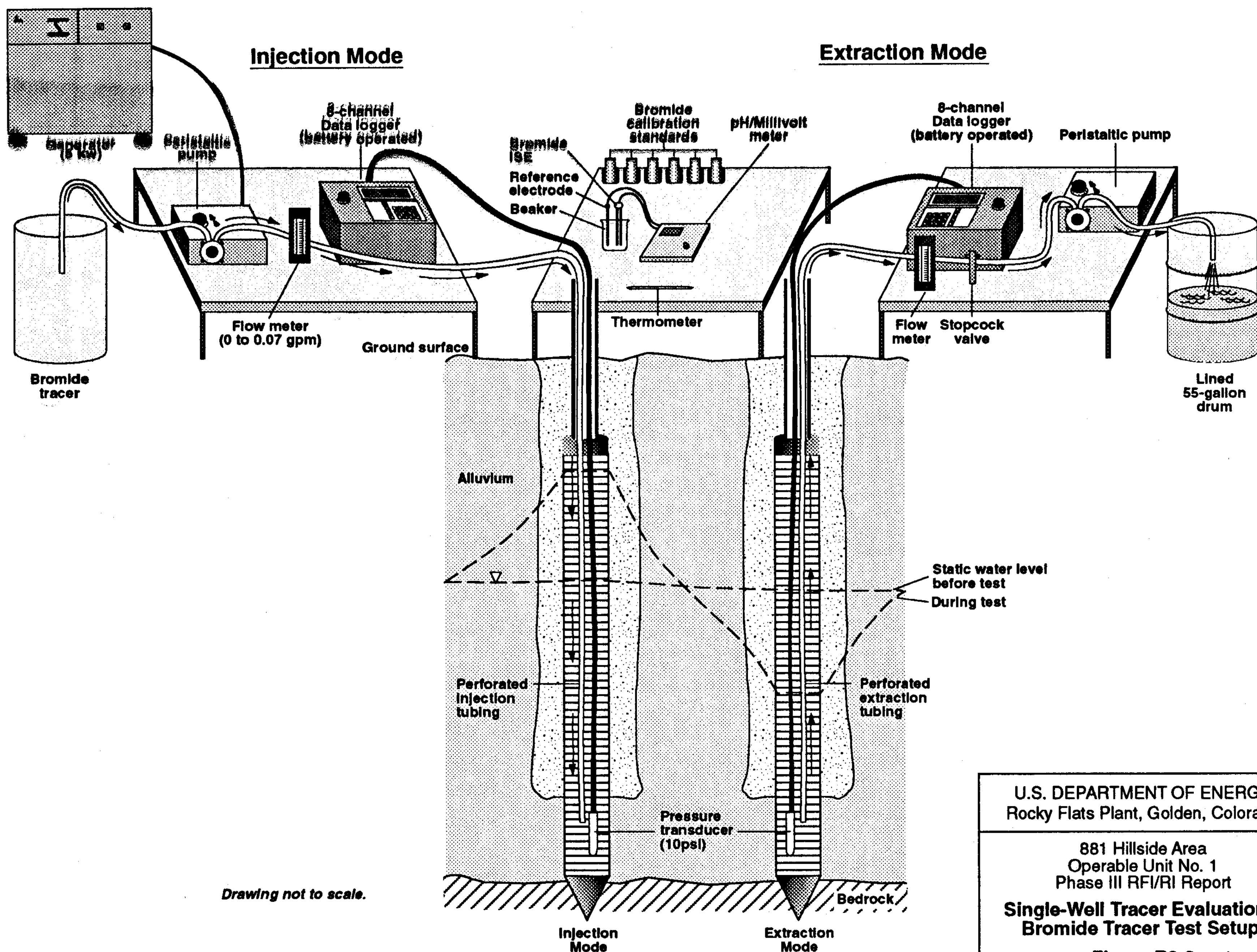
Phase III RFI/RI Report

Single-Well Tracer Evaluation–Distilled Water Tracer Test Setup

Figure B2-8 June 1992



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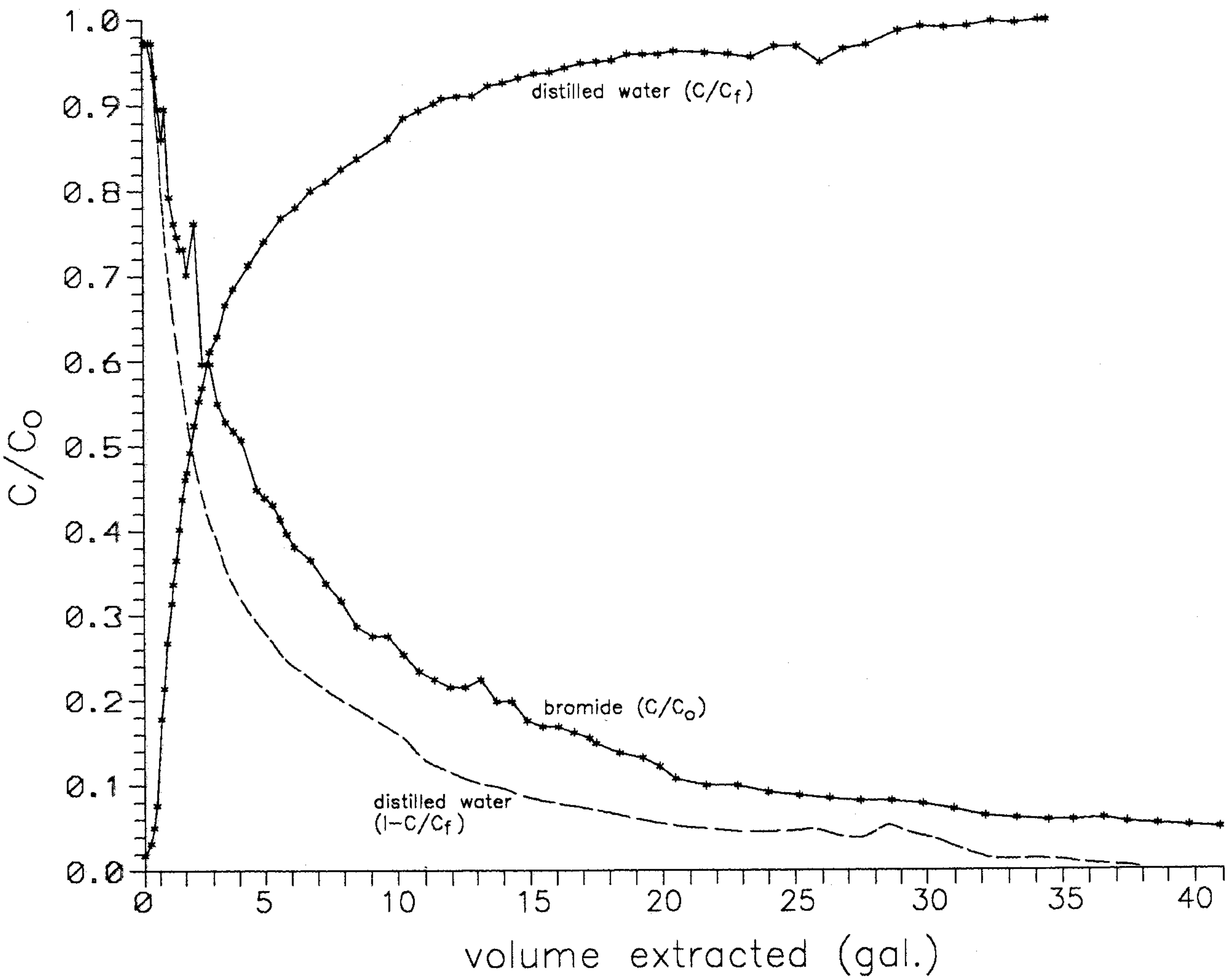
Phase III RFI/RI Report

Single-Well Tracer Evaluation–Bromide Tracer Test Setup

Figure B2-9 June 1992



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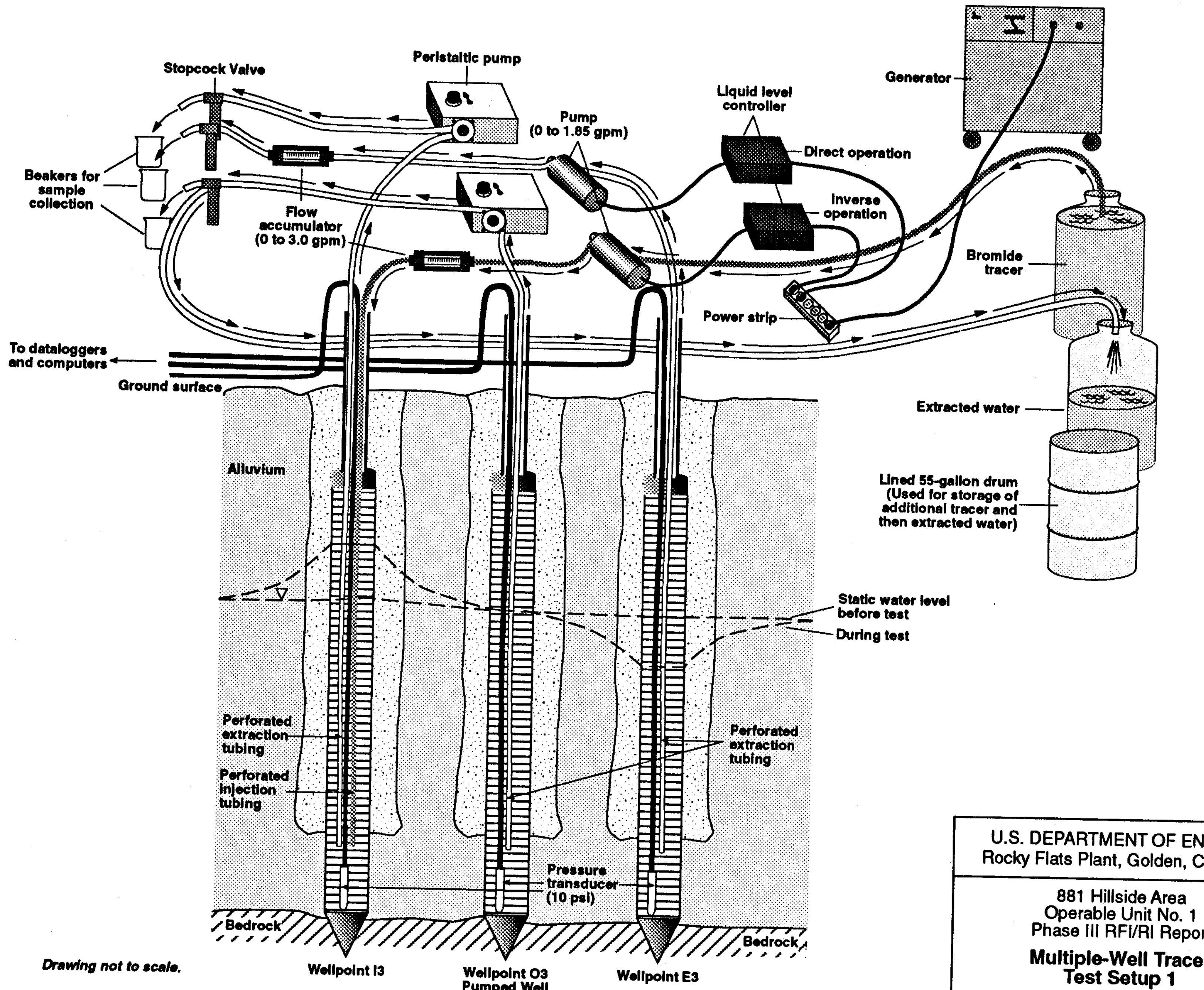
Single-Well Tracer Evaluation Tests
Breakthrough Curves
Figure B2-10

JUNE 1992



Drawing not to scale.

