Shell Oil Company

EAST BAY
MARKETING DISTRICT

P.O. Box 4023
Concord, CA 94524
(415) 676-1414

June 5, 1990

Mr. Rick Mueller
City of Pleasanton
Pleasanton Fire Department
Post Office Box 520
Pleasanton, California 94566-0802

SUBJECT: SHELL SERVICE STATION
3790 HOPYARD ROAD
PLEASANTON, CALIFORNIA

Dear Mr. Mueller:

Enclosed is a copy of the Aquifer Test Report, dated May 25, 1990, which documents the aquifer tests and groundwater sampling conducted during the first quarter of 1990 at the subject location.

If you should have any questions or comments regarding this project please do not hesitate to call me at (415) 676-1414 ext. 127.

Very truly yours,

Diane M. Lundquist
District Environmental Engineer

DML/jw

enclosure

cc: Mr. Tom Callaghan, Regional Water Quality Control Board
Mr. John Werfal, Gettler-Ryan Inc.

RECEIVED

MAY 29 1990

GETTLER-RYAN INC. (415) 783-4800

GENERAL CONTRACTORS

GSI

GeoStrategies Inc.

2140 WEST WINTON AVENUE
HAYWARD, CALIFORNIA 94545

May 25, 1990

Gettler-Ryan Inc.
2150 West Winton Avenue
Hayward, California 94545

Attn: Mr. Jerry Mitchell

Re: AQUIFER TEST REPORT
Shell Service Station
3790 Hopyard Road
Pleasanton, California

Gentlemen:

This Aquifer Test Report has been prepared for the above referenced location.

If you have any questions, please call

GeoStrategies Inc. by,

Melissa Wann
Project Geologist

Christopher M. Palmer
Senior Geologist
C.E.G. 1262, R.E.A. 285

REGISTERED GEOLOGIST
CHRISTOPHER M. PALMER
№ 1262
CERTIFIED ENGINEERING GEOLOGIST
STATE OF CALIFORNIA

MLW/CMP/mlg

Report No. 7632-5

GeoStrategies Inc.

AQUIFER TEST REPORT

Shell Service Station
3790 Hopyard Road
Pleasanton, California

Report No. 7632-5

May 25, 1990

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EXECUTIVE SUMMARY

Site-related activities for the Shell Service Station located at 3790 Hopyard Road in Pleasanton, California which occurred from January 1 to March 30, 1990 are summarized below:

- o Aquifer tests were performed at the site to estimate hydraulic properties of the shallow aquifer. These tests were performed to better understand chemical migration characteristics in the shallow aquifer and the potential impact to the Arroyo Mocho Canal, a local drainage feature located approximately 250 feet downgradient of the site.

- o A 1.5 gallons per minute (gpm) constant-rate discharge pumping test was conducted on Well SR-3 on February 26, 1990. The pumping test was terminated after 560 minutes of pumping and a maximum drawdown of 10.9 feet. Calculated transmissivity from pumping well data using the Cooper-Jacob method was 147 gpd/ft. Observed drawdowns were measured and recorded in Wells S-2 through S-5, S-10, SR-1 and SR-2. The Graphical Well Analysis Package (GWAP) computer software program developed by Groundwater Graphics (August, 1988) which includes Neuman's method of analyzing aquifer test data for water-table aquifers (Neuman, 1975) was used to analyze constant-rate test data and calculate transmissivity, hydraulic conductivity and storativity for observation wells where a response to pumping was observed. Calculated transmissivity values ranged from 143 to 1570 gpd/ft. Hydraulic conductivity values ranged from 1.0 to 10.5 ft/day.

- o Slug tests were performed on Wells S-2, S-3, S-5, S-7 through S-10 and SR-3 on February 22 and 23, 1990. Calculated transmissivity values ranged from 478 to 8690 gpd/ft. Hydraulic conductivities ranged from 3.2 to 58.2 ft/day. The wide range of transmissivity and hydraulic conductivity values is suspected to be caused by the heterogeneity of the subsurface as well as inherent analysis problems associated with slug tests in clayey aquifers. Higher values of transmissivity and hydraulic conductivity probably reflect annular space surface (i.e. larger values produced by well sandpacks).

- Drawdown data from the constant-rate discharge test performed on Well SR-3 identified two potential preferential pathways in the shallow aquifer; one pathway to the south and one pathway to the east. The distribution of TPH-Gasoline and benzene depicted on chemical concentration maps support these findings.

- The monitoring well network was sampled on March 6, 1990 after completion of aquifer testing. Water-level data collected prior to sampling were plotted and contoured. The hydraulic gradient was calculated to be 0.01, with ground-water flow towards the south-southeast.

- Ground-water samples were collected and analyzed for Total Petroleum Hydrocarbons calculated as Gasoline (TPH-Gasoline) and Benzene, Toluene, Ethylbenzene and Xylenes (BTEX). TPH-Gasoline concentrations ranged from None Detected (ND) in Wells S-3 and S-7 through S-10 to 1.1 parts per million (ppm) in Well S-5. Benzene concentrations ranged from ND in Wells S-3 and S-7 through S-10 to 0.1 ppm in Well S-5. Benzene concentrations exceeded the current Regional Water Quality Control Board (RWQCB) Maximum Contaminant Level (MCL) in Wells S-2, S-4 through S-6, and SR-1 through SR-3.

- GSI recommends that a Remedial Action Plan be prepared which will evaluate whether passive remediation via natural degradation would be effective because of low transmissivities and hydraulic conductivities. GSI plans to use the Shell Oil Research and Development "Simulated Benzene Transport Model" to evaluate and track natural biodegradation of hydrocarbons at the site.

INTRODUCTION

This report presents the methods, results, and data interpretations for the aquifer tests conducted at the Shell Service Station located at 3790 Hopyard Road, Pleasanton, California (Plate 1) and the ground-water sampling which took place following the tests. The aquifer tests were performed to 1) estimate hydraulic properties of the shallow aquifer and evaluate potential migration pathways for hydrocarbons, and 2) use the results of the aquifer test to select, develop and implement the appropriate remediation at the site. The Arroyo Mocho Canal which is located approximately 250 feet south of the site is suspected to be a potential local shallow ground-water discharge area, therefore, the data collected from these aquifer tests were evaluated to see if hydrocarbons may be migrating in this direction and at what rate.

Two aquifer testing methods were employed at the site. Slug tests were performed on February 22 and 23, 1990 in Wells S-2 through S-5, S-9, S-10 and SR-3. Slug tests were performed because of encountered low purge rates observed during previous ground-water sampling at the site. A review of purge data indicated potential purging rates of less than 2 gpm in most wells and less than 1 gpm in several wells. A constant-rate discharge pumping test and subsequent recovery test was performed on February 26 and 27, 1990 in Well SR-3 (Plate 2). A review of historical well purging data in conjunction with subsurface geologic data identified Well SR-3 as the best location to perform a low-yield long-term constant-rate discharge test.

HYDROGEOLOGY

The site is located in the Livermore Valley ground-water basin, a 170-square mile basin drained by Arroyo de la Laguna (California Department of Water Resources, 1975). The Livermore Valley ground-water basin, at the northwestern end of the Diablo Range, is nearly coincident with the Livermore Valley.

Locally, the surface soils consist of the Clear Lake Clay, a dark gray, very deep soil that occurs in large bodies in nearly level basins. (Welch, et al., 1961). As reported by Welch, the soil is slowly permeable and when it is dry and deeply fractured, the Clear Lake clay absorbs water readily. The surface soils are underlain by Holocene medium-grained alluvium generally consisting of well-bedded, unconsolidated, moderately-sorted, moderately-permeable fine sand, silt and clayey silt with occasional thin beds of coarse sand (Helley, et al., 1979).

The local ground-water flow direction is to the south-southeast toward Arroyo Mocho Canal based on potentiometric data. The Canal which is located approximately 250 feet south of the study site, is an unlined drainage canal and was mapped by Welch (1961) as a intermittent stream. Since 1961 the Arroyo Mocho Canal has been deepened from 6 feet to approximately 14 feet below grade and is now reported to be perennial. Recharge of the shallow groundwater in the area is by surface infiltration from rainfall near the site and in the hills to the west.

Lithologic boring log data from previous site investigations indicate that the site is underlain primarily by clay with silt which contains thin discrete interbeds of sand, peat and clayey sand. Groundwater was first encountered during drilling in the clay unit at depths ranging from 13 to 19 feet below ground surface. Potentiometric data indicate that groundwater occurs at depths of approximately 12.5 to 17.5 feet below ground surface. Initial examination and review of boring logs and well purge data for ground-water sampling suggested a low permeability, unconfined clayey water-bearing zone beneath the site. Based on the lithologic data available, the top and bottom of the unconfined aquifer unit is indiscernible. For the purpose of our tests, we assumed an aquifer thickness of 20 feet, based on the average length of installed well screens. Exploratory boring logs for the site are presented in Appendix A.

As shown on Plate 3, ground-water flow in the shallow water bearing zone is to the south-southeast with an approximate hydraulic gradient of 0.01. The gradient is suspected to be influenced by the interbeds of sand and clayey sand which appear to be distributed randomly and at different elevations throughout the subsurface. The hydraulic interconnection between these discreet interbeds is not clearly understood and may create a steeper gradient calculation than actually exists.

CONSTANT-RATE TEST

Procedures

The constant-rate discharge test involved placing a 1/2-horsepower, electric submersible pump in Well SR-3 11 feet below static water level to allow for maximum drawdown, if needed. The pump intake was positioned within the lower portion of the screened interval and secured with a McDonald pipe holder at the well head. Discharge flowed through a one-inch inside diameter (I.D.) PVC pipe which was routed to a 2-inch I.D. hose connected to a flowmeter manifold assembly. Discharge was directed through the flowmeter manifold system to a holding tank located on-site.

The flowmeter manifold system controlled the flow rates next to the well-head by use of a ball valve at the head of the system. Industrial quality V-tube in-line vertical flowmeters permitted flow rate measurements with an accuracy of 3 to 5 percent and a 98 to 99 percent reproducibility (full scale). Flowmeters were visually monitored frequently during the test by GSI field personnel. Fluctuations of flow rate and time of occurrence were noted on field data pump test sheets, if any fluctuations were observed.

Well SR-3 and selected observation wells were monitored for depth to water on February 26, 1990, prior to the constant-rate discharge test. Water levels observed before the beginning of the constant-rate discharge test were used as static water-level data, to monitor and measure drawdown and residual drawdown in observation wells.

A pumping rate of 1.5 gallons per minute (gpm) was selected using purge data collected during the development of Well SR-3 in conjunction with subsurface lithologic data. The rationale for selecting 1.5 gpm was that a low pumping rate would effectively stress the shallow aquifer zone while allowing for long-term data collection without dewatering the test well. However, the test was terminated after 560 minutes of pumping just prior to dewatering the well. Maximum drawdown in the well was 10.9 feet. Well recovery data collection began instantly after the pump was turned off.

Water levels in Well SR-3 and Wells S-2, S-3 and S-5, in close proximity to the pumping well were monitored using pressure transducers connected to a Hermit Datalogger Model SE 2000 (HERMIT). All wells comprising the monitoring network were used as observation wells and were monitored during the test. Following the completion of pumping, water-level recovery was measured and recorded until a minimum of 90 percent recovery was achieved in test well SR-3.

Pumping test equipment was decontaminated prior to testing using an Alconox wash and a clean water rinse or was cleaned with a high pressure, hot water wash.

Data Analysis

A semi-log time-drawdown plot using the modified non-equilibrium method (Cooper and Jacob, 1946) was constructed during pumping to track drawdown in pumping well SR-3 and estimate transmissivity. Drawdown data collected after 100 minutes of pumping appear to indicate recharge to the aquifer most likely due to delayed drainage and/or slight compaction of the aquifer in the near vicinity of the well.

GWAP software was used to analyze drawdown data from each of the observation wells; (Wells S-2 through S-6, SR-1 and SR-2). Because of the apparent recharge noted on the field data plots (Cooper-Jacob plots), the GWAP program which uses a series of type-curves for unconfined aquifer conditions was selected. Specifically, the curve-matching method which takes into account delayed drainage effects was used (Neuman, 1975). A "best-fit" curve match was selected and values for transmissivity (T), storativity (S) and hydraulic conductivity (K) were calculated.

Constant-Rate Test Results

Water-level drawdowns were detected and measured in six observation wells; Wells S-2 through S-5, SR-1 and SR-2. Drawdown data collected from pumping well SR-3 were analyzed using the Cooper-Jacob method. Transmissivity was calculated to be 147 gpd/ft. for Well SR-3. Observation wells S-2, S-3, S-4, S-5, SR-1 and SR-2 were also analyzed using the Cooper-Jacob method. T-values for these wells ranged from 143 to 1570 gpd/ft. This range for transmissivity reflects low transmissive sediments (i.e. clays). The locations of the observation wells with respect to the pumping well are shown on Plate 2. Data calculations sheets and semi-log data plots are presented in Appendix B. The analyses are summarized in Table 1. Analysis of two observation well plots (Wells S-2 and S-5) and the pumping well (SR-3) plot generated during the test appear to indicate the effects of delayed drainage (i.e. gravity drainage) which is evidenced by characteristic changes in the drawdown (s) versus time (t) slope as shown on data plots for Wells SR-3, S-2 and S-5. Delayed drainage refers to water that is introduced as recharge to a pumping well or observation well which has been influenced by pumping as a result of movement of water due solely to gravity.

Drawdown versus time data collected from Well S-3 located approximately 80 feet upgradient of the pumping well was plotted using the Cooper-Jacob method. Due to the scattered nature of the data points, calculation of hydraulic parameters in the vicinity of this well were not possible.

Wells S-4 and SR-2 located approximately 80 feet cross-gradient from the pumping well showed influence due to pumping after 100 minutes. Transmissivity was calculated to be 1070 and 1100 gpd/ft, respectively for these wells. Hydraulic conductivity was calculated to be approximately 7 ft/day (Table 1). Hydraulic parameters calculated for these two wells using GWAP software were slightly lower; K-values ranged from 3.5 to 4 ft/day (Table 2). These K-values are within an expected range for the subsurface conditions at the site. Plots generated using GWAP (Neuman's unconfined aquifer analysis method) are presented in Appendix C.