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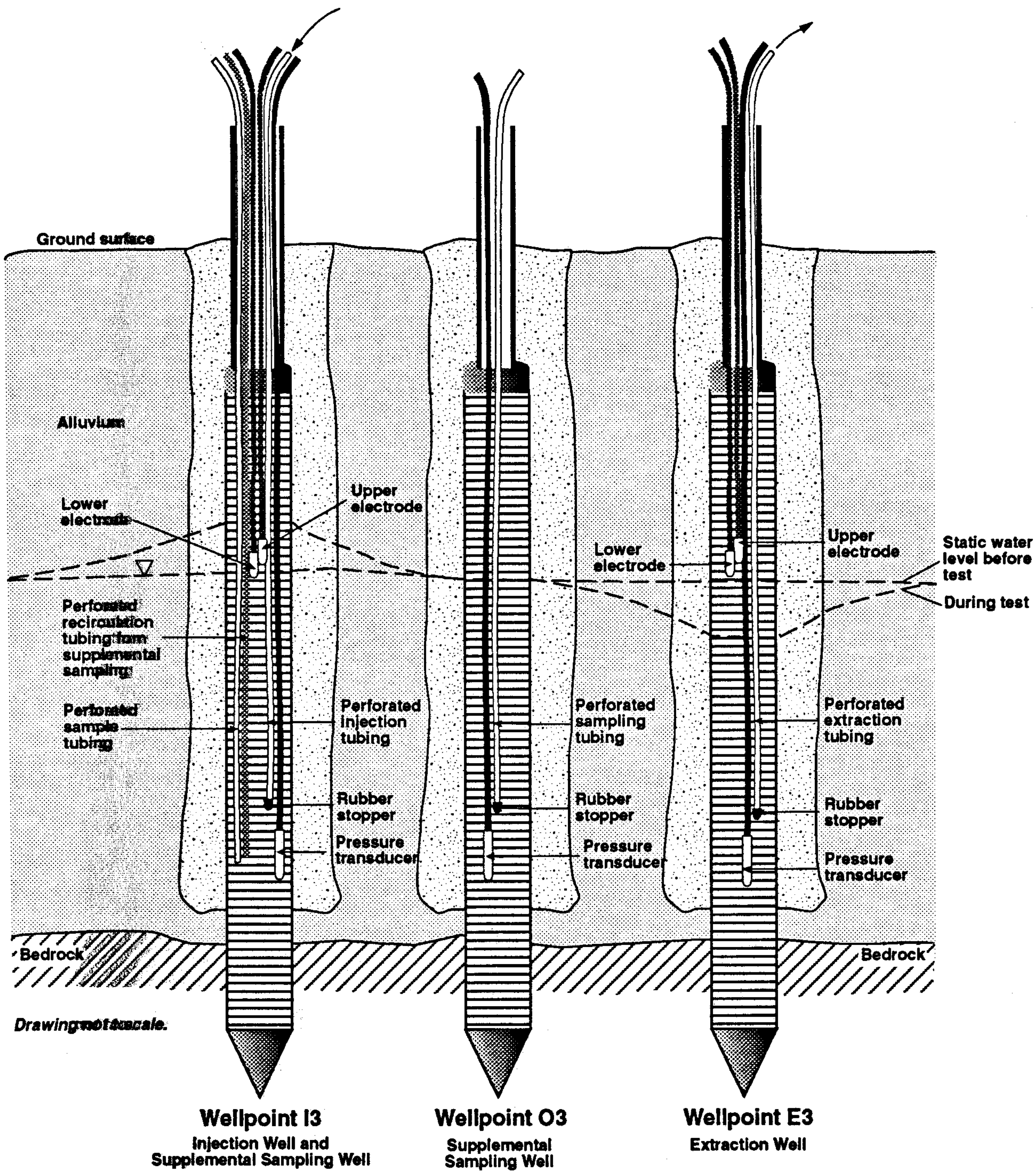
Multiple-Well Tracer Test Setup 1

Figure B2-11 June 1992



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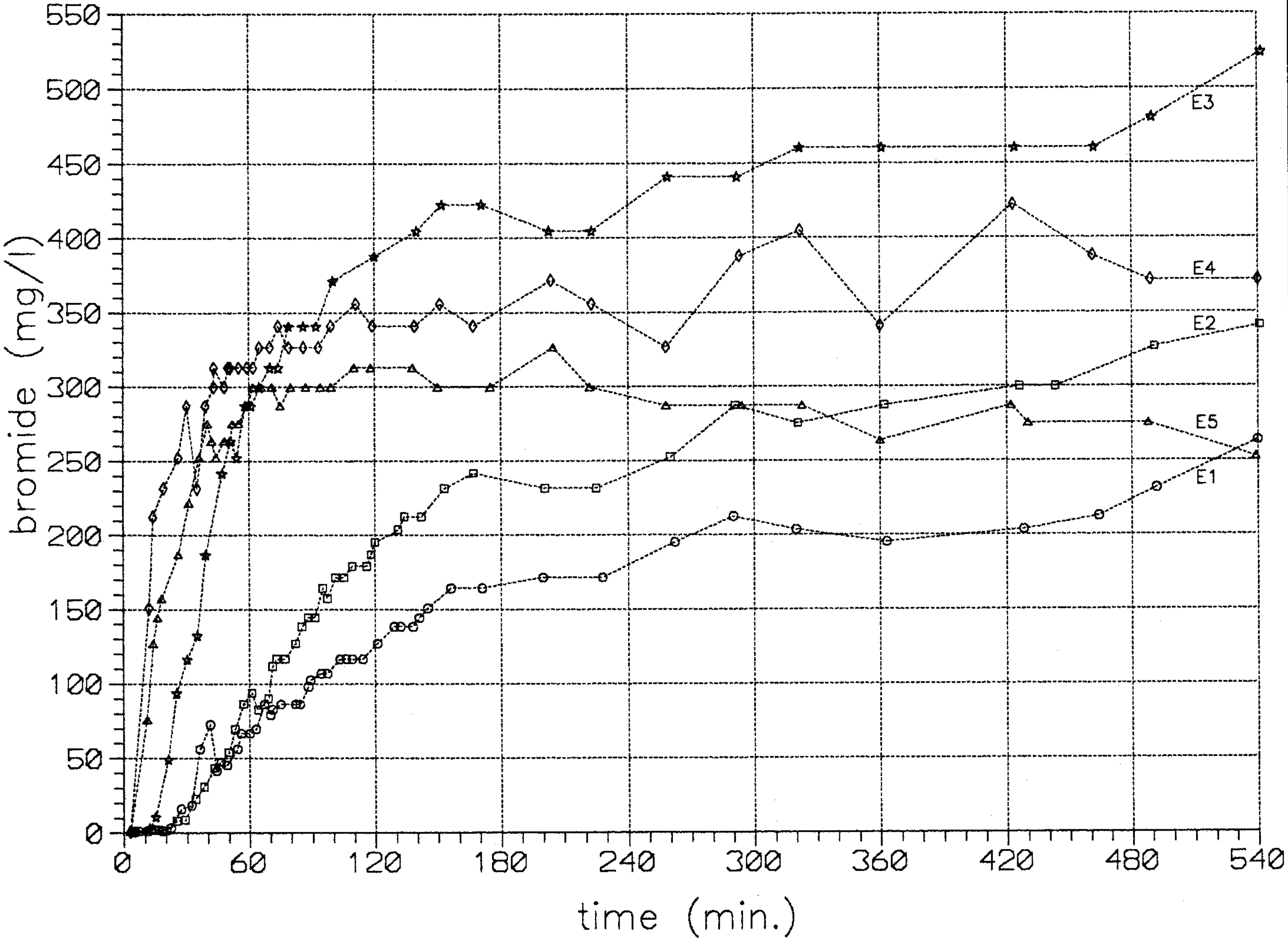
Phase III RFI/RI Report

Multiple-Well Tracer Test Setup 2

Figure B2-12 June 1992



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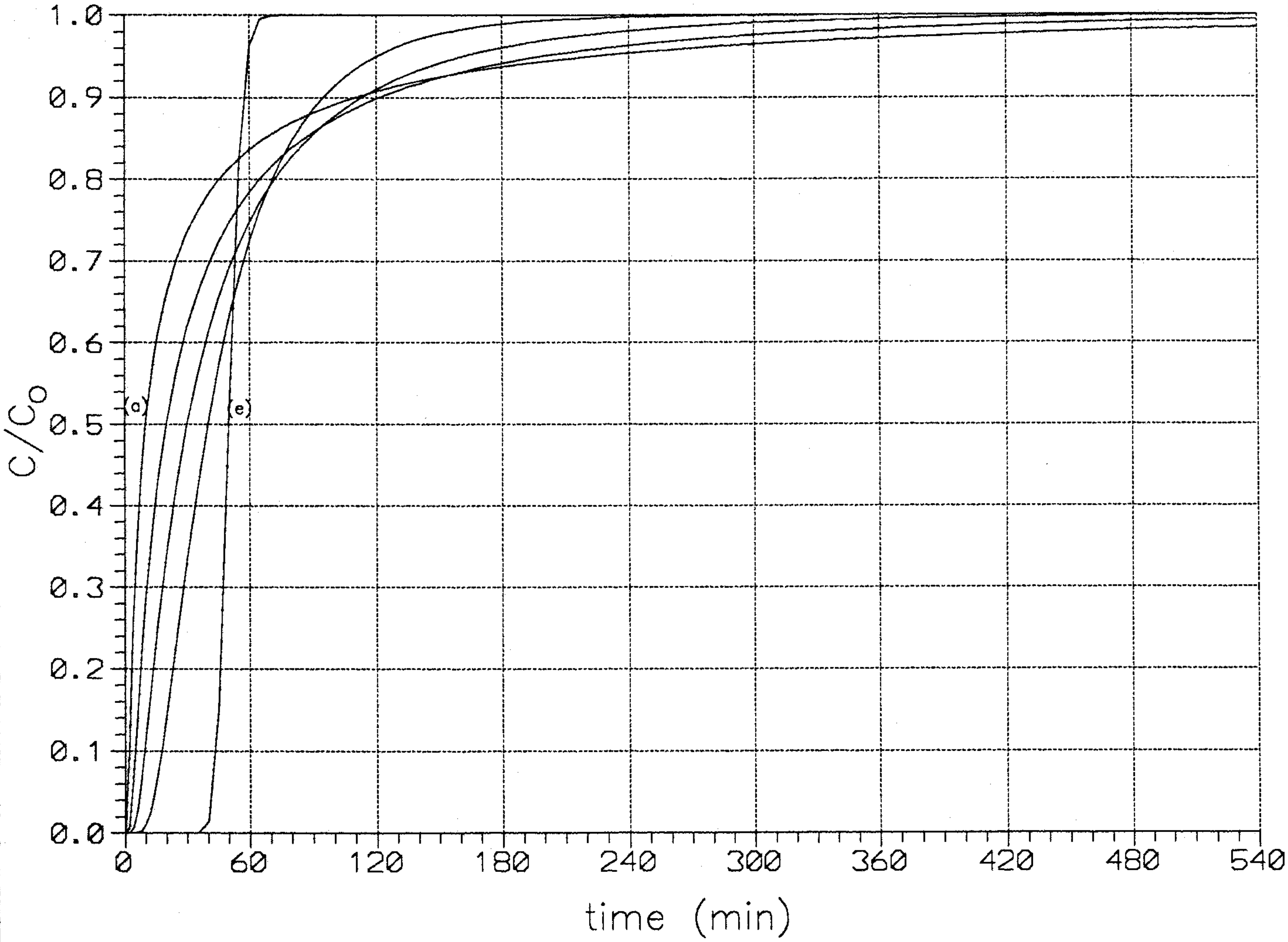
Multiple-Well Tracer Test
Bromide Concentration vs. Time for Wells E1-E5
Figure B2-13

JUNE 1992



$\bar{v}$= 0.1 ft./min.
L= 5.0 ft.

	t @ C/C_0 = 0.5 (min.)	D_ℓ ($ft.^2$/min.)
(a)	10	2.2
	20	0.80
	30	0.35
	40	0.13
(e)	50	0.0026

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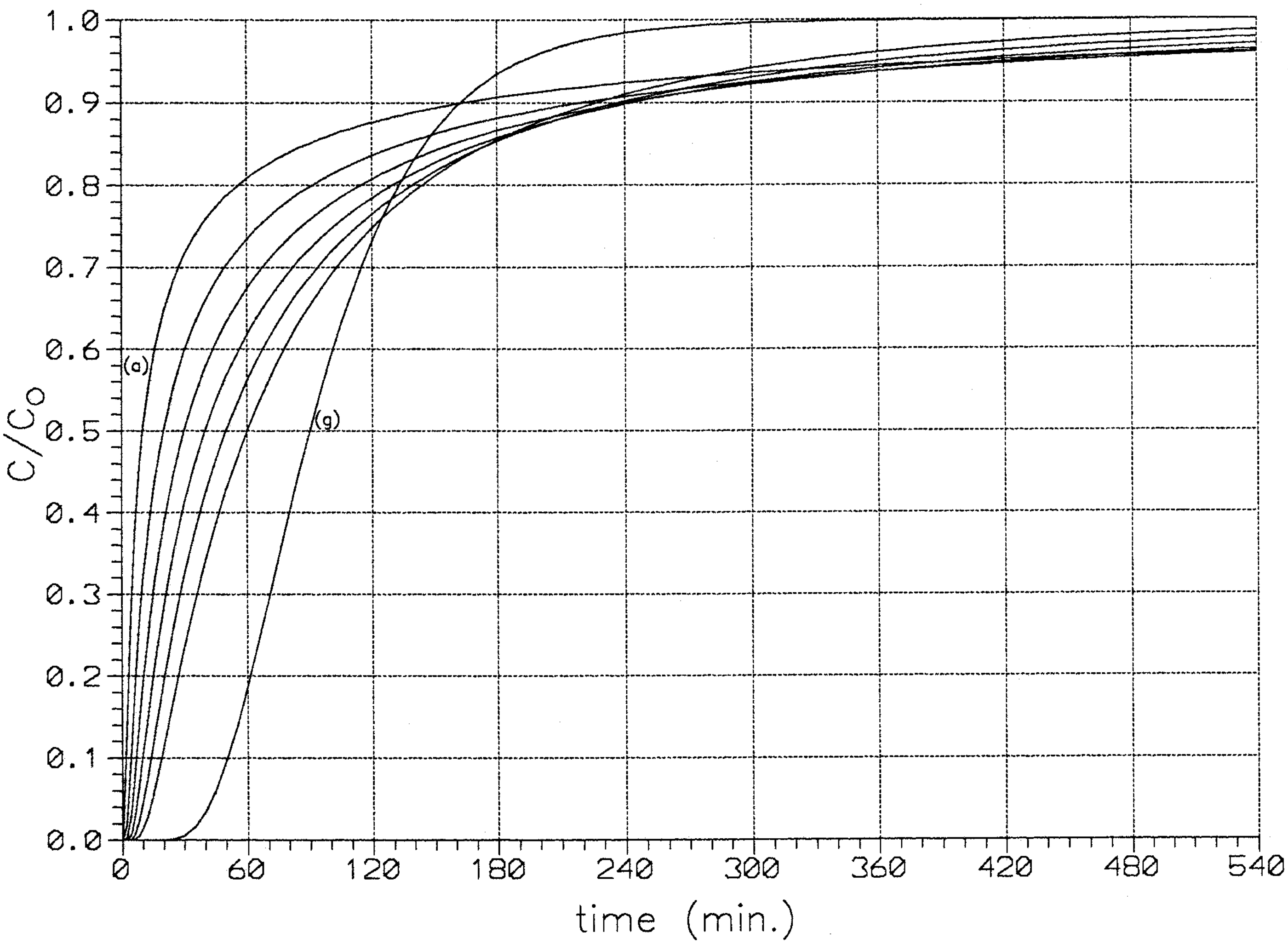
Type Curves for Velocity=0.1 ft./min.
Figure B2-14

JUNE 1992



$\bar{v}$= 0.05 ft./min.
L= 5.0 ft.

	t @ C/C_o= 0.5 (min.)	D_ℓ ($ft.^2$/min.)
(a)	10	2.5
	20	1.1
	30	0.63
	40	0.40
	50	0.27
	60	0.18
(g)	90	0.028

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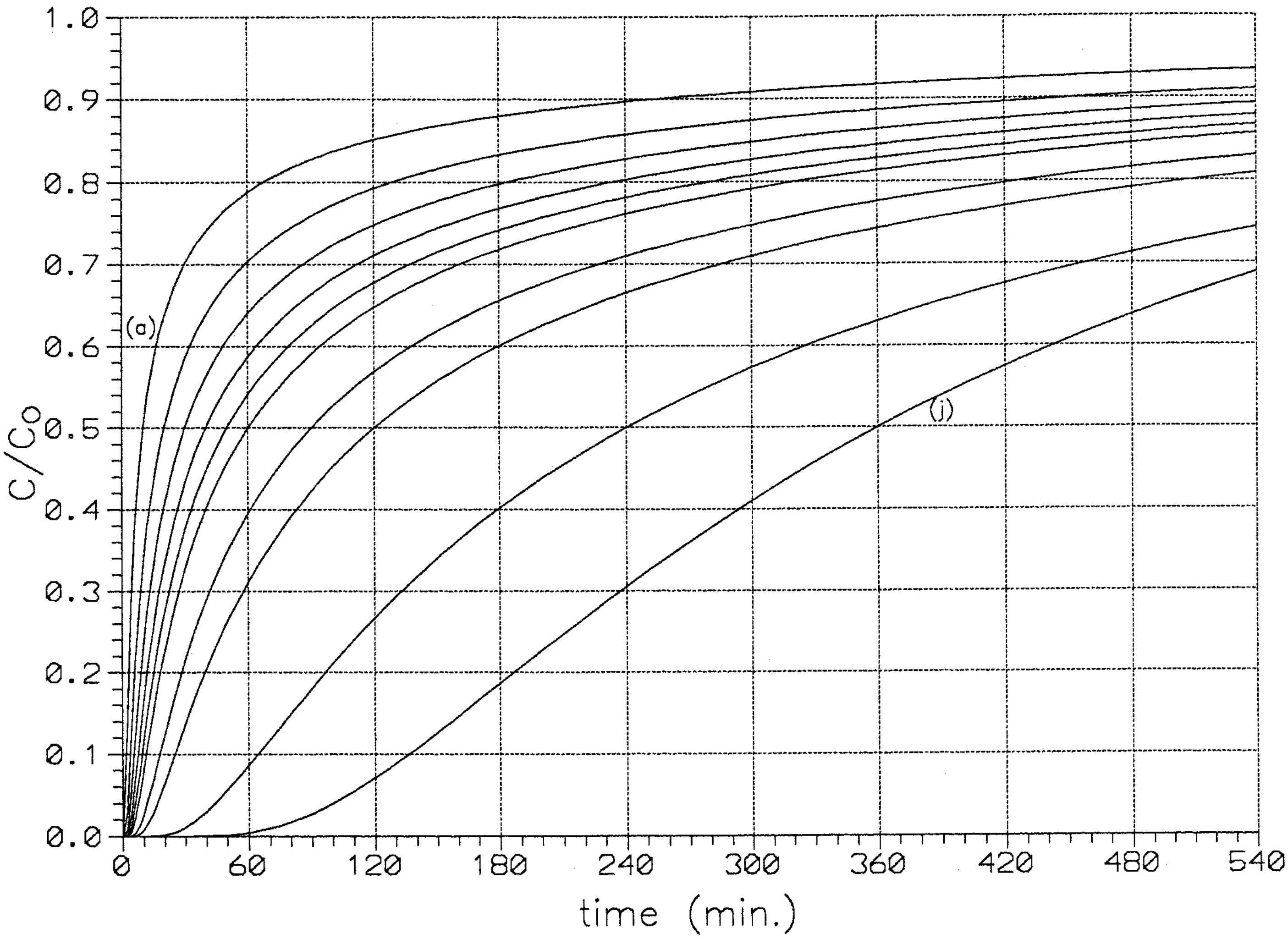
Type Curves for Velocity= 0.05 ft./min.
Figure B2-15

JUNE 1992



$\overline{v}$= 0.1 ft./min.
L= 5.0 ft.

t @ C/C_o = 0.5 (min.)	D_x (ft.^{2}/min.)
(a) 10	2.7
20	1.3
30	0.86
40	0.63
50	0.49
60	0.40
90	0.25
120	0.17
240	0.058
(j) 360	0.020