Wells S-5 and SR-1 located downgradient from pumping well SR-3 also showed response to pumping after approximately 100 minutes. Data plots from these wells appear to show some effects of recharge. The Cooper-Jacob method yielded T- and K-values (Table 1) which are an order of magnitude higher than those values calculated using GWAP (Table 2). Therefore, calculations for T- and K-values using the Cooper-Jacob method could be suspect because this method does not account for the effects of delayed drainage in the analysis. Therefore, it is our opinion that data analyzed using the GWAP software which uses the Neuman method are probably more accurate. GWAP data appear to indicate a slightly higher T-value in the downgradient direction from SR-3.

Well S-2 is located adjacent to pumping well SR-3 at a distance of 10 feet. Using the Cooper-Jacob method, transmissivity was calculated to be 344 gpd/ft and hydraulic conductivity was estimated to be 2.3 ft/day. GWAP calculations were approximately half of these values (Table 2).

Because the aquifer is unconfined, the GWAP values are probably more representative of actual subsurface conditions. Data from the constant-rate test are indicative of a heterogeneous subsurface and suspected recharge within the aquifer caused by delayed drainage.

Residual Drawdown Data Analysis

Residual drawdown (well recovery) data from Well SR-3 and S-2 were analyzed. Transmissivity was calculated to be 114 gpd/ft for SR-3 and 215 gpd/ft for Well S-2. These T-values are lower than the T-values calculated by other methods. An S-value of 0.085 was calculated using the data collected from Well S-2. This value is within the range of expected values in unconfined aquifers (Freeze and Cherry, 1979 and Driscoll, 1986) Hydraulic conductivity was calculated to be 0.74 ft/day. These data are similar to the results obtained using the GWAP method for the constant-rate test. Data plots and calculations are presented in Appendix D.

Distance-Drawdown Data Analysis

A semi-log distance-drawdown data plot was constructed (Appendix D) using Wells S-2, S-5 and SR-1. The T-value calculated from this method was 226 gpd/ft and the S-value was calculated to be 0.0014.

A straight line through the data points extended to the zero drawdown intercept gives an approximation of radius of influence (r_0). Using this method, radius of influence was calculated to be 130 feet from pumping well SR-3. This value should not be considered as the radius of capture, as it was derived from imprecise graphical techniques and limited data points. The true radius of capture is typically less than predicted. Observed drawdowns in wells impacted by the constant-rate test after 500 minutes of pumping were plotted and contoured (Plate 4).

SLUG TESTING

Procedures

Slug tests were performed in Wells S-2, S-3, S-5, S-7 through S-10 and SR-3. These tests were performed in selected wells that are suspected to yield less than 1.0 gpm (based on well purge and boring log data). Slug tests were conducted by displacing a known volume of water in the well by introducing a "PVC slug" (slug-in test) and recording changes in the water-level. Water-levels were recorded continuously until water-level equilibrium within the well was reached (water-level returned to within 90% or greater of the initial static water-level). The test was stopped and a new test was started by removing the slug from the well (slug-out test). This test was run until the water-level had recovered to within 90% or greater of the initial static water-level. A schematic diagram of the slugs used to perform these tests is presented on Plate 5.

Water-levels were measured and recorded immediately prior to slug-in testing in each well. A pressure transducer connected to the HERMIT was then placed in the well approximately 2 feet above the bottom of the well casing and secured at the wellhead. The pressure transducer was referenced to zero immediately prior to introducing the slug into the well. The slug was dropped in a well creating an instantaneous rise in water column. The fall of the water column to static level was continuously measured by the transducer and recorded by the HERMIT. Upon equilibrium, a new test was setup and the transducer reading was referenced to zero again. The slug-out test was started by removing the slug from a well creating an instantaneous fall in the water column. Water-level rise to static level was continuously measured by the transducer and recorded by the HERMIT.

Slug test equipment was decontaminated between tests using an Alconox wash and a clean water rinse.

Data Analysis

Field data consisted of observed and recorded changes in water level over the duration of the test. These data were plotted on arithmetic graph paper in the field using the Ferris and Knowles method (Ferris and Knowles, 1954) for analyzing slug test data. This analysis method enabled estimations of transmissivity (T) values from field data plots using a best-fit straight line graphic approach. Plotting data in the field also permitted the tracking of a test and correlation of T-values to lithology described in exploratory boring logs.

A computer program which utilizes curve matching techniques was also used to analyze the slug test data. GWAP uses a series of type-curves developed after Cooper, Bredehoeft, and Papadopulos (1967) to obtain a "best-fit" curve match to calculate values for transmissivity, storativity and hydraulic conductivity.

Slug Test Results

Due to the low permeability of the aquifer material, the data plotted using the Ferris and Knowles method showed little to no linearity and the transmissivity values calculated were very low. The lack of linearity is suspected to be due to the heterogeneity of the aquifer and associated low permeability, and the difficulty to properly design and develop very low-yield wells in clayey aquifer environments. Therefore it is our opinion that this method of analysis given the site geology and limitations for well design, may not be applicable to evaluate transmissivity. Transmissivity values ranged from 18.02 to 302.81 gpd/ft. using the Ferris and Knowles analysis method. The field plots and calculated T-values for this method are presented in Appendix E.

Analysis of the slug test data (slug-in and slug-out) using the GWAP program derived T-values ranging from 478 to 8,690 gallons per day per foot (gpd/ft) (Tables 3 and 4). K-values ranged from 3.2 to 58.2 feet per day (ft/day). Calculated S-values are unrealistically small and therefore are most likely unrepresentable of actual aquifer conditions. Computer generated plots for the slug-in and slug-out tests are presented in Appendix F. The presence of more transmissive sediments in Wells S-3 and S-10 as indicated on the exploratory boring logs (Appendix A), may account for the slightly higher calculated transmissivities for these wells. These data appear to indicate a preferred pathway cross-gradient toward Well S-10 to the east, but cannot be verified based on limited data points.

Calculated values of T and K using the slug test data are very low but consistent with what would be expected considering the amount of clayey material encountered in the subsurface. The wide range in values are most likely attributed to the heterogeneity of the clay (especially the complexity of the interbedded sandy horizons) in the subsurface as well as inherent well construction difficulties in low-permeable, fine grained aquifers where classic well design procedures fail. Higher transmissivity values are probably a result of a small area of influence and the influence from the well annular space material (i.e. sandpack).

GROUNDWATER QUALITY DATA

Ground-water samples were collected from the monitoring network by Gettler-Ryan Inc. (G-R) on March 6, 1990, after the completion of all aquifer testing. All wells were analyzed for Total Petroleum Hydrocarbons calculated as Gasoline (TPH-Gasoline) using EPA Method 8015 (modified) and benzene, toluene, ethylbenzene and xylenes (BTEX) using EPA Method 8020. The chemical analytical results for TPH-Gasoline and BTEX are summarized on Table 5, along with the potentiometric data for this sampling.

The areal distribution of hydrocarbons in the shallow groundwater beneath the site has been mapped (Plates 6 and 7). As indicated on Plates 6 and 7, the dissolved hydrocarbon contaminant plume appears to be elongated toward the east and to the south. Plume configuration appears to be consistent with the preferred migration pathways indicated by aquifer test results. Also consistent with the low flow conditions indicated by the test results at the site, is the fact that the hydrocarbon plume has essentially maintained the same position for more than a 1/2 year; two continuous quarterly samplings (GSI Quarterly Reports, December, 1989, and March, 1990). A copy of the Gettler-Ryan (G-R) Groundwater Sampling Report for the March, 1990 sampling is presented in Appendix G.

DISCUSSION

Results from the analytical techniques used to evaluate the constant-rate discharge test indicate that the shallow aquifer is unconfined and exhibits the effects of delayed drainage recharge during pumping. This is evidenced by the Cooper-Jacob semi-log plot of log time (t) versus drawdown (s) show several breaks in the drawdown curve plotted for pumping well SR-3 (Appendix D). In addition, upgradient Well S-3 showed scattered data points which may indicate that drainage was occurring at different rates from different subsurface units (interbeds) over the duration of the test.

T-values typically increase with distance from the pumping well, which suggests that heterogeneities (i.e. lateral facies changes) within the aquifer influence well performance and the development of the cone of depression. Examination of boring logs confirm lateral changes in lithology exist in the shallow aquifer. These lateral lithologic changes can take place over short distances and may cause a delayed response to pumping in some observation wells due to poor hydraulic interconnection of the discreet sandy and clayey sand interbeds. Aquifer test results are consistent with what would be expected given the subsurface geology and general low permeable nature of encountered sediments.

Comparison of slug test data and constant-rate test data indicate a possible preferred migration pathway exists in the direction of Wells S-4 and S-10 toward the east and downgradient (south-southeast) toward Well S-5. The existence of a preferred pathway is evidenced by slightly higher T- and K-values in the direction of S-4 and S-10 from SR-3 and cone of depression development and configuration. These preferred pathways also appear to be supported by the areal distribution of hydrocarbons shown on the most recent chemical isoconcentration maps (Plates 6 and 7) for this site.

The results of constant-rate test data using the Cooper-Jacob method, the Distance-Drawdown Method, and the Residual-Drawdown Analysis indicate that T-values and K-values are very low in this aquifer. T-values calculated by GWAP for the slug tests are on average higher than those calculated for the constant-rate test. This is most likely attributable to influence by the sandpack material and the inherent well design problems associated with fine grained aquifers.

CONCLUSION

Near dewatering of the well occurred during the test at a pumping rate of 1.5 gpm. Low T- and K-values values calculated from the slug tests and the constant-rate discharge test for observation wells suggest very slow transport of contaminants in the ground-water beneath the site. Boring log data further support aquifer test conclusions by the lack of appreciable transmissive sediments in the shallow aquifer zone.

Based on aquifer test data and conjunctive data for this site, GSI recommends that a Remedial Action Plan (RAP) be prepared to evaluate whether passive remediation via natural degradation would be an effective method of remediation. The RAP will include historical data; a summary of previous investigations, potentiometric data and chemical data trends. Additionally, results of the aquifer tests will be used to simulate contaminant migration and natural degradation by soil bacteria using the "Simulated Benzene Transport Model" developed by Shell Oil Company described in Appendix H.

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Table 1

SUMMARY OF NON-EQUILIBRIUM ANALYTICAL METHOD RESULTS (Cooper-Jacob, 1946)

WELL	PUMP RATE (gpm)	MAXIMUM DRAWDOWN (feet)	DISTANCE TO PUMPING WELL (feet)	TRANSMISSIVITY (gpd/ft)	HYDRAULIC CONDUCTIVITY (ft/day)	STORATIVITY
S-2	1.5	3.995	10	344	2.3	0.053746
S-3	1.5	0.318	80.6	1320	8.8	0.004230
S-4	1.5	0.28	82.4	1070	7.2	0.002822
S-5	1.5	0.085	121	5657	37.8	0.006760
SR-1	1.5	0.17	98.5	2084	13.9	0.003222
SR-2	1.5	0.34	79.4	1100	7.4	0.002036
SR-3	1.5	10.9	0	147		

Note: Pumping well was SR-3 at a rate of 1.5 gpm

Table 2

SHELL CONSTANT-RATE TEST RESULTS
GRAPHICAL WELL ANALYSIS PACKAGE (GWAP) after Neuman, 1975

WELL	MAXIMUM DRAWDOWN (feet)	DISTANCE TO PUMPING WELL (feet)	TRANSMISSIVITY (gpd/ft)	HYDRAULIC CONDUCTIVITY (ft/day)	STORATIVITY
SR-1	0.17	98.5	989	6.604	4.68E-003
SR-2	0.34	79.4	519	3.462	2.98E-003
S-2	3.99	10.0	143	0.956	2.02E-003
S-3	0.32	80.6	1300	8.717	5.45E-003
S-4	0.28	82.4	653	4.372	3.84E-003
S-5	0.09	121.0	1570	10.481	9.34E-003
S-6	0.08	155.0	989	6.604	6.38E-003

gpd = gallons per day
Pumping Well = SR-3 at 1.5 gpm

Table 3

SHELL SLUG-IN TEST RESULTS
GRAPHICAL WELL ANALYSIS PACKAGE (GWAP) METHOD

WELL	DATE	TRANSMISSIVITY (gpd/ft)	HYDRAULIC CONDUCTIVITY (ft/day)	STORATIVITY
SR-3	02/22/90	2290	15.374	1.00E-006
S-2	02/22/90	1440	9.639	1.00E-006
S-3	02/22/90	8110	54.28	1.00E-006
S-5	02/23/90	2230	14.97	1.00E-006
S-7	02/23/90	2810	18.85	1.00E-006
S-8	02/23/90	1820	12.139	1.00E-006
S-9	02/23/90	2130	14.305	1.00E-007
S-10	02/23/90	8690	58.155	1.00E-007

Table 4

SHELL SLUG-OUT TEST RESULTS
GRAPHICAL WELL ANALYSIS PACKAGE (GWAP) METHOD

WELL	DATE	TRANSMISSIVITY (gpd/ft)	HYDRAULIC CONDUCTIVITY (ft/day)	STORATIVITY
SR-3	02/22/90	1260	8.422	1.00E-001
S-2	02/22/90	478	3.195	1.00E-001
S-3	02/22/90	5740	38.37	1.00E-002
S-5	02/23/90	1230	8.209	1.00E-007
S-7	02/23/90	3880	25.94	1.00E-007
S-8	02/23/90	2810	18.85	1.00E-008
S-9	02/23/90	723	4.840	1.00E-004
S-10	02/23/90	7400	49.47	1.00E-009

gpd = gallons per day

TABLE 5

GROUND-WATER ANALYSIS DATA

WELL #	SAMPLE DATE	ANALYZED DATE	TPH (PPM)	BENZENE (PPM)	TOLUENE (PPM)	ETHYLBENZENE (PPM)	XYLENES (PPM)	WELL ELEV (FT)	STATIC WATER ELEV (FT)	PRODUCT THICKNESS (FT)	DEPTH TO WATER (FT)
S-2	05-Mar-90	07-Mar-90	0.71	0.057	<0.0005	<0.0005	0.088	329.21	314.76	----	14.45
S-3	05-Mar-90	07-Mar-90	<0.050	<0.0005	<0.0005	<0.0005	<0.001	327.67	315.16	----	12.51
S-4	05-Mar-90	07-Mar-90	0.35	0.043	<0.0005	0.024	0.047	328.53	314.22	----	14.31
S-5	05-Mar-90	07-Mar-90	1.1	0.10	0.11	0.079	0.24	329.66	313.85	----	15.81
S-6	06-Mar-90	13-Mar-90	0.42	0.0031	<0.0005	0.014	<0.001	327.62	312.99	----	14.63
S-7	06-Mar-90	09-Mar-90	<0.050	<0.0005	<0.0005	<0.0005	<0.001	328.67	311.65	----	17.02
S-8	05-Mar-90	14-Mar-90	<0.050	<0.0005	0.0005	<0.0005	<0.001	327.00	312.44	----	14.56
S-9	06-Mar-90	13-Mar-90	<0.050	<0.0005	<0.0005	<0.0005	<0.001	328.24	310.68	----	17.56
S-10	06-Mar-90	13-Mar-90	<0.050	<0.0005	<0.0005	<0.0005	<0.001	326.55	312.38	----	14.17
SR-1	05-Mar-90	08-Mar-90	0.064	0.020	<0.0005	0.0015	0.004	329.78	313.70	----	16.08