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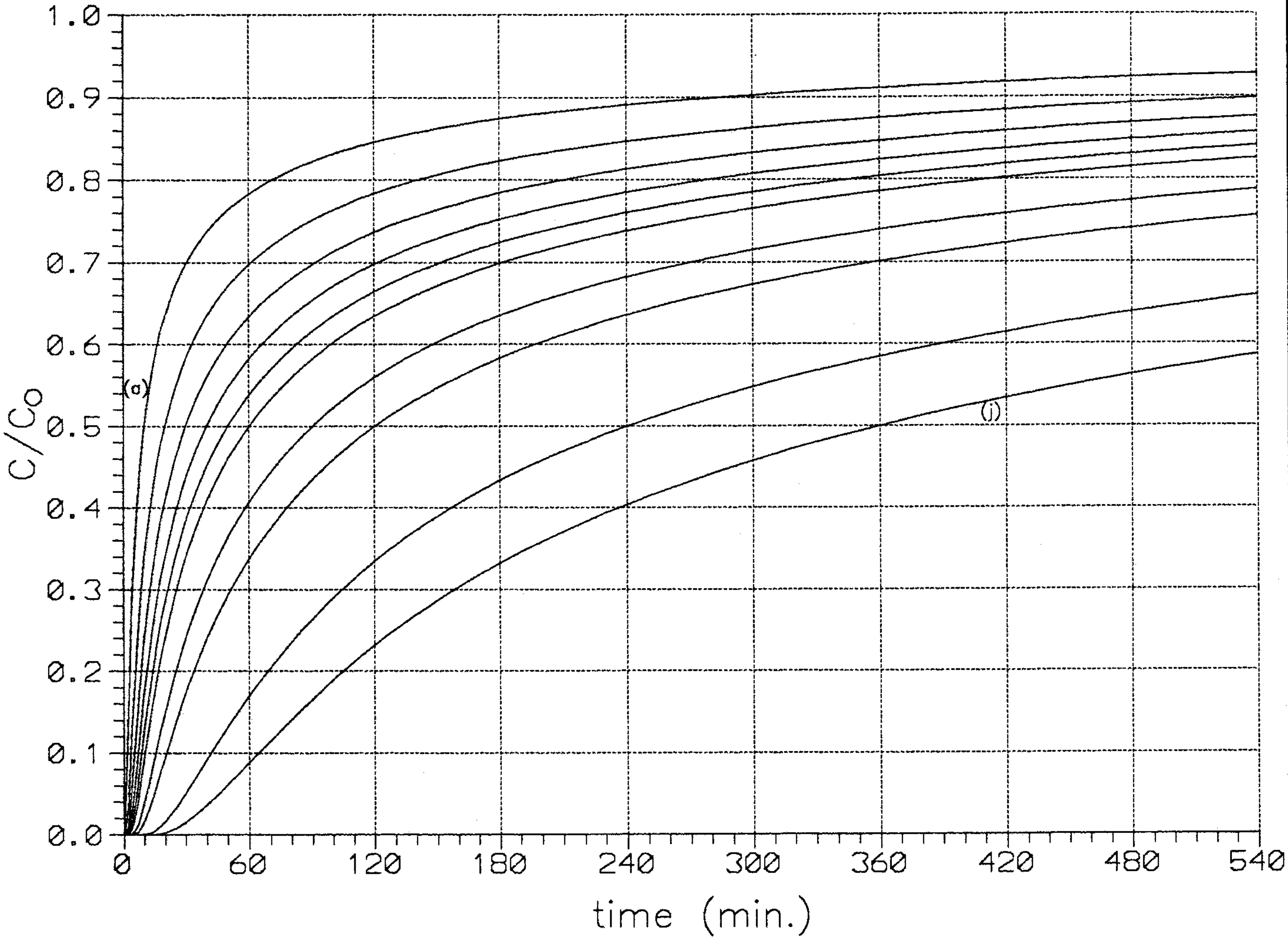
Type Curves for Velocity =0.01 ft./min.
Figure B2-16

JUNE 1992



$\bar{v}$= 0.001 ft./min.
L= 5.0 ft.

	t @ C/C_o = 0.5 (min.)	D_ℓ ($ft.^2$/min.)
(a)	10	2.7
	20	1.4
	30	0.91
	40	0.68
	50	0.54
	60	0.45
	90	0.30
	120	0.22
	240	0.11
(j)	360	0.071

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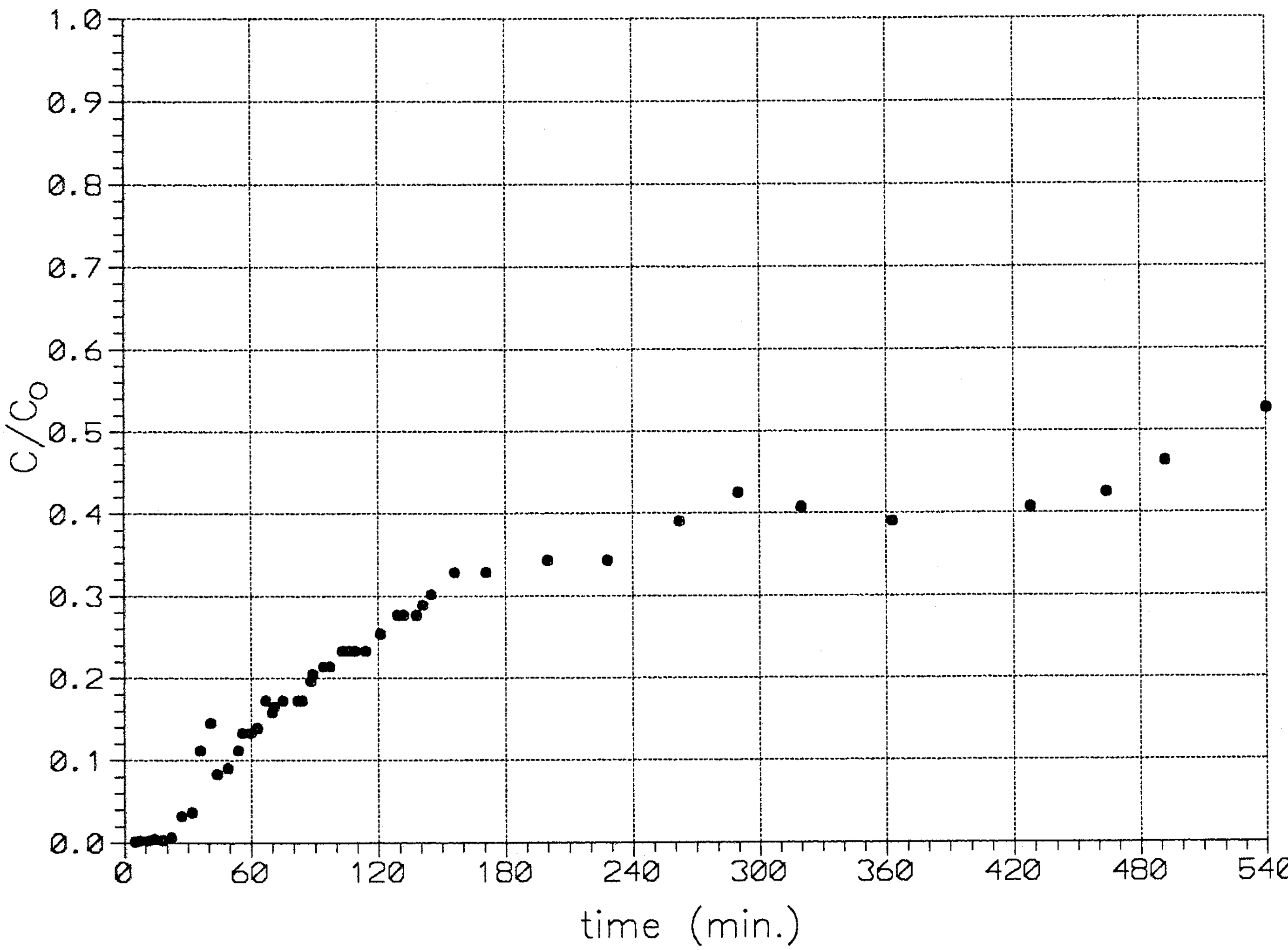
Type Curves for Velocity =0.001 ft./min
Figure B2-17

JUNE 1992



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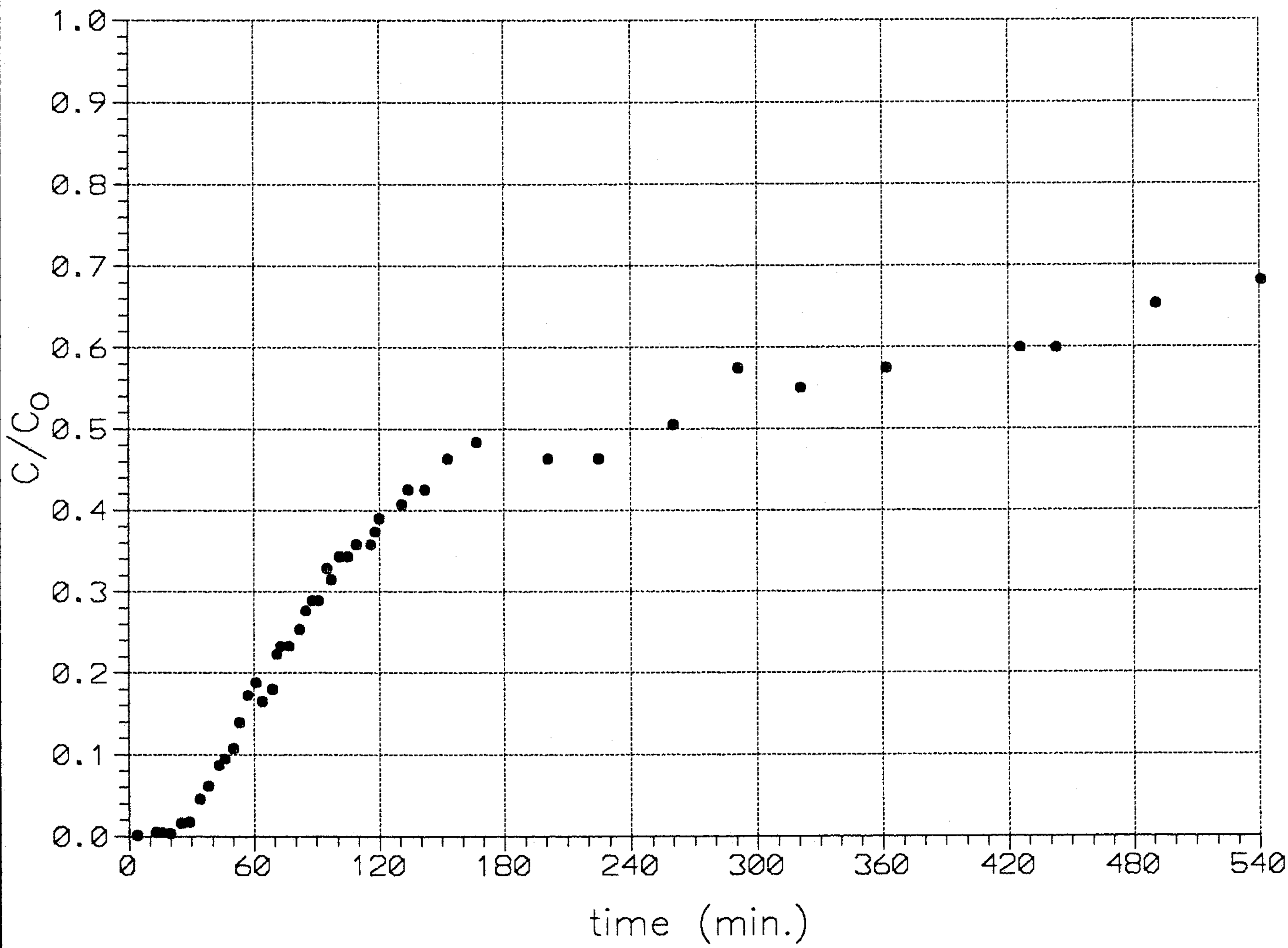
Multiple-Well Tracer Test
Breakthrough Curve for Wells I1-E1
(C_o=500 mg/l)
Figure B2-18

JUNE 1992



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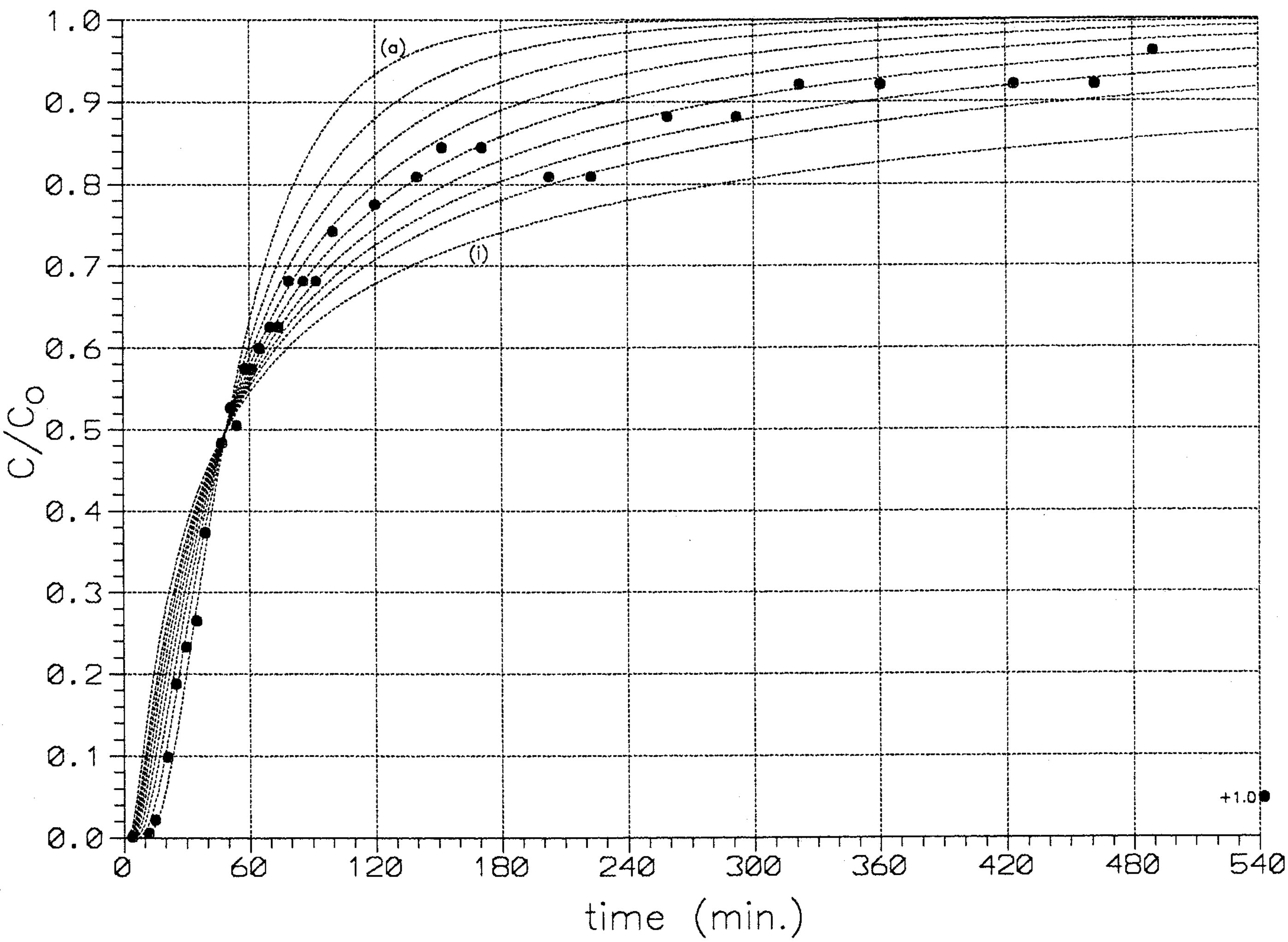
Multiple-Well Tracer Test
Breakthrough Curve for Wells I2-E2
(C_o=500 mg/l)
Figure B2-19

JUNE 1992



C_o = 500 mg/l
L= 5.85 ft.
C/C_o = 0.5 @ 49 min.

	$\bar{V}$ (ft./min.)	D_l (ft.^{2}/min.)
(a)	0.1	0.12
	0.09	0.18
	0.08	0.24
	0.07	0.30
	0.06	0.37
	0.05	0.43
	0.04	0.50
	0.03	0.57
(i)	0.01	0.70

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Multiple-Well Tracer Test
Breakthrough Curve for Wells I3-E3
Figure B2-20

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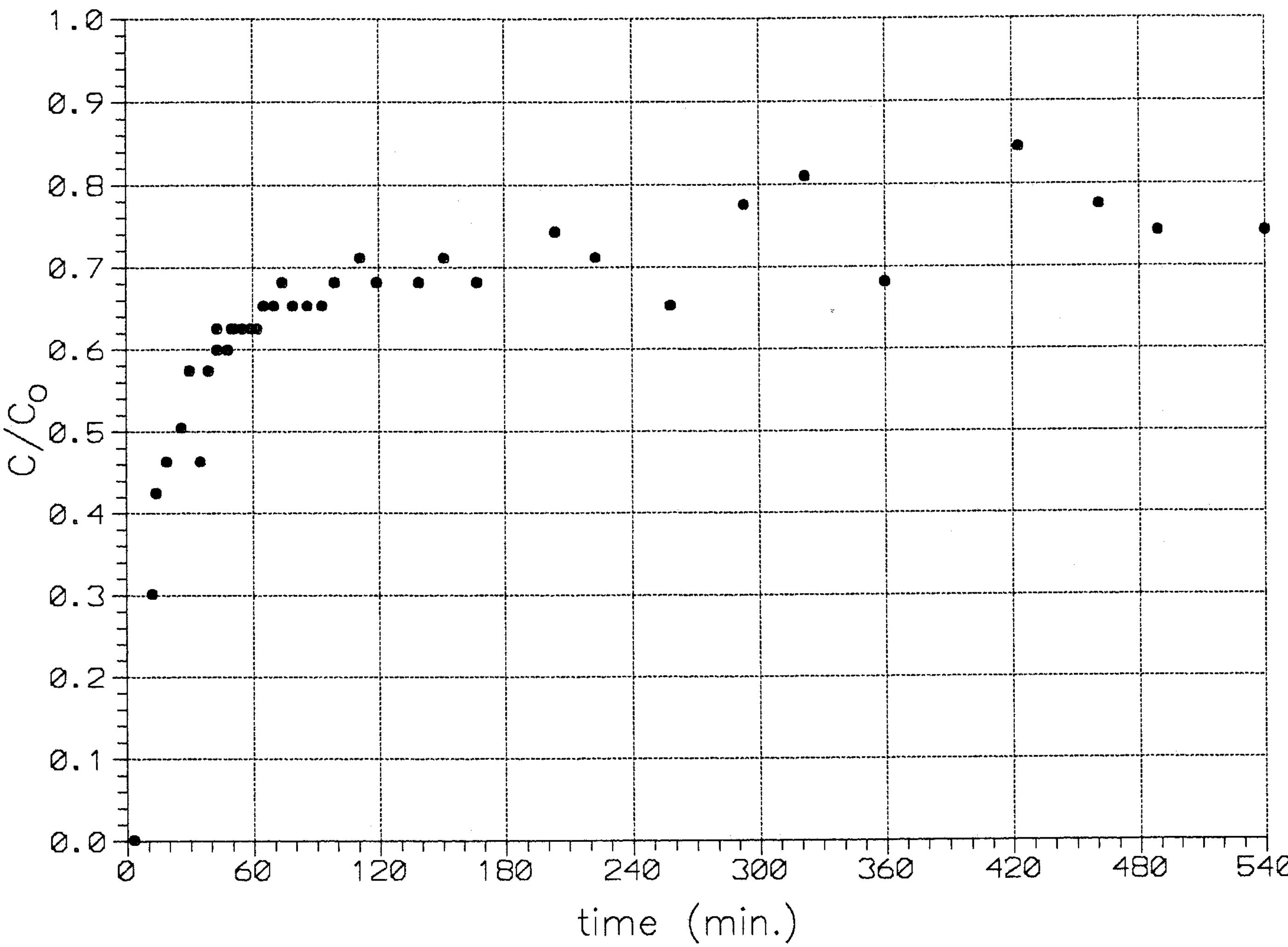

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Rocky Flats Plant Golden, Colorado

881 HILLSIDE AREA
OPERABLE UNIT NO. 1
PHASE III RFI/RI REPORT

Multiple-Well Tracer Test
Breakthrough Curve for Wells I4-E4
(C_o=500 mg/l)
Figure B2-21

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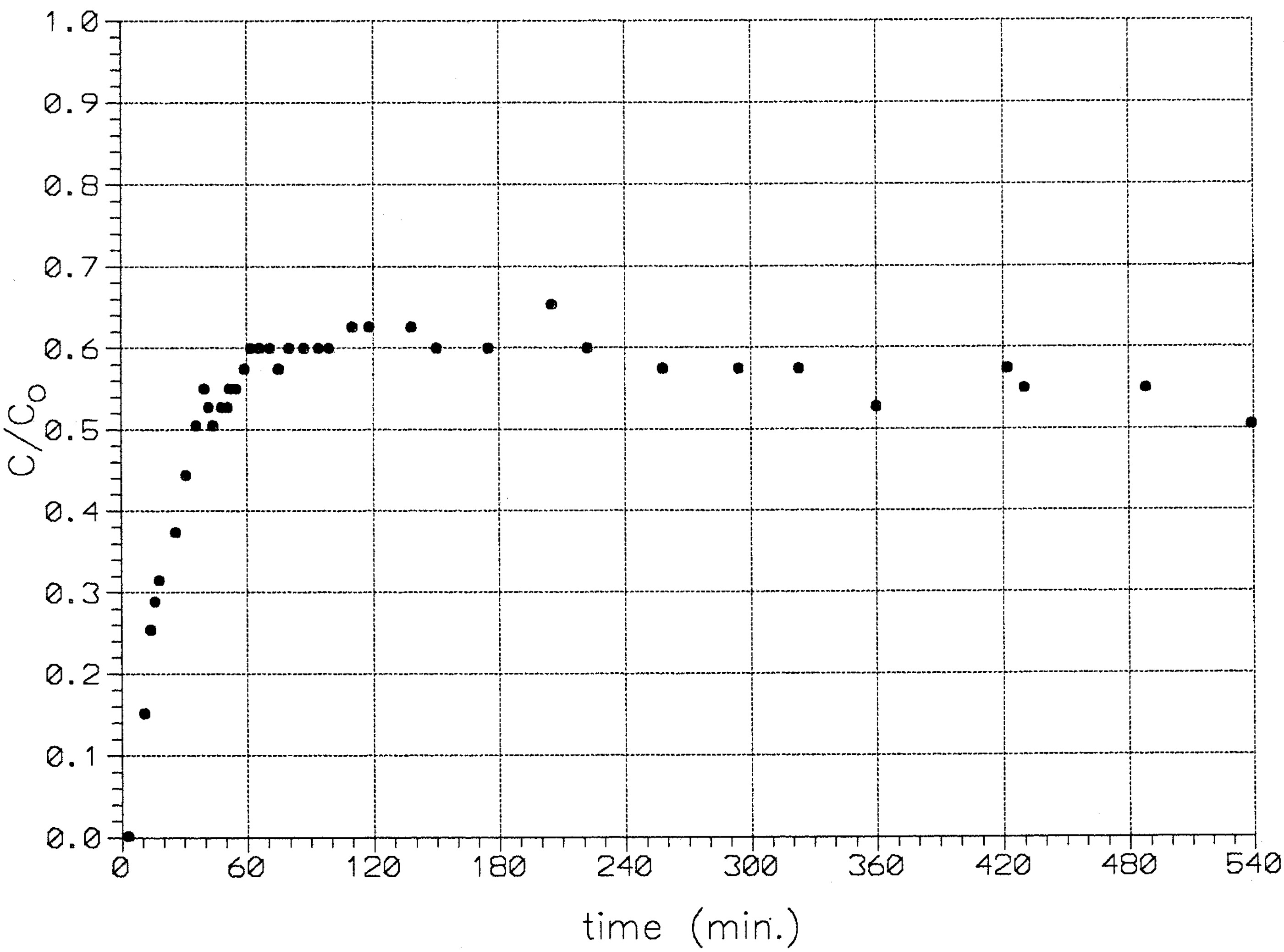