CURRENT REGIONAL WATER QUALITY CONTROL BOARD MAXIMUM CONTAMINANT LEVELS
Benzene 0.001 ppm   Xylenes 1.750 ppm   Ethylbenzene 0.68 ppm

CURRENT DHS ACTION LEVELS
Toluene 0.100 ppm

TPH = Total Petroleum Hydrocarbons as Gasoline
PPM = Parts Per Million   SR = Recovery Well   SF = Field Blank   TB = Trip Blank

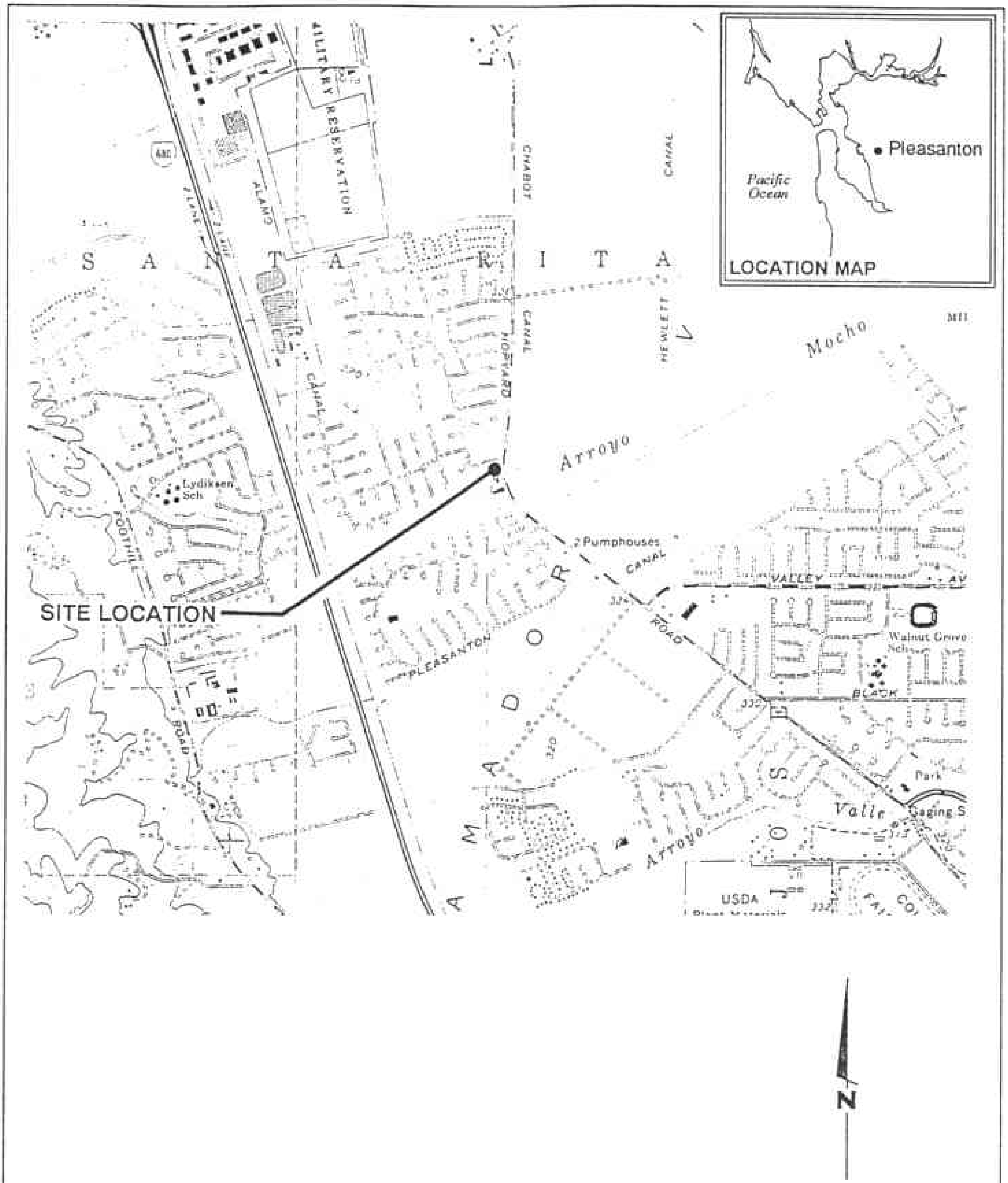
Note: 1. All data shown as <x are reported as ND (none detected)
2. Water Level elevations referenced to mean sea level (MSL)
3. DHS Action Levels and MCL are subject to change pending State review

Project No. 7632-5

TABLE 5

GROUND-WATER ANALYSIS DATA

WELL #	SAMPLE DATE	ANALYZED DATE	TPH (PPM)	BENZENE (PPM)	TOLUENE (PPM)	ETHYLBENZENE (PPM)	XYLENES (PPM)	WELL ELEV (FT)	STATIC WATER ELEV (FT)	PRODUCT THICKNESS (FT)	DEPTH TO WATER (FT)
SR-2	05-Mar-90	07-Mar-90	0.14	0.0030	<0.0005	0.012	0.007	328.35	314.05	----	14.30
SR-3	05-Mar-90	07-Mar-90	0.070	0.015	0.0008	0.0058	0.010	329.11	314.77	----	14.34
SD-2	05-Mar-90	08-Mar-90	0.38	0.022	0.0012	<0.0005	0.044	----	----	----	----
SF-8	05-Mar-90	08-Mar-90	<0.050	<0.0005	<0.0005	<0.0005	<0.001	----	----	----	----
SF-6	06-Mar-90	13-Mar-90	<0.050	<0.0005	<0.0005	<0.0005	<0.001	----	----	----	----
TB	05-Mar-90	08-Mar-90	<0.050	<0.0005	<0.0005	<0.0005	<0.001	----	----	----	----
TB	06-Mar-90	13-Mar-90	<0.050	<0.0005	<0.0005	<0.0005	<0.001	----	----	----	----



Base Map: USGS Topographic Map

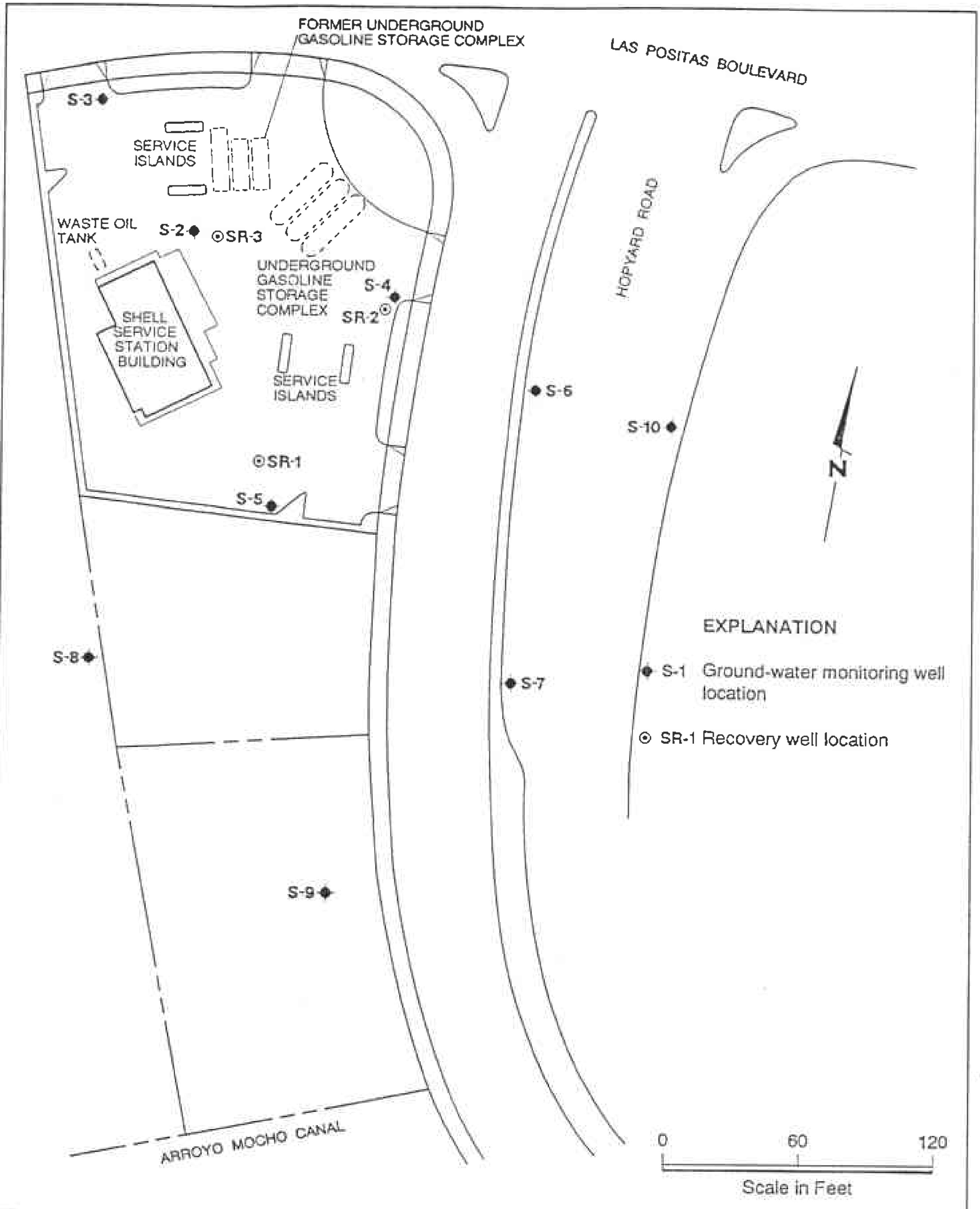
Approximate Scale : 1" = 2000'

GeoStrategies Inc.

Vicinity Map
Shell Service Station
3790 Hopyard Road
Pleasanton, California

PLATE 1

JOB NUMBER	REVIEWED BY RG/CEG	DATE	REVISED DATE	REVISED DATE
7632		3/90		

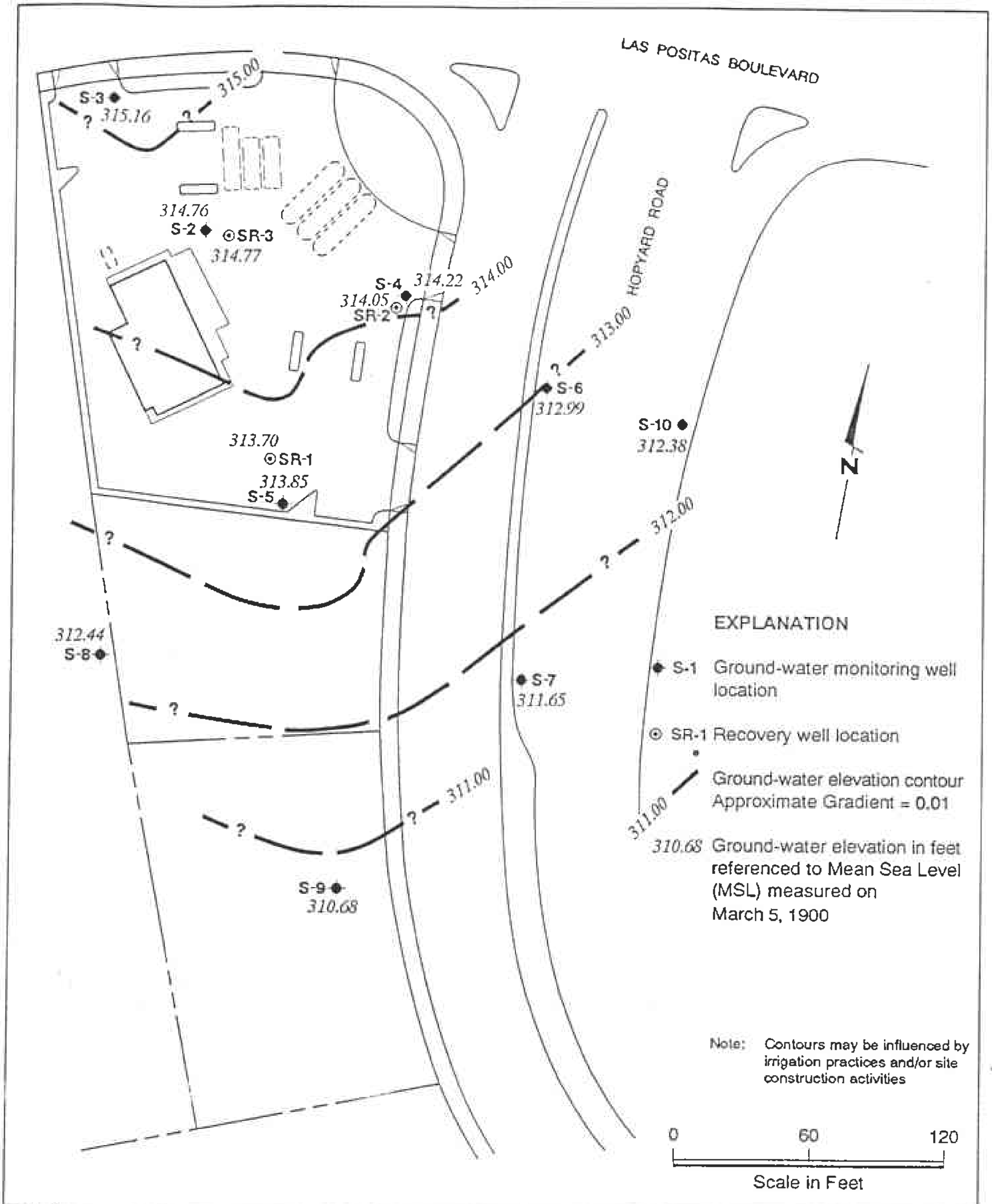


GSI GeoStrategies Inc.