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881 HILLSIDE AREA
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Multiple-Well Tracer Test
Breakthrough Curve for Wells I5-E5
(C_o=500 mg/l)
Figure B2-22

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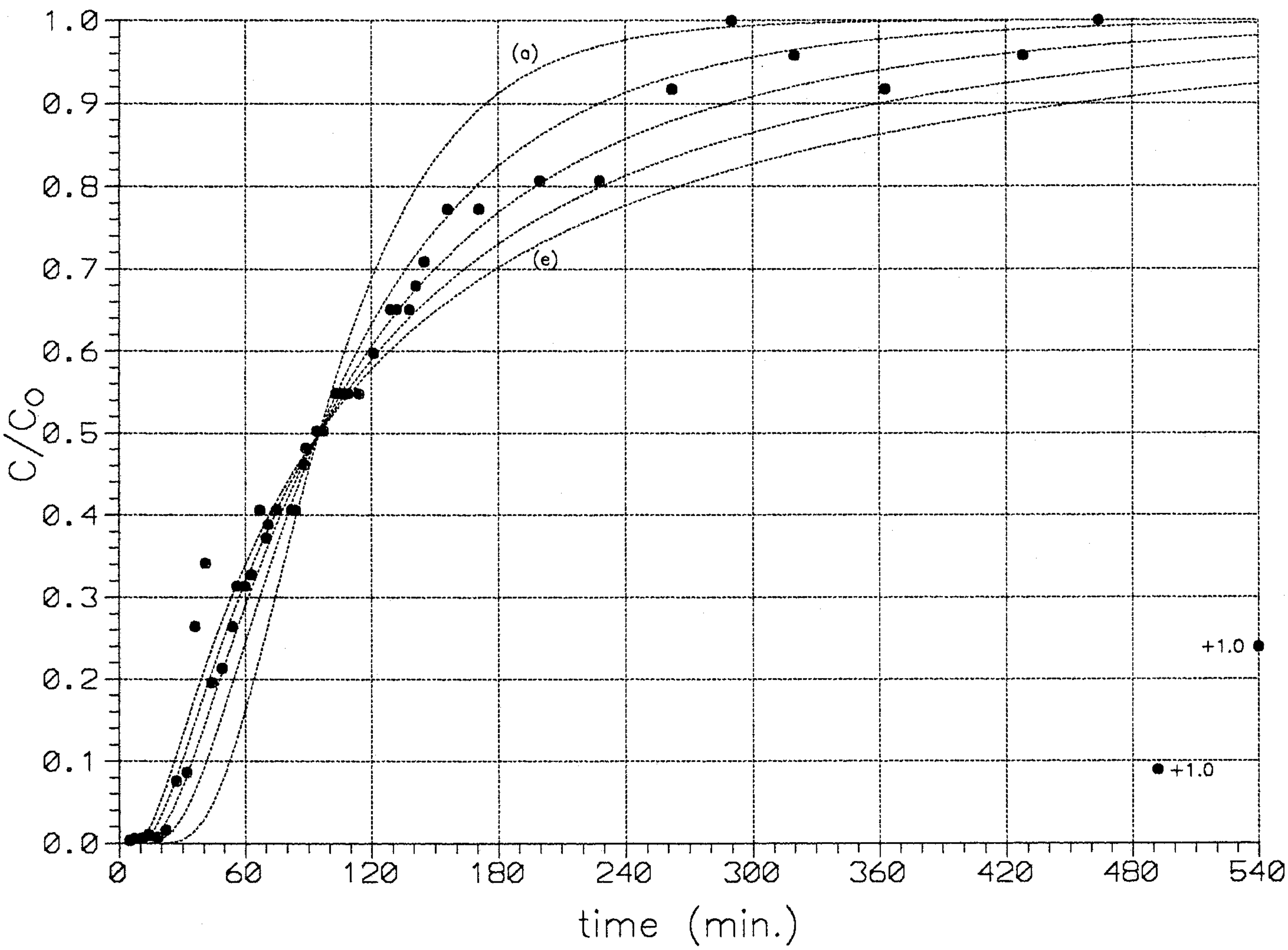

C_o =213 mg/l
L= 4.78 ft.
C/Co= 0.5 @ 95 min.

	$\bar{v}$ (ft. /min.)	D_o (ft.^{2}/min.)
(a)	0.045	0.026
	0.040	0.051
	0.035	0.076
	0.030	0.10
(e)	0.025	0.13

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Rocky Flats Plant Golden, Colorado

881 HILLSIDE AREA
OPERABLE UNIT NO. 1
PHASE III RFI/RI REPORT

Multiple-Well Tracer Test
Breakthrough Curve for Wells I1-E1
Figure B2-23

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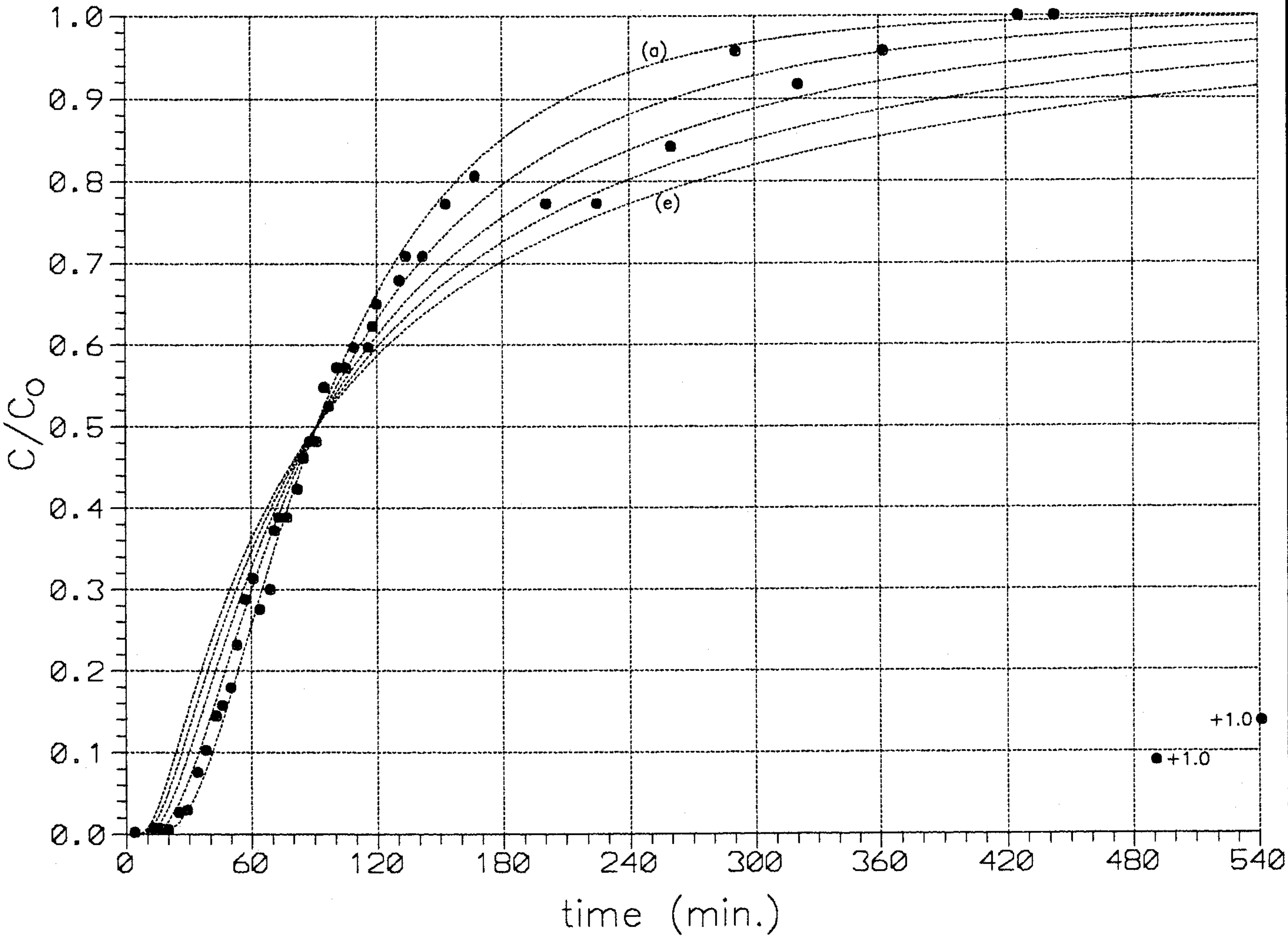

C_o =300 mg/l
L= 5.04 ft.
C/C_o = 0.5 @ 91 min.

	$\overline{v}$ (ft. /min.)	D_ℓ (ft.^{2} /min.)
(a)	0.045	0.054
	0.040	0.081
	0.035	0.11
	0.030	0.14
(e)	0.025	0.16

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Rocky Flats Plant Golden, Colorado