Site Plan
Shell Service Station
3790 Hopyard Road
Pleasanton, California

PLATE **2**

JOB NUMBER	REVIEWED BY RG/CEG	DATE	REVISED DATE	REVISED DATE
7632	CWD CEG 1262	4/90		

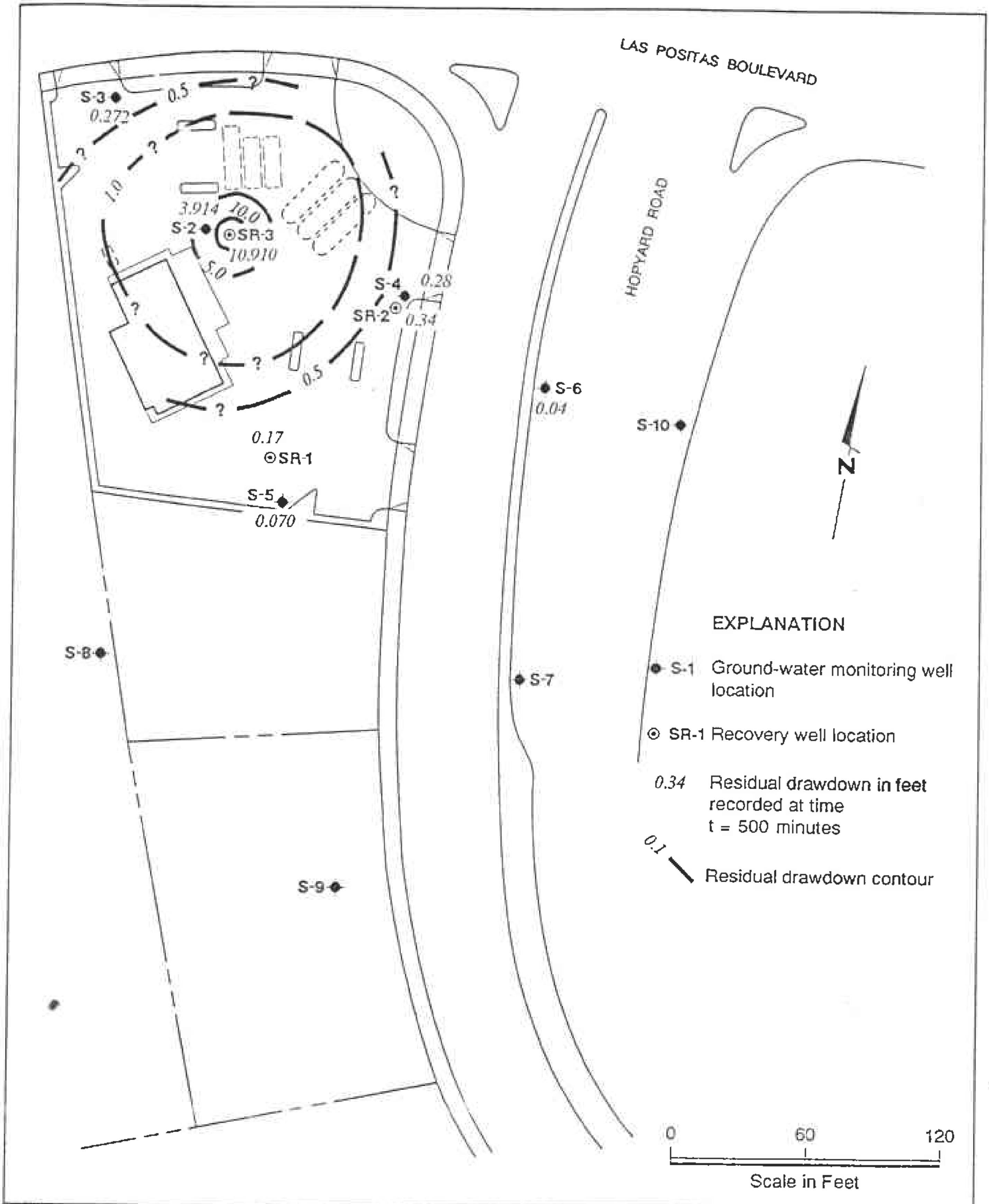


GSI GeoStrategies Inc.

Potentiometric Map
Shell Service Station
3790 Hopyard Road
Pleasanton, California

PLATE **3**

JOB NUMBER	REVIEWED BY RG/CEG	DATE	REVISED DATE	REVISED DATE
7632	CMP CEG 1262	4/90		

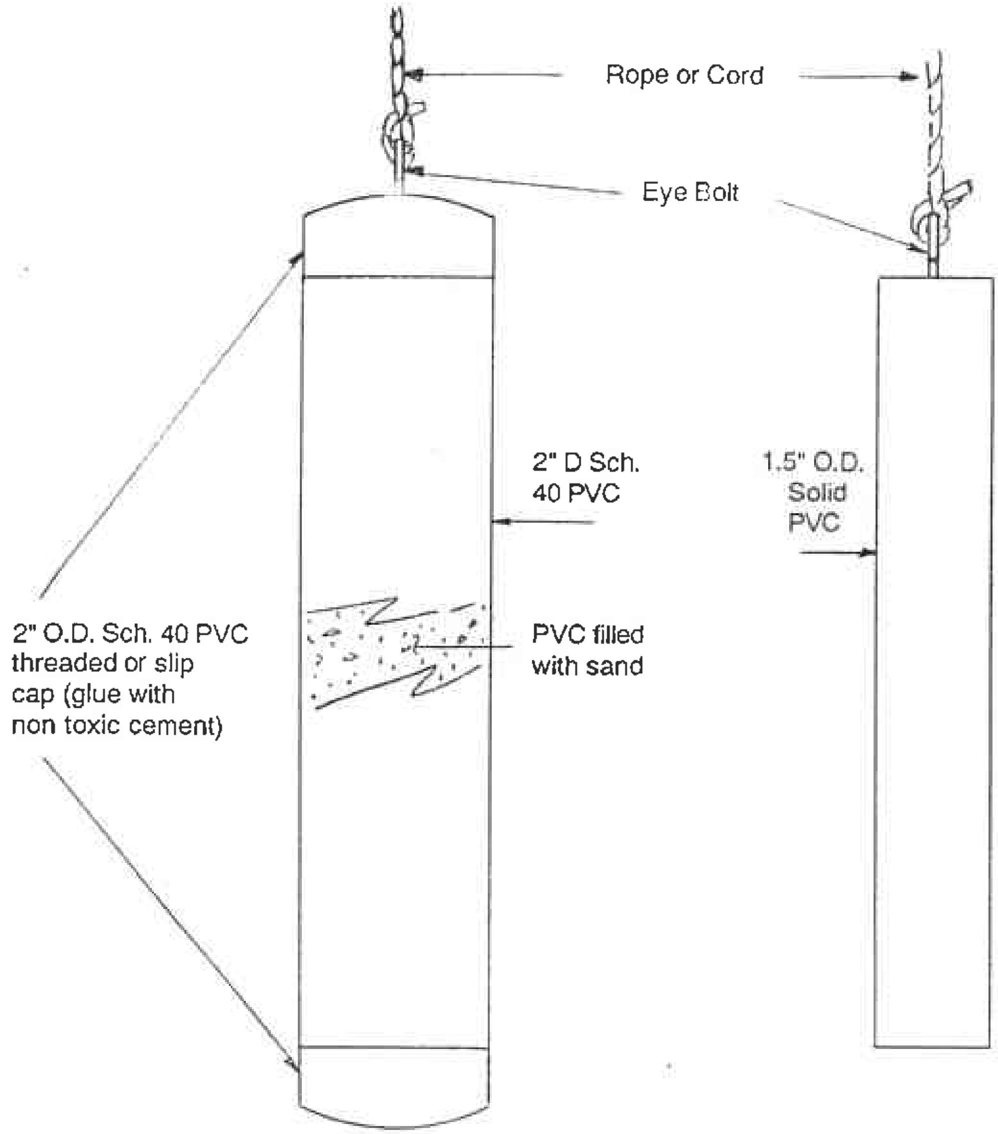


GSI GeoStrategies Inc.

Well SR-3 Radius of Influence Map
Shell Service Station
3790 Hopyard Road
Pleasanton, California

PLATE 4

JOB NUMBER	REVIEWED BY RG/CEG	DATE	REVISED DATE	REVISED DATE
7632	CMP CEG 1262	4/90		



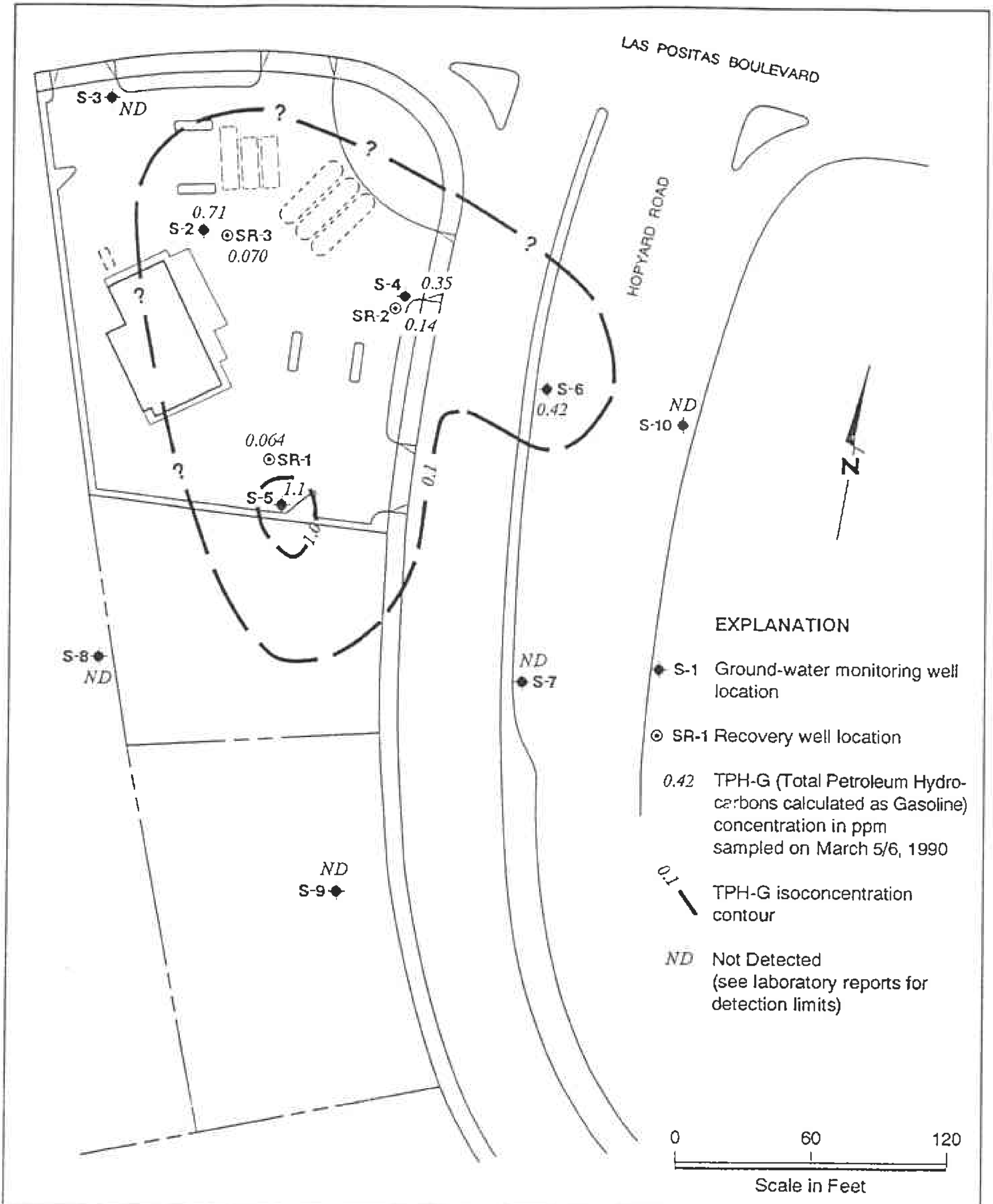
Example: Slug used in Monitoring Well Slug Test

GeoStrategies Inc.

Schematic Slug Diagram
Shell Service Station
3790 Hopyard Road
Pleasanton, California

PLATE **5**

JOB NUMBER	REVIEWED BY RG/CEG	DATE	REVISED DATE	REVISED DATE
7632	[illegible signature]	4/90		

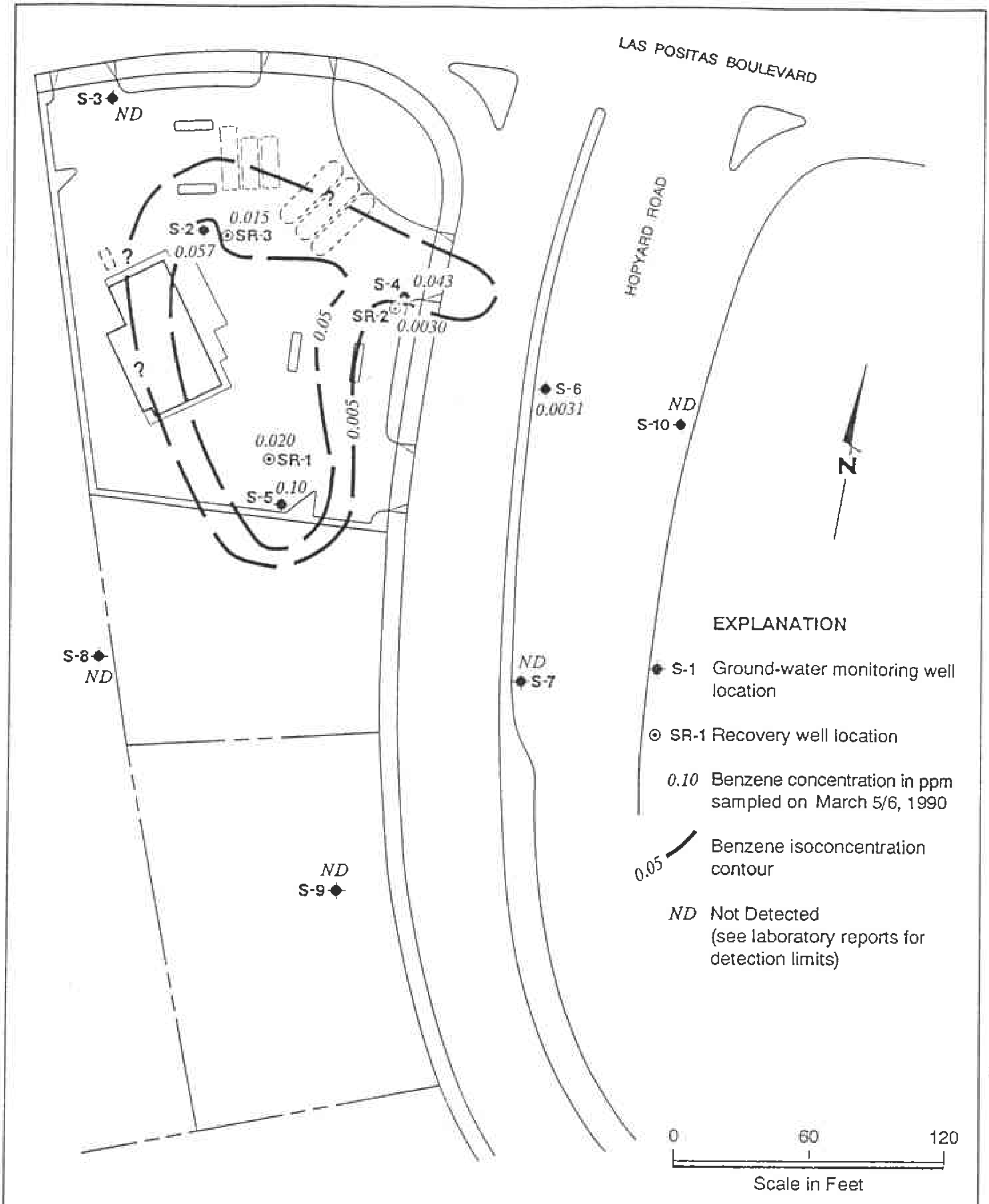


GSI GeoStrategies Inc.