881 HILLSIDE AREA
OPERABLE UNIT NO. 1
PHASE III RFI/RI REPORT

Multiple-Well Tracer Test
Breakthrough Curve for Wells I2-E2
Figure B2-24

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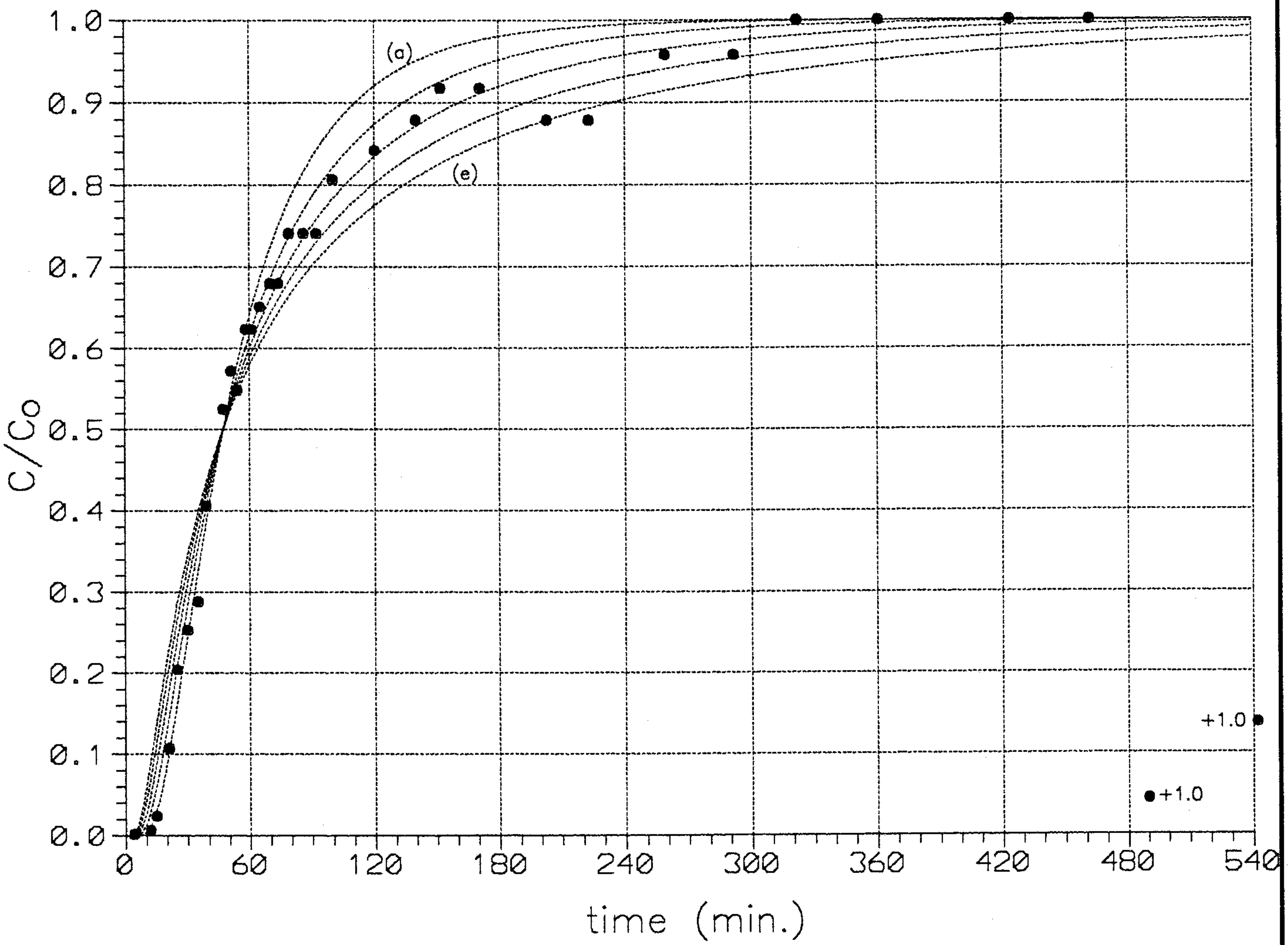

C_o =461 mg/l
L= 5.85 ft.
C/C_o = 0.5 @ 47 min.

	$\overline{v}$ (ft./min.)	D_ℓ (ft.^{2}/min.)
(a)	0.10	0.15
	0.090	0.21
	0.080	0.27
	0.070	0.34
(e)	0.060	0.40

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Rocky Flats Plant Golden, Colorado

881 HILLSIDE AREA
OPERABLE UNIT NO. 1
PHASE III RFI/RI REPORT

Multiple-Well Tracer Test
Breakthrough Curve for Wells I3-E3
Figure B2-25

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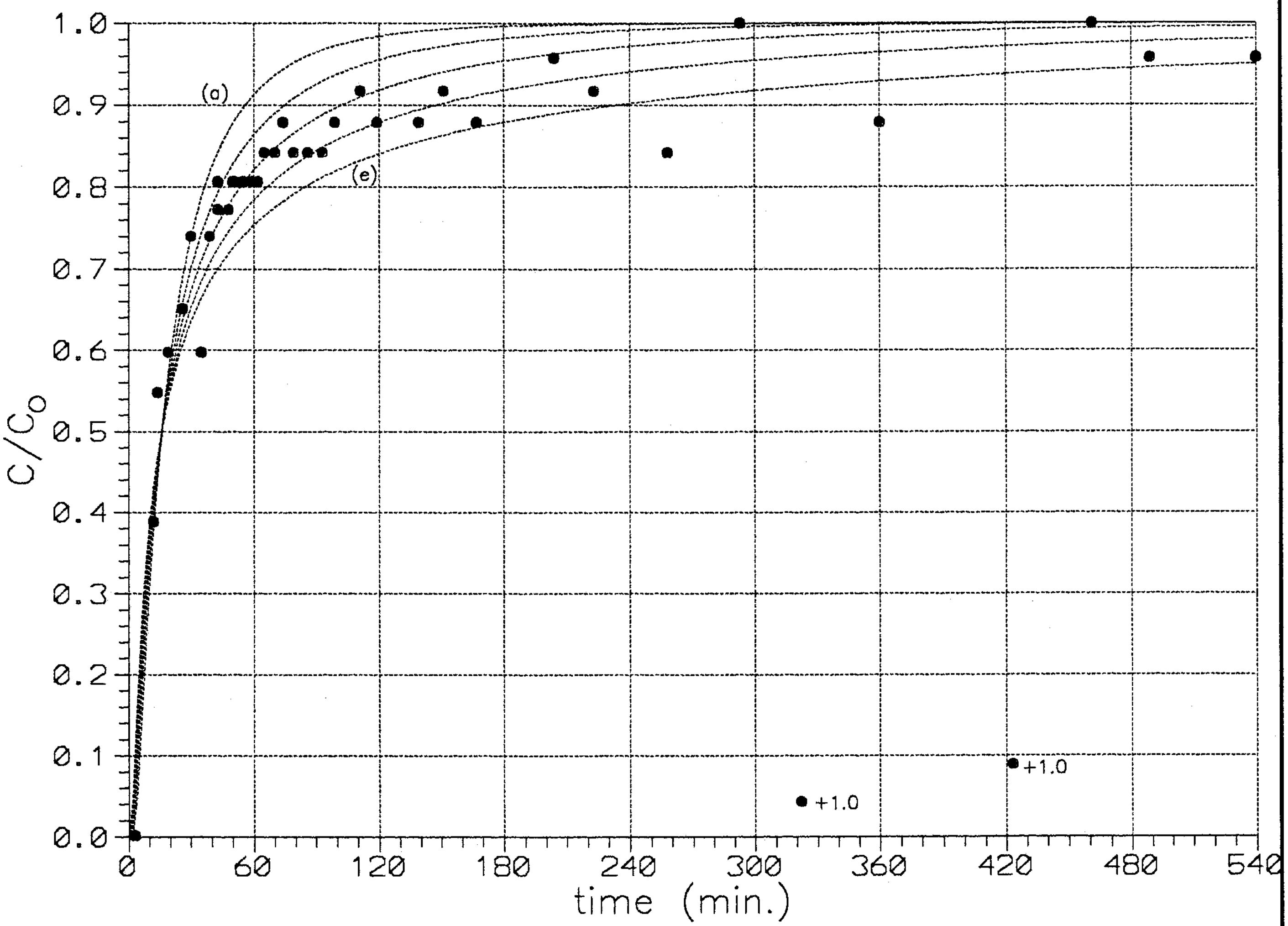

C_o =388 mg/l
L= 5.05 ft.
C/C_o = 0.5 @ 16 min.

	$\overline{V}$ (ft./min.)	D_ℓ (ft.^{2}/min.)
(a)	0.20	0.61
	0.16	0.83
	0.12	1.1
	0.080	1.3
(e)	0.060	1.5

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Rocky Flats Plant Golden, Colorado

881 HILLSIDE AREA
OPERABLE UNIT NO. 1
PHASE III RFI/RI REPORT

Multiple-Well Tracer Test
Breakthrough Curve for Wells I4-E4
Figure B2-26

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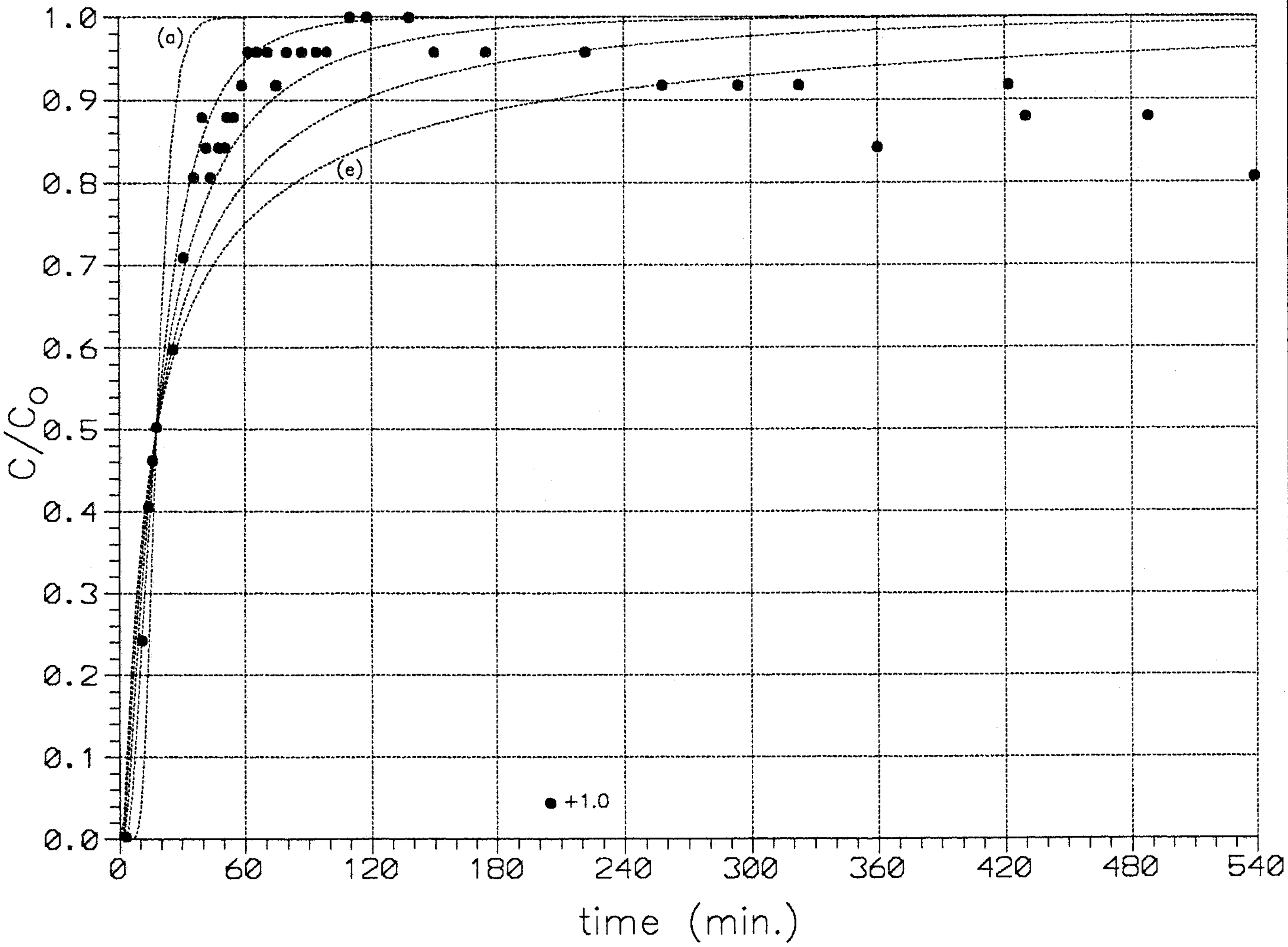

C_o=313 mg/l
L= 4.75 ft.
C/C_o= 0.5 @18 min.