TPH-G Isoconcentration Map
Shell Service Station
3790 Hopyard Road
Pleasanton, California

PLATE 6

JOB NUMBER	REVIEWED BY RG/CEG	DATE	REVISED DATE	REVISED DATE
7632	CMP CEG 1262	4/90		



GSI GeoStrategies Inc.

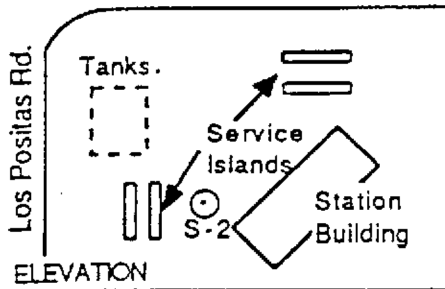
Benzene Isoconcentration Map
Shell Service Station
3790 Hopyard Road
Pleasanton, California

PLATE **7**

JOB NUMBER	REVIEWED BY RG/CEG	DATE	REVISED DATE	REVISED DATE
7632	NMP CEG 1262	4/90		

APPENDIX A
EXPLORATORY BORING LOGS

LOCATION MAP Hopyard Rd.



ELEVATION

PACIFIC ENVIRONMENTAL GROUP, INC.

WELL / BORING NO. [illegible]
PAGE 1 OF 1

PROJECT NO. 101-08.01
LOGGED BY: E.L.
DRILLING METHOD: HSA
SAMPLING METHOD: CAL. MOD.
CASING TYPE: SHC. #40 PVC
SLOT SIZE: 0.020
GRAVEL PACK: 12 X 20 SAND

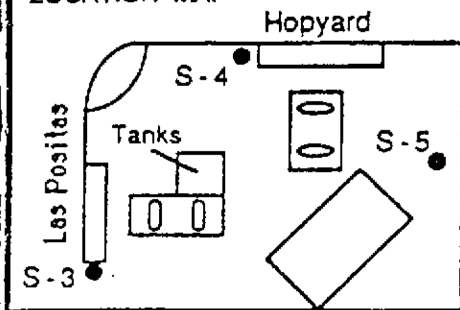
CLIENT: G-R/SHELL
DATE DRILLED: 10/28/87
LOCATION: Hopyard & Los Positas
HOLE DIAMETER: 8"
HOLE DEPTH: 35'
WELL DEPTH: 35'
WELL DIAMETER: 3"

Well completion: Concrete; Bentonite; 12 X 20 Sand; Caved

MOISTURE CONTENT	TIP	PENETRATION RESISTANCE (BLOW/FT)	DEPTH (feet)	SOIL TYPE	LITHOLOGY / REMARKS
			0–1		ASPHALT & BASEROCK FILL
			2	CL	CLAY; gray; moderate plasticity; silty; trace fine to coarse sand; faint product odor.
Dp	4.5	P	4		@3.5'; as above; 5-10% coarse sand to fine gravel; **moderate product odor.**
Dp	83.5	11	10	CH	CLAY; gray; high plasticity; trace coarse gravel; rootholes; stiff; **faint product odor.**
Dp	314	6	14	CL	CLAY; gray; moderate plasticity; trace fine sand; roots; occasional peaty interbeds; 5-15% organics; hydrogen sulfide odor; medium stiff; **faint product odor.**
Wt	333	3	20		@ 19'; as above; soft; no product odor.
Wt	20.5	7	24		@ 24'; as above; peat absent; medium stiff; no product odor.
Wt	5.5	10	30		@29'; as above; no product odor.
Wt	11.5	12	34	CH	CLAY; gray; high plasticity; trace silt; stiff; no product odor.

BOTTOM OF BORING AT 35 FEET

LOCATION MAP



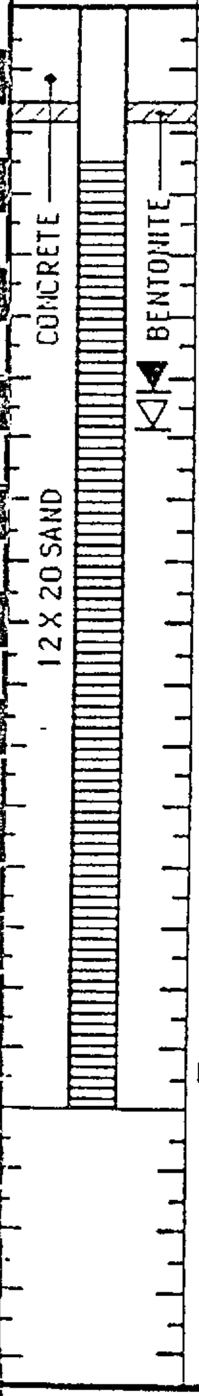
PACIFIC ENVIRONMENTAL GROUP, INC.

WELL / BORING NO. [illegible]
PAGE 1 OF 1

PROJECT NO. 101-08.02
LOGGED BY: C.P.
DRILLING METHOD: HSA
SAMPLING METHOD: CAL MOD
CASING TYPE: Sch 40 PVC
SLOT SIZE: 0.020
GRAVEL PACK: 12 X 20 SAND

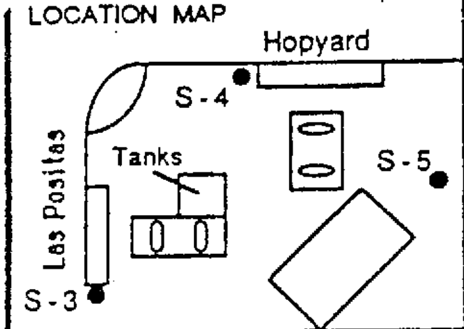
CLIENT: G.R. Shell
DATE DRILLED: 1-26-88
LOCATION: Hopyard & Las Positas
HOLE DIAMETER: 8"
HOLE DEPTH: 36'
WELL DEPTH: 36'
WELL DIAMETER: 3"

WELL COMPLETION



MOISTURE CONTENT	H-NU READING	PENETRATION RESISTANCE (BLOWS/FT)	DEPTH (FEET)	SOIL TYPE	LITHOLOGY / REMARKS
			0		ASPHALT & BASEROCK - FILL
			2	CL	CLAY; dark olive gray; moderate plasticity; trace coarse sand; roots; firm; no product odor.
Dp	0.6	PUSH	4		
			6		
			8		
Dp	3.0	13	10		@9'; as above; ; stiff; no product odor.
			12		
Dp	2.0	4	14		@14'; as above; medium olive gray; rootholes; soft; no product odor.
			16		
			18		
Mst	0.0	5	20	CH	CLAY; mottled olive and gray; high plasticity; trace-5% organics; soft; no product odor.
			22		
Mst	4.0	7	24		@24'; as above; mottled olive gray and black; trace organics; iron oxide staining; firm; no product odor.
			26		
			28		
Mst	0.3	10	30	CL	CLAY; low plasticity; mottled olive and gray; 10-15% coarse sand; stiff; no product odor.
			32		
Mst	0.0	11	34		@34'; as above; olive; trace organics; no sand; no product odor.
			36		BOTTOM OF BORING AT 36'
			38		
			40		
			42		
			44		

LOCATION MAP	PACIFIC ENVIRONMENTAL GROUP, INC.	WELL / BORING NO. S-4 PAGE 1 OF 1



PROJECT NO. 101-08.02
LOGGED BY: C.P.
DRILLING METHOD: HSA
SAMPLING METHOD: CAL MOD
CASING TYPE: Sch 40 PVC
SLOT SIZE: 0.020
GRAVEL PACK: 12 X 20 SAND

CLIENT: G.R. Shell
DATE DRILLED: 1-26-88
LOCATION: Hopyard & Las Positas
HOLE DIAMETER: 8"
HOLE DEPTH: 36'
WELL DEPTH: 36'
WELL DIAMETER: 3"

WELL COMPLETION: CONCRETE; BENTONITE; 12 X 20 SAND

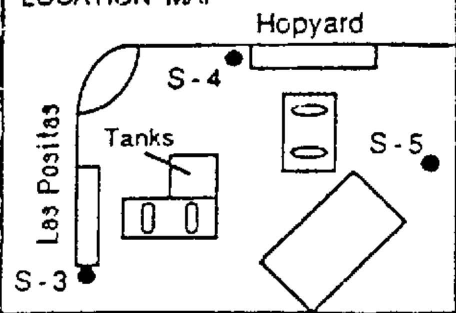
MOISTURE CONTENT	H-NU READING	PENETRATION RESISTANCE (BLOWS/FT)	DEPTH (FEET)	SOIL TYPE	LITHOLOGY / REMARKS
			0		ASPHALT, GRAVEL, & BRICK.
			2	CL	CLAY; olive gray; low plasticity; trace coarse sand; trace organics; trace coarse gravel; firm; no product odor.
Dp	12.2	PUSH	4		
Dp	20	14	10		@9'; as above; moderate plasticity; no gravel; stiff; no product odor.
Dp	78	5	15		@14'; as above; mottled medium brown and olive; low plasticity; trace medium sand; iron oxide staining; charcoal; roots; low plasticity; firm; no product odor; peat lens @14 1/2'.
Dp	188	8	20		@19'; as above; mottled green & olive; 5-10% silt; rootholes; firm; **moderate product odor.**
Mst	110	12	25		@24'; as above; black; moderate plasticity; stiff; no product odor.
Mst	22	14	30	CH	CLAY; dark gray; trace fine gravel; trace fine sand; no product odor.
Mst	2.2	10	35		@34'; as above; olive; high plasticity; rootholes; trace organics; stiff; no prodcut odor.
			36		BOTTOM OF BORING AT 36'

DEPTH scale: 2, 4, 6, 8, 10, 12, 14, 16, 18, 20, 22, 24, 26, 28, 30, 32, 34, 36, 38, 40, 42, 44

PACIFIC ENVIRONMENTAL GROUP, INC.

WELL / BORING NO. S-5
PAGE 1 OF 1

LOCATION MAP



PROJECT NO. 101-08.02
LOGGED BY: C.P.
DRILLING METHOD: HSA
SAMPLING METHOD: CAL MOD
CASING TYPE: Sch 40 PVC
SLOT SIZE: 0.020
GRAVEL PACK: 12 X 20 SAND

CLIENT: G.R. Shell
DATE DRILLED: 1-26-88
LOCATION: Hopyard & Las Positas
HOLE DIAMETER: 8"
HOLE DEPTH: 36'
WELL DEPTH: 35 1/2'
WELL DIAMETER: 3"

WELL COMPLETION: CONCRETE; BENTONITE; 12 X 20 SAND; CAVED

MOISTURE CONTENT	H-NU READING	PENETRATION RESISTANCE (BLOWS/FT)	DEPTH (FEET)	SOIL TYPE	LITHOLOGY / REMARKS
					ASPHALT & BASEROCK/GRAVEL
			2	CL	CLAY; dark olive gray; 10-15% fine gravel; medium plasticity; trace organics; trace medium sand; firm; no product odor.
Dp	5.9	PUSH	4		
			6		
			8		
Dp	42	14	10		@9'; as above; dark olive silty; no gravel; trace medium to coarse sand; clay sheared through center of sampler; stiff; faint product odor.
			12		
			14		
Dp	35	8	16	CH	CLAY; dark bluish gray; medium to high plasticity; trace coarse sand; peaty; 10-15% organics; stiff; moderate product odor (oil).
			18		
Dp	254	9	20	CL	CLAY; medium brownish gray; moderate plasticity; trace-5% organics; iron oxide staining; rootholes; stiff; visible product sheen; strong product odor.
			22		
Dp	50	7	24		@24'; as above; mottled gray and olive brown; firm; moderate product odor.
			26		
			28		
Dp	58	8	30		@29'; as above; dark olive; trace organics; trace medium sand; firm; faint product odor. @30.5; silt lens.
			32		
Dp	8.0	10	34		@34'; as above; medium olive gray; firm; thin lens of silty clay; no product odor.
			36		BOTTOM OF BORING AT 36'
			38		
			40		
			42		
			44		

Woodward-Clyde Consultants

PROJECT NAME GETTLER-RYAN NO. 8820011A

MONITORING WELL LOCATION	Los Positas and Hopyard, Pleasanton, CA (S-6)	ELEVATION AND DATUM	
DRILLING AGENCY	Bay Land Drilling Co.	DRILLER	Kurt
DATE STARTED / DATE FINISHED	10/4/88		
DRILLING EQUIPMENT	Truck mounted CME - 75	COMPLETION DEPTH	35'
SAMPLER	Modified California		
DRILLING METHOD	8" Hollow stem augers	DRILL BIT	
NO. OF SAMPLES	DIST. 7	UNDIST.	
WATER LEVEL	FIRST	COMPL. 12.1'	24 HRS.
LOGGED BY:	K. Stevens	CHECKED BY:	M. Borkowski

Item	Description	From	To	
SIZE AND TYPE OF CASING	3" PVC Threaded	35	0	FT.
TYPE OF PERFORATION	0.020" Slot	35	10	FT.
SIZE AND TYPE OF PACK	2/12 Lonestar Sand	35	8	FT.
TYPE OF SEAL NO. 1	Bentonite	8	6.5	FT.
TYPE OF SEAL NO. 2	Concrete	6.5	0	FT.