	$\overline{v}$ (ft. /min.)	D_l (ft.^{2} /min.)
(a)	0.25	0.068
	0.20	0.31
	0.15	0.57
	0.10	0.84
(e)	0.050	1.1

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Rocky Flats Plant Golden, Colorado

881 HILLSIDE AREA
OPERABLE UNIT NO. 1
PHASE III RFI/RI REPORT

Multiple-Well Tracer Test
Breakthrough Curve for Wells I5-E5
Figure B2-27

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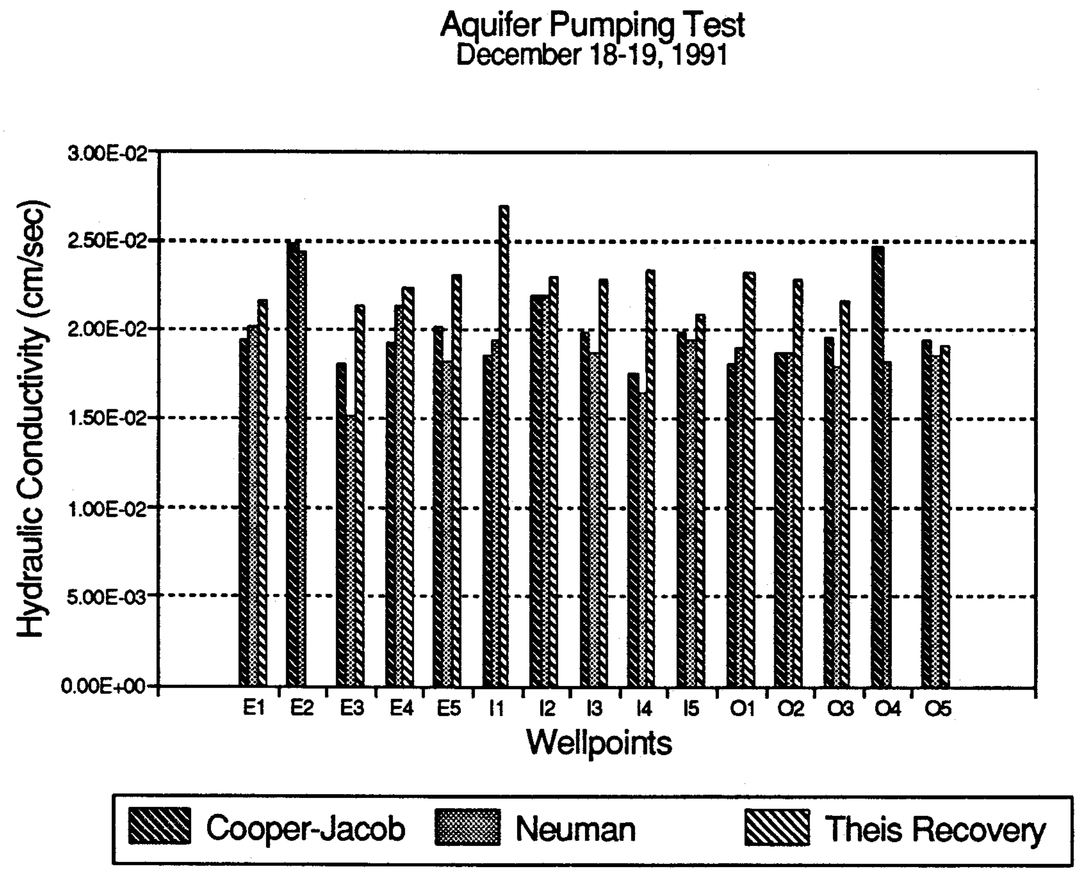

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Rocky Flats Plant **Golden, Colorado**

881 HILLSIDE AREA
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PHASE III RFI/RI REPORT

Summary of Estimated
Hydraulic Conductivities
by Wellpoint
Figure B2-28

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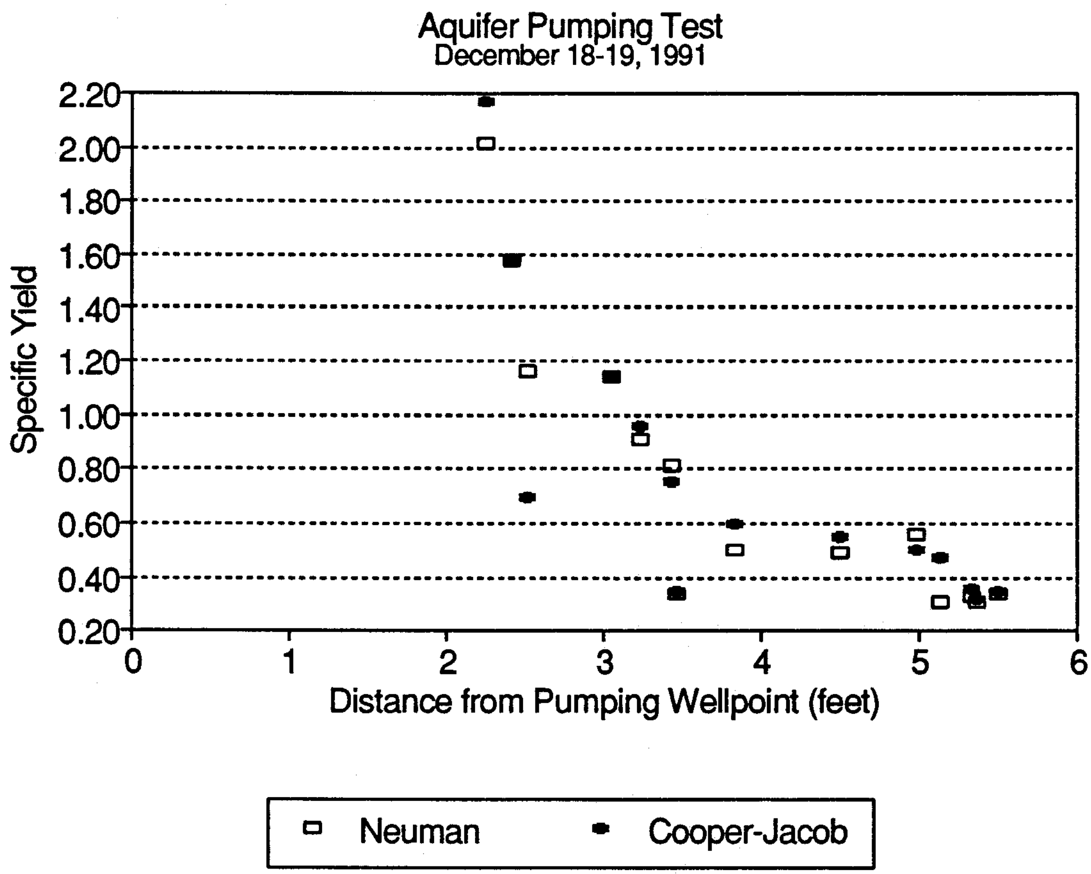

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881 HILLSIDE AREA
OPERABLE UNIT NO. 1
PHASE III RFI/RI REPORT

Estimated Specific Yields
vs
Distance from
Pumping Wellpoint
Figure B2-29

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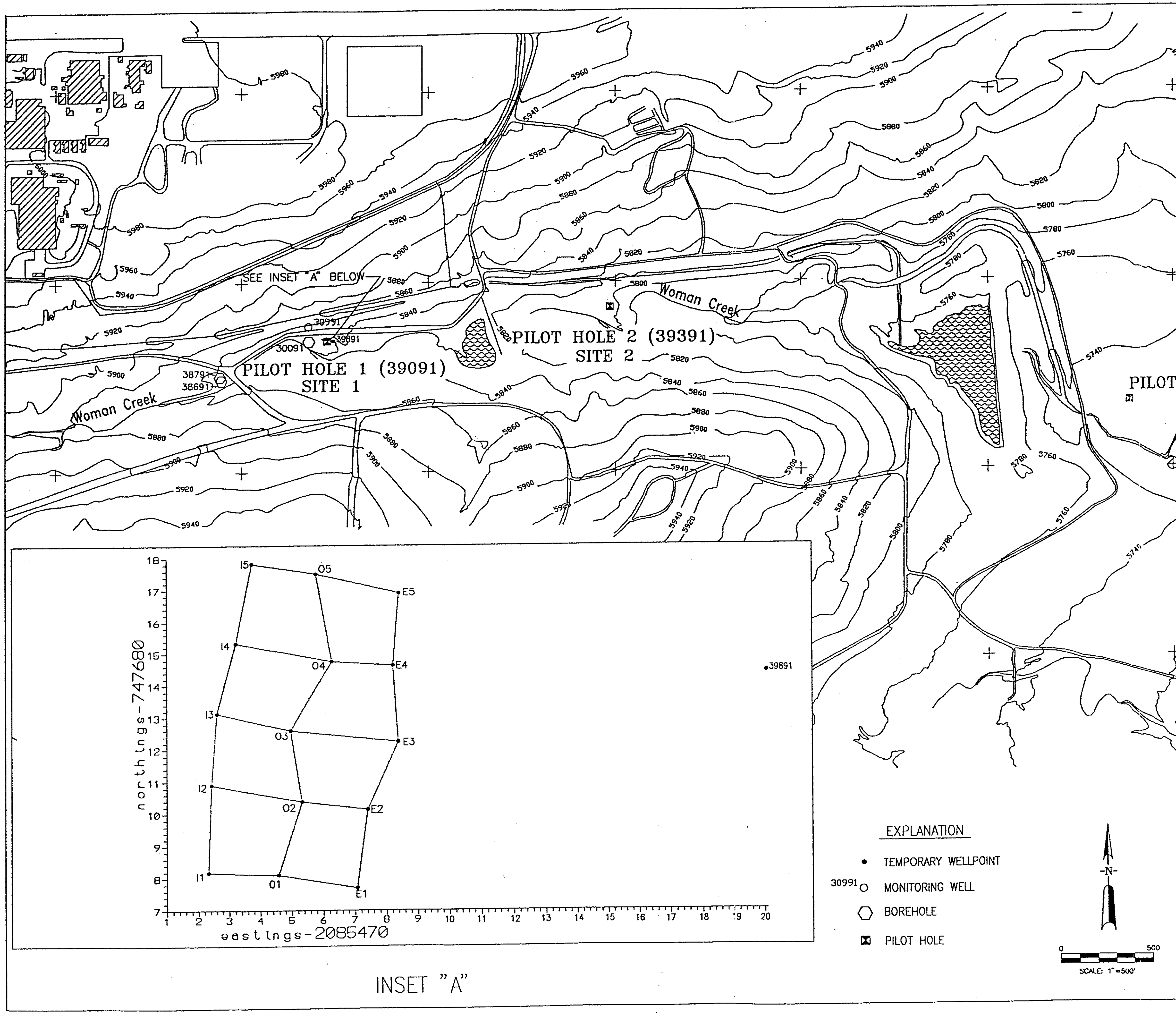

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PHASE III RFI/RI REPORT

Pumping and Tracer
Test Locations
Figure B2-1

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