Depth (feet)	Samples	Blows	MATERIAL DESCRIPTION		USCS
0			Asphalt and Gravel Base		
					SM
5	1	pushed @ 230 psi	SILTY SAND silty sand with some gravel, loose, poorly sorted, dry	H Nu = 0.5 ppm No Hydrocarbon odor	CL
10	2	3, 4, 7	CLAY dark gray clay, trace silt, very stiff, plastic	H Nu = 5.5 ppm No Hydrocarbon odor	CL
15	3*	2, 2, 5	dark gray with trace gravel, very stiff, plastic, dry to damp	H Nu = 6 ppm No Hydrocarbon odor	CL
20	4*	2, 3, 6	dark gray with layer fine silt, medium stiff, damp	~~H Nu = 180 ppm~~ Hydrocarbon odor	CL
25	5*	2, 3, 7	mottled brown, black, gray clay with occasional gravel, stiff, plastic, damp	H Nu = 4 ppm No Hydrocarbon odor	CL
30	6	4, 4, 6	dark gray clay, very stiff, plastic	H Nu = 4.5 ppm	CL
			~~GRAVEL~~ layer coarse gravel and some coarse sand, poorly sorted, wet	No Hydrocarbon odor	GP
35					

PROJECT NAME GETTLER-RYAN NO. 8820011A

Depth (feet)	Samples	Blows	MATERIAL DESCRIPTION		USCS	Well Construction
35	7	4 5 7	CLAY dark gray clay with trace gravel, soft, plastic, wet	H Nu = 1.5 ppm No Hydrocarbon odor	CL	
40			Total Depth = 35.5 feet * = Lab Sample			
45						
50						
55						
60						
65						
70						
75						
80						

Woodward-Clyde Consultants PROJECT NAME GETTLER-RYAN NO. 8820011A

MONITORING WELL LOCATION	Los Positas and Hopyard, Pleasanton, CA	ELEVATION AND DATUM	
DRILLING AGENCY Bay Land Drilling Co.	DRILLER Kurt	DATE STARTED / DATE FINISHED	10/4/88
DRILLING EQUIPMENT	Truck mounted CME - 75	COMPLETION DEPTH 35'	SAMPLER Modified California
DRILLING METHOD 8" Hollow stem augers	DRILL BIT	NO. OF SAMPLES DIST. 7	UNDIST.
SIZE AND TYPE OF CASING 3" PVC Threaded	FROM 35 TO 0 FT.	WATER LEVEL FIRST	COMPL. 15.8' / 24 HRS.
TYPE OF PERFORATION 0.020" Slot	FROM 35 TO 10 FT.	LOGGED BY: K. Stevens	CHECKED BY: M. Borkowski
SIZE AND TYPE OF PACK 2/12 Lonestar Sand	FROM 35 TO 8 FT.		
TYPE OF SEAL NO. 1 Bentonite	FROM 8 TO 6.5 FT.		
TYPE OF SEAL NO. 2 Concrete	FROM 6.5 TO 0 FT.		

Depth (feet)	Samples	Blows	MATERIAL DESCRIPTION		USCS
0			Asphalt and Gravel Base		SM
5	1	pushed@ 250 psi	**SAND** silty sand with some gravel, loose, poorly sorted, dry	HNu = 0ppm No Hydrocarbon odor	CL
10	2	pushed@ 250 psi	**CLAY** dark gray clay with some gravel, stiff, plastic, damp	HNu = 0ppm No Hydrocarbon odor	SC / CL
15	3	2, 1, 3	**CLAYEY SAND** clayey sand with little gravel, loose, poorly sorted, moist	HNu = 0ppm No Hydrocarbon odor	PT
			CLAY dark gray clay with black mottling, trace sand and gravel, medium stiff, low plasticity		CL
20	4	3, 3, 6	**PEAT** peat with trace clay, root material, moist	HNu = 0ppm No Hydrocarbon odor	
			CLAY dark gray clay, trace roots and root impressions, stiff, plastic		
25	5	2, 4, 7	dark gray clay	HNu = 0ppm No Hydrocarbon odor	
30	6	4, 6, 7	mottled brown, black, gray clay with occasional gravel, moist to wet, soft, with occasional streaks of white	HNu = 0ppm No Hydrocarbon odor	
35					

PROJECT NAME GETTLER-RYAN NO. 8820011A

Depth (feet)	Samples	Blows	MATERIAL DESCRIPTION		USCS	Well Construction
35	7		dark green clay with trace gravel, soft, plastic, moist to wet	HNu = 0 ppm No Hydrocarbon odor	CL	
			Total Depth = 35.5 feet			
			* = Lab Sample			
40						
45						
50						
55						
60						
65						
70						
75						
80						

Woodward-Clyde Consultants

PROJECT NAME GETTLER - RYAN NO. 8820011A/0118

MONITORING WELL LOCATION 3790 Hopyard Rd, Pleasanton, CA (S-8)			ELEVATION AND DATUM 100.00' site datum		
DRILLING AGENCY Baylands	DRILLER K. Voss		DATE STARTED 2/24/89 DATE FINISHED 2/24/89		
DRILLING EQUIPMENT Truck-mounted CME-75			COMPLETION DEPTH 35'	SAMPLER Modified California	
DRILLING METHOD 8" hollow stem auger	DRILL BIT CME Carbide		NO. OF SAMPLES	DIST. ____	UNDIST. 7
SIZE AND TYPE OF CASING 3" PVC	FROM 34.5 TO 0.5 FT.		WATER LEVEL	FIRST 16' Approx.	COMPL. ____ 24 HRS. ____
TYPE OF PERFORATION 020 slotted	FROM 34.5 TO 9.5 FT.		LOGGED BY: C. Parten		CHECKED BY: M. Bonkowski
SIZE AND TYPE OF PACK 8 X 16	FROM 35.0 TO 7.5 FT.				
TYPE OF SEAL	NO. 1 Bentonite	FROM 7.5 TO 6.5 FT.			
	NO. 2 Grout	FROM 6.5 TO surface FT.			

Depth (feet)	Samples	Blows	MATERIAL DESCRIPTION	USCS	Well Construction
0			3" Asphalt: base, gray brown SANDY CLAY with SAND	CL	
5	1	50 psi push	SILTY CLAY grayish brown, damp, medium firm, some roots	CL	
10	2	4 5 7	SILTY CLAY gray brown mottled, medium firm — HNu = 0 ppm	CL	
15	3	3 4 6	SILTY CLAY as above — HNu = 0 ppm	CL	
20	4	3 4 6	SILTY CLAY gray and brown mottling, orange speckles (look like brick), roots, damp, medium firm — HNu = 0 ppm	CL	
25	5	3 5 6	SILTY CLAY gray and brown mottling, damp, medium firm — HNu = 0 ppm	CL	
30	6	3 4 6	SILTY CLAY as above — HNu = 0 ppm	CL	
35	7	3 5 6	SILTY CLAY gray and brown mottling, damp to moist, medium firm	CL	

Total Depth = 35.0 feet

LOG OF MONITORING WELL NO. S-8 SHEET 1 OF 1

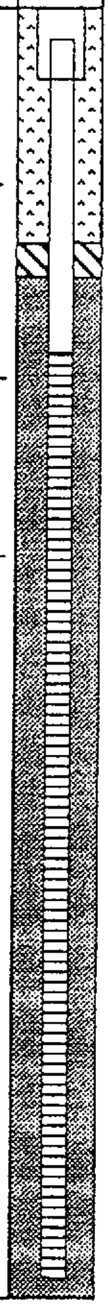
Woodward-Clyde Consultants

PROJECT NAME GETTLER - RYAN NO. 8820011A/0118

MONITORING WELL LOCATION	3790 Hopyard Rd, Pleasanton, CA (S-9)			ELEVATION AND DATUM	101.24' site datum
DRILLING AGENCY	Baylands	DRILLER	K. Voss	DATE STARTED / DATE FINISHED	2/24/89 / 2/24/89
DRILLING EQUIPMENT	Truck-mounted CME-75			COMPLETION DEPTH 35.0'	SAMPLER California Modified
DRILLING METHOD	8" Hollow-stem auger	DRILL BIT	CME Carbide	NO. OF SAMPLES DIST. —	UNDIST. 7
SIZE AND TYPE OF CASING	3" PVC	FROM 34.5 TO 0.5 FT.		WATER LEVEL FIRST —	COMPL. — 24 HRS. —
TYPE OF PERFORATION	020 slotted	FROM 34.5 TO 9.5 FT.		LOGGED BY:	CHECKED BY:
SIZE AND TYPE OF PACK	8 X 16	FROM 35 TO 7.5 FT.		C. Parten	M. Bonkowski
TYPE OF SEAL NO. 1	Bentonite pellets	FROM 7.5 TO 6.5 FT.			
TYPE OF SEAL NO. 2	Grout	FROM 6.5 TO surface FT.			

Depth (feet)	Samples	Blows	MATERIAL DESCRIPTION		USCS
0			Asphalt (3" thick), base, silty clay fill		
5	1	150 Push 250	**SILTY CLAY with GRAVEL** gray brown, medium firm, damp, gravel to 1/2" sandy in upper portion of sample	HNu = 0 ppm	CL
10	2	4 4 7	**SILTY CLAY to SANDY CLAY** gray brown to greenish brown, medium firm, damp	HNu = 0 ppm	CL
15	3	2 2 3	**SILTY CLAY** gray brown with black mottling, soft, moist, some charcoal	HNu = 0 ppm	CL
20	4		**SILTY CLAY** gray brown mottling, soft, brick fragments and roots	HNu = 0 ppm	CL
25	5		**SILTY CLAY** gray brown mottling, medium firm, damp	HNu = 0 ppm	
30	6		**SANDY CLAY to CLAYEY SAND** silty clay at bottom of sampler	HNu = 0 ppm	CL-SC
35	7	6 6 7	**SILTY CLAY** gray brown mottled, medium firm, damp	HNu = 0 ppm	CL

Well Construction:



Total Depth = 35.0 feet

LOG OF MONITORING WELL NO. S-9 SHEET 1 OF 1

Field location of boring:

(See Plate 2)

Project No.:	7632
Date:	08/09/89
Boring No:	S-10
Client:	Shell Oil Company
Location:	3790 Hopyard Road
City:	Pleasanton, California
Sheet	1 of 2
Logged by:	J. Vargas
Driller:	Bayland
Drilling method:	Hollow-Stem Auger
Hole diameter:	8-inches
Casing installation data:	See Well Construction Detail
Top of Box Elevation:	
Datum:	

Water Level	12.93			
Time				
Date	08/11/89			

PID (ppm)	Blows/ft. or Pressure (psi)	Type of Sample	Sample Number	Depth (ft.)	Sample	Well Detail	Soil Group Symbol (USCS)	Description
				0				
								PAVEMENT SECTION - 2 feet
				1				
				2				
								GRAVEL with SAND (GP) - olive gray (5Y 4/2), loose, damp; 60% gravel; 30-40% sand; 5% clay.
				3				
				4				
	250	S&H						
	150	push		5				
NS	150							
				6				
								CLAY with SILT (CL) - very dark gray (5Y 3/1), medium stiff, damp; 70% clay; 20% silt; 10% sand; medium plasticity; no chemical odor.
				7				
				8				
				9				
	150	S&H						**gravel and sand stringers**; no chemical odor.
	150	push		10				
NS	150							
				11				
				12				
				13				
				14				
	2	S&H						stiff; roots; black organics; mottled brown; no chemical odor.
	3			15				
0	5		S-10-15					
				16				
				17				
				18				
				19				

Remarks: NS = no sample

GSI GeoStrategies Inc.

Log of Boring

BORING NO. **S-10**

JOB NUMBER	REVIEWED BY RG/CEG	DATE	REVISED DATE	REVISED DATE
7632	CMP CEG 1262	08/89		

Field location of boring: (See Plate 2)	Project No.: 7632	Date: 08/09/89	Boring No: S-10
	Client: Shell Oil Company		
	Location: 3790 Hopyard Road		
	City: Pleasanton, California		Sheet 2 of 2
	Logged by: J. Vargas	Driller: Bayland	
Drilling method: Hollow-Stem Auger	Casing installation data: See Well Construction Detail		
Hole diameter: 8-inches	Top of Box Elevation:	Datum:	

Water Level				
Time				
Date				

PID (ppm)	Blows/ft. or Pressure (psi)	Type of Sample	Sample Number	Depth (ft.)	Sample	Well Detail	Soil Group Symbol (USCS)	Description
	2	S&H						
	4			20				
0	7		S-10-20					
				21				
				22				
				23				
				24				saturated at 24 feet; interbedded lamina of fine sand;
	3	S&H						trace coarse sand; no chemical odor.
	5			25				
0	8		S-10-25					
				26				
				27				
				28				
				29				
	4	S&H						damp; no chemical odor.
	5			30				
0	7		S-10-30					
				31				
				32				
				33				CLAY with SILT (CL) - dark gray (5Y 4/1), stiff, damp;
								80% clay; 20% silt; high plasticity; brown oxidation
				34				stains; no chemical odor.
	5	S&H						
	5			35				
0	7		S-10-35					
				36				Bottom of boring at 35.5 feet.
								Bottom of sample at 35.5 feet.
				37				08/09/89
				38				
				39				

Remarks:

GSI GeoStrategies Inc.

Log of Boring

BORING NO. **S-10**

JOB NUMBER	REVIEWED BY RG/CEG	DATE	REVISED DATE	REVISED DATE
7632	CWD CEG 1262	08/89		

Field location of boring: (See Plate 2)	Project No.: 7632
	Date: 08/09/89
	Boring No: [redacted]
	Client: Shell Oil Company
	Location: 3790 Hopyard Road
	City: Pleasanton, California
	Sheet 1 of 2
	Logged by: J. Vargas
	Driller: Bayland
Drilling method: Hollow-Stem Auger	Casing installation data: See Well Construction Detail
Hole diameter: 12-inches	Top of Box Elevation:
	Datum:

Water Level				
Time				
Date				

PID (ppm)	Blows/ft. or Pressure (psi)	Type of Sample	Sample Number	Depth (ft.)	Sample	Well Detail	Soil Group Symbol (USCS)	Description
				0				
								PAVEMENT SECTION - 1.0 foot
				1				
								CLAY with SILT (CL) - dark olive gray (5Y 3/2), stiff,
				2				damp; medium plasticity; 20% silt; 10-15% fine to coarse
								sand; trace organics, trace fine gravel, mottled brown;
				3				green staining; no chemical odor.
				4				
	250	S&H						COLOR CHANGE to black (5Y 2.5/1) at 4.5 feet.
	250	push		5				
0	400		SR-1-5					CLAYEY SAND (SC) - dark gray (5Y 4/1), medium dense,
				6				damp; 60% fine sand; 40% clay; no chemical odor.
								CLAY with SILT (CL) - black (5Y 2.5/1), very stiff, damp;
				7				medium plasticity; 80% clay; 20% silt; no chemical odor.
				8				
				9				COLOR CHANGE to olive (5Y 4/4) at 9.0 feet.
	400	S&H	SR-1-9					COLOR CHANGE to black (5Y 2.5) at 9.5 feet; no
	400	push		10				chemical odor.
NS	450							
				11				
				12				
				13				
				14				
	3	S&H						
	5			15				stiff; no chemical odor.
0	10		SR-1-15					
				16				
				17				
				18				
						∇		

Remarks: Drilled with 8-inch Hollow-Stem Augers on 08/09/89.
Completed on 9/20/89 with 12-inch Hollow-Stem Augers.

GSI GeoStrategies Inc.

Log of Boring

BORING NO. SR-1

JOB NUMBER	REVIEWED BY RG/CEG	DATE	REVISED DATE	REVISED DATE
7632	CMD CEG 1262	08/89		

Field location of boring:	Project No.: 7632	Date: 08/09/89	Boring No: SR-1
(See Plate 2)	Client: Shell Oil Company		
	Location: 3790 Hopyard Road		
	City: Pleasanton, California		Sheet 2 of 2
	Logged by: J. Vargas	Driller: Bayland	
	Casing installation data: See Well Construction Detail		
Drilling method: Hollow-Stem Auger			
Hole diameter: 12-inches	Top of Box Elevation:	Datum:	

Water Level				
Time				
Date				

PID (ppm)	Blows/ft. or Pressure (psi)	Type of Sample	Sample Number	Depth (ft.)	Sample	Well Detail	Soil Group Symbol (USCS)	Description
	3	S&H						SANDY CLAY (CL) - olive gray (5Y 4/2), stiff, saturated;
	5			20				medium plasticity; 60% clay; 40% sand; brown-gray
13.6	8		SR-1-20					mottling; roots; moderate chemical odor.
				21				
				22				
				23				
				24				
	0	S&H						
	1			25				CLAY with SILT (CL) - black (5Y 2.5/1), soft, damp,
0	4		SR-1-25					medium plasticity; 10-20% silt; trace organics; roots;
				26				burrows; no chemical odor.
				27				
								moist clay to sand interbed at 24 feet.
				28				
				29				
	4	S&H						
	4			30				stiff; saturated sandy lamina at 29.5 feet. Increased
0	6		SR-1-30					sand, mottled; no chemical odor.
				31				
				32				
				33				
				34				
	3	S&H						
	5			35				saturated at 34.5 to 35 feet; no chemical odor.
0	7		SR-1-35					
				36				
				37				Bottom of boring at 35.5 feet.
								Bottom of sample at 35.5 feet.
				38				09/20/89
				39				

Remarks:

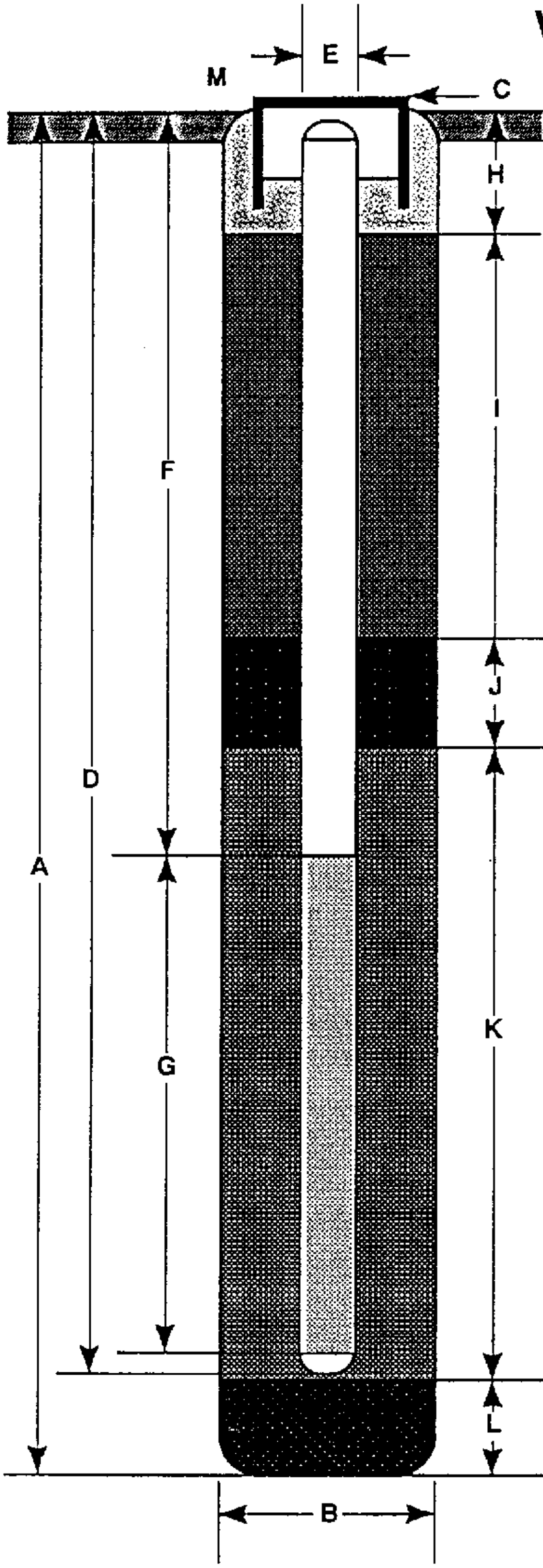
GSI GeoStrategies Inc.

Log of Boring

BORING NO.
SR-1

JOB NUMBER	REVIEWED BY RG/CEG	DATE	REVISED DATE	REVISED DATE
7632	CMP CEG 1262	08/89		

WELL CONSTRUCTION DETAIL



A	Total Depth of Boring				35.5	ft.
B	Diameter of Boring				12	in.
	Drilling Method		Hollow-Stem Auger			
C	Top of Box Elevation				329.78	ft.
	[X] Referenced to Mean Sea Level					
	[ ] Referenced to Project Datum					
D	Casing Length				34.5	ft.
	Material		Schedule 40 PVC			
E	Casing Diameter				4	in.
F	Depth to Top Perforations				10	ft.
G	Perforated Length				25	ft.
	Perforated Interval from	10		to	35	ft.
	Perforation Type		Machine Slot			
	Perforation Size		0.020			in.
H	Surface Seal from	0		to	1	ft.
	Seal Material		Concrete			
I	Backfill from	1		to	6	ft.
	Backfill Material		Concrete			
J	Seal from	6		to	8	ft.
	Seal Material		Bentonite Pellets			
K	Gravel Pack from	8		to	35.5	ft.
	Pack Material		2/12 Lonestar Sand			
L	Bottom Seal					ft.
	Seal Material					
M	Christy Box with locking well cap and lock					

Note: Depths measured from initial ground surface.

GSI GeoStrategies Inc.

Well Construction Detail

WELL NO. **SR-1**

JOB NUMBER	REVIEWED BY RG/CEG	DATE	REVISED DATE	REVISED DATE
7632	CMP CEG 1262	10/89		

Field location of boring:	(See Plate 2)
Project No.:	7632
Date:	09/20/89
Boring No:	SR-2
Client:	Shell Oil Company
Location:	3970 Hopyard Road
City:	Pleasanton, California
Sheet	1 of 2
Logged by:	D. Ferreira
Driller:	Bayland
Casing installation data:	See Well Construction Detail
Drilling method:	Hollow-Stem Auger
Hole diameter:	12-inches
Top of Box Elevation:	
Datum:	
Water Level	
Time	
Date	

PID (ppm)	Blows/ft. or Pressure (psi)	Type of Sample	Sample Number	Depth (ft.)	Sample	Well Detail	Soil Group Symbol (USCS)	Description
				0				
				1				PAVEMENT SECTION - 0.6 feet
				2				
				3				CLAY with GRAVEL (CL) - brown (10YR 5/4), stiff, damp, low plasticity; 15% gravel; 10% sand; no chemical odor. SANDY CLAY (CL) - dark gray (5Y 4/1), stiff, damp, low plasticity; increasing sand to 30%; no chemical odor.
				4				
	100	S&H						
	100	push		5				
0	100		SR-2-5					CLAY (CL) - very dark gray (5Y 3/1), medium stiff, damp, low plasticity; 5% fine sand; 5% silt; trace organics; trace pebbles; roots; **weak chemical odor.**
				6				
				7				
				8				
				9				
	150	S&H						
	150	push		10				COLOR CHANGE to dark gray (5Y 4/1); medium plasticity; no chemical odor.
5	150		SR-2-10					
				11				
				12				
				13				
				14				
	0	S&H						
	2			15				COLOR CHANGE to very dark gray (5Y 3/1), low plasticity; 10% silt; **weak chemical odor.**
12	4		SR-2-15					
				16				
				17				
				18				
				19		∇		

Remarks: Boring drilled with 8-inch Hollow-Stem Augers 09/20/89.
Completed 09/20/89 with 12-inch Hollow-Stem Augers.

GSI GeoStrategies Inc.

Log of Boring

BORING NO. **SR-2**

JOB NUMBER	REVIEWED BY RG/CEG	DATE	REVISED DATE	REVISED DATE
7632	CMP CEG 1262	08/89		

Field location of boring:	Project No.: 7632	Date: 09/20/89	Boring No: SR-2
(See Plate 2)	Client: Shell Oil Company		
	Location: 3970 Hopyard Road		
	City: Pleasanton, California		Sheet 2 of 2
	Logged by: D. Ferreira	Driller: Bayland	
	Casing installation data: See Well Construction Detail		
Drilling method: Hollow-Stem Auger			
Hole diameter: 12-inches	Top of Box Elevation:	Datum:	

Water Level				
Time				
Date				

PID (ppm)	Blows/ft. or Pressure (psi)	Type of Sample	Sample Number	Depth (ft.)	Sample	Well Detail	Soil Group Symbol (USCS)	Description
	3	S&H						COLOR CHANGE to dark gray (2.5Y N4/), stiff,
	4			20				saturated, low plasticity; trace very fine sand; trace silt;
81	5		SR-2-20					trace organics; weak sulfur odor.
				21				
				22				
				23				
				24				COLOR CHANGE to very dark gray (5Y 3/1), moist, low
	2	S&H						plasticity; trace very fine sand; trace silt; trace organics;
	5			25				trace wood fragments; rootholes filled with silty clay;
73	6		SR-2-25					weak sulfer odor
				26				
				27				
				28				
				29				CLAY (CH) - dark gray (5Y4/1) - stiff, moist, high
	3	S&H						plasticity; trace very fine to fine sand; trace silt; trace
	6			30				organics; oxidation filling rootholes; moderate sulfur
45	9		SR-2-30					odor.
				31				
				32				
				33				
				34				
	6	S&H						moderate to high plasticity.
	6			35				
4	9		SR-2-35					Bottom of boring at 35.5 feet.
				36				Bottom of sample at 35.5 feet.
								09/20/89
				37				
				38				
				39				

Remarks:

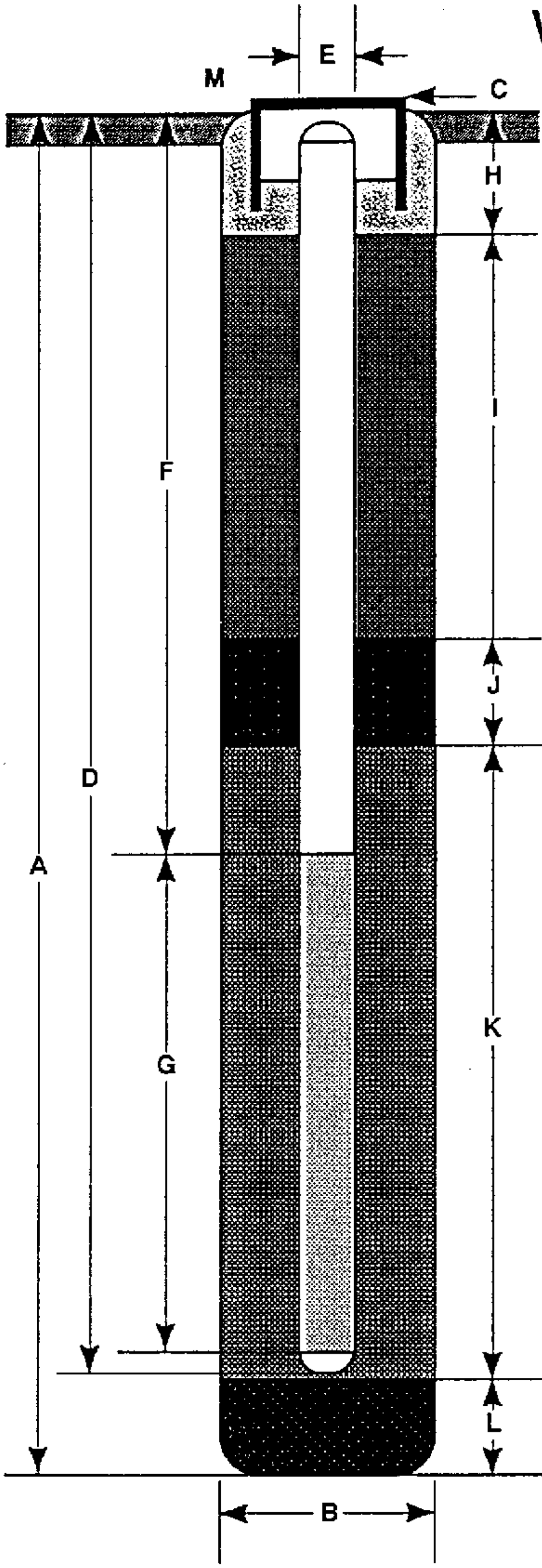
GSI GeoStrategies Inc.

Log of Boring

BORING NO. **SR-2**

JOB NUMBER	REVIEWED BY RG/CEG	DATE	REVISED DATE	REVISED DATE
7632	CMP CEG 1262	09/89		

WELL CONSTRUCTION DETAIL



A	Total Depth of Boring	35.5	ft.
B	Diameter of Boring	12	in.
	Drilling Method	Hollow-Stem Auger	
C	Top of Box Elevation	328.35	ft.
	[X] Referenced to Mean Sea Level		
	[ ] Referenced to Project Datum		
D	Casing Length	34.5	ft.
	Material	Schedule 40 PVC	
E	Casing Diameter	4	in.
F	Depth to Top Perforations	10	ft.
G	Perforated Length	25	ft.
	Perforated Interval from	10 to 35	ft.
	Perforation Type	Machine Slot	
	Perforation Size	0.020	in.
H	Surface Seal from	0 to 1	ft.
	Seal Material	Concrete	
I	Backfill from	1 to 6	ft.
	Backfill Material	Concrete	
J	Seal from	6 to 8	ft.
	Seal Material	Bentonite Pellets	
K	Gravel Pack from	8 to 35.5	ft.
	Pack Material	2/12 Lonestar Sand	
L	Bottom Seal		ft.
	Seal Material		
M	Christy Box with locking well cap and lock		

Note: Depths measured from initial ground surface.

GSI GeoStrategies Inc.

Well Construction Detail

WELL NO. **SR-2**

JOB NUMBER	REVIEWED BY RG/CEG	DATE	REVISED DATE	REVISED DATE
7632	CWP CEG 1262	10/89		

Field location of boring:	Project No.: 7632	Date: 09/19/89	Boring No: [illegible]
(See Plate 2)	Client: Shell Oil Company		
	Location: 3970 Hopyard Road		
	City: Pleasanton, California		Sheet 1 of 2
	Logged by: D. Ferreira	Driller: Bayland	
	Casing installation data: See Well Construction Detail		
Drilling method: Hollow-Stem Auger			
Hole diameter: 12-inches	Top of Box Elevation:	Datum:	

Water Level				
Time				
Date				

PID (ppm)	Blows/ft. or Pressure (psi)	Type of Sample	Sample Number	Depth (ft.)	Sample	Well Detail	Soil Group Symbol (USCS)	Description
				0				
								PAVEMENT SECTION - 0.8 feet
				1				
								FILL - Clay (CL) - very dark gray (2.5Y N3/), stiff, damp, medium to high plasticity; no chemical odor.
				2				
				3				10% gravel; cobbles at 2 feet; trace sand; oxidation stains at 2.5 feet in rootholes.
				4				
	150	S&H						
	250	push		5				FILL - Gravel (GP) - dark gray (2.5Y N4/), medium dense, saturated (perched zone); asphalt fragments; asphalt odor.
50	150		SR-3-10					
				6				
				7				
				8				
				9				
	100	S&H						CLAY (CL) - very dark gray (5Y 3/1), medium stiff, damp, medium plasticity; trace silt; weak chemical odor.
	100	push		10				
50	150		SR-3-10					
				11				
				12				
				13				
				14				
	2	S&H						CLAY (CL-CH) - black (2.5Y N2/), stiff, moist, medium to high plasticity; trace silt; slightly mottled; rootholes; moderate H_2S odor.
	3			15				
220	6		SR-3-15					
				16				
				17				
				18				
				19		∇		

Remarks: Boring drilled 09/19/89 with 8-inch Hollow-Stem Augers.
Completed on 09/19/89 with 12-inch Hollow-Stem Augers.

GSI GeoStrategies Inc.

Log of Boring

BORING NO. **SR-3**

JOB NUMBER	REVIEWED BY RG/CEG	DATE	REVISED DATE	REVISED DATE
7632	CWVP CEG 1262	08/89		

Field location of boring:	Project No.: 7632	Date: 09/19/89	Boring No: SR-3
(See Plate 2)	Client: Shell Oil Company		
	Location: 3970 Hopyard Road		
	City: Pleasanton, California		Sheet 2 of 2
	Logged by: D. Ferreira	Driller: Bayland	
	Casing installation data: See Well Construction Detail		
Drilling method: Hollow-Stem Auger	Top of Box Elevation:	Datum:	
Hole diameter: 12-inches			

Water Level				
Time				
Date				

PID (ppm)	Blows/ft. or Pressure (psi)	Type of Sample	Sample Number	Depth (ft.)	Sample	Well Detail	Soil Group Symbol (USCS)	Description
	0	S&H						COLOR CHANGE to dark gray (5Y 4/1), medium stiff,
	2			20				saturated; trace fossils; trace calcium nodules; no
235	5		SR3-20					chemical odor.
				21				
				22				
				23				
				24				
	6	S&H		25				stiff, moist, medium plasticity; trace silt; trace organics;
	5							weak H_2S odor.
284	7		SR3-25	26				
				27				
				28				
				29				
	3	S&H		30				COLOR CHANGE to gray (10YR 5/1), damp, medium to
	6							high plasticity, saturated rootholes; small mollusk fossils;
115	6		SR3-30	31				red oxidation at 30 feet; no chemical odor.
				32				
				33				
				34				
	4	S&H						
	5			35				CLAY (CH) - dark gray (10YR 4/1), stiff, moist, high
135	7		SR-3-35					plasticity; saturated rootholes; 10% organic matter; trace
				36				sand; trace silt; trace cobbles; no chemical odor.
				37				Bottom of sample at 35.5 feet.
								Bottom of boring at 35.5 feet.
				38				09/19/89
				39				

Remarks:

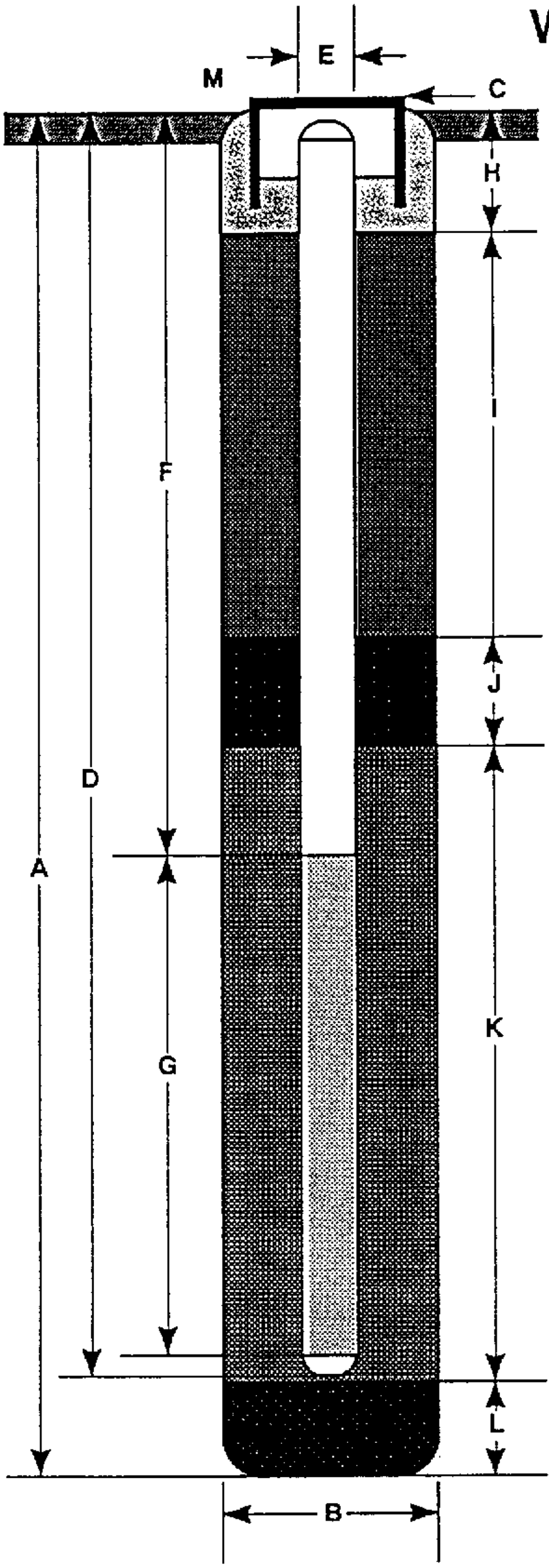
GSI GeoStrategies Inc.

Log of Boring

BORING NO. **SR-3**

JOB NUMBER	REVIEWED BY RG/CEG	DATE	REVISED DATE	REVISED DATE
7632	CMP CEG 1262	9/89		

WELL CONSTRUCTION DETAIL



A Total Depth of Boring 35.5 ft.

B Diameter of Boring 12 in.
Drilling Method Hollow-Stem Auger

C Top of Box Elevation 329.11 ft.
[X] Referenced to Mean Sea Level
[ ] Referenced to Project Datum

D Casing Length 34.5 ft.
Material Schedule 40 PVC

E Casing Diameter 4 in.

F Depth to Top Perforations 10 ft.

G Perforated Length 25 ft.
Perforated Interval from 10 to 35 ft.
Perforation Type Machine Slot
Perforation Size 0.020 in.

H Surface Seal from 0 to 1 ft.
Seal Material Concrete

I Backfill from 1 to 6 ft.
Backfill Material Concrete

J Seal from 6 to 8 ft.
Seal Material Bentonite Pellets

K Gravel Pack from 8 to 35.5 ft.
Pack Material 2/12 Lonestar Sand

L Bottom Seal ______ ft.
Seal Material ______

M Christy Box with locking well cap and lock

Note: Depths measured from initial ground surface.

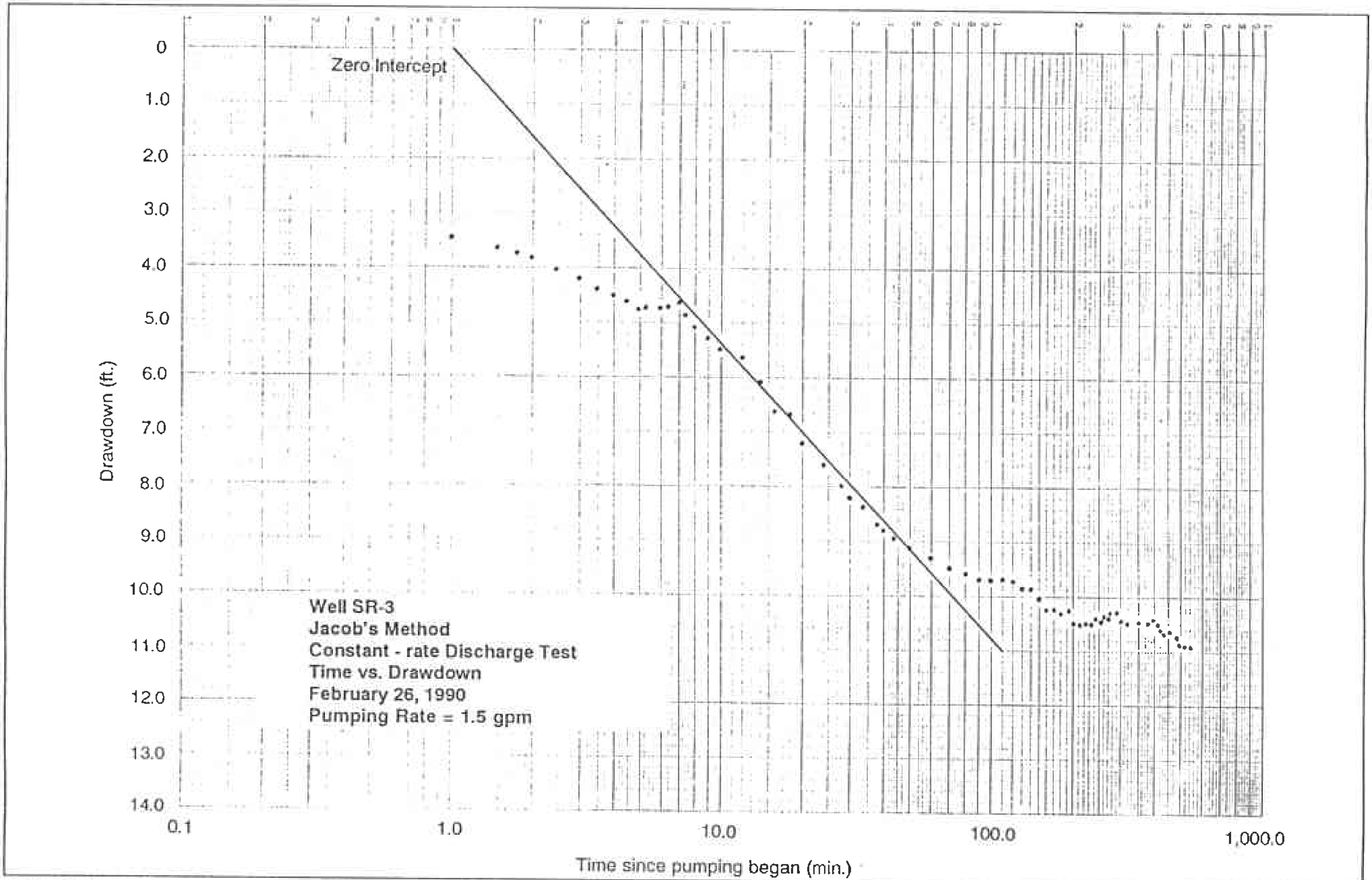
GSI GeoStrategies Inc.

Well Construction Detail

WELL NO.
SR-3

JOB NUMBER	REVIEWED BY RG/CEG	DATE	REVISED DATE	REVISED DATE
7632	CMD CEG 1262	10/89		

APPENDIX B
JACOB'S STRAIGHT-LINE METHOD PLOTS



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JOB NUMBER	REVIEWED BY RG/CEG	DATE	REVISED DATE	REVISED DATE
7632	[illegible] CEG 1262	4/90		

DATA SHEET: Modified Non-Equilibrium Method (Jacob, 1950)

PUMPING WELL SR-3

OBSERVATION WELL SR-1

Q	Average discharge rate	1.5	gpm
r	Distance from observation well to pumping well	98.5	feet
Δs	Change in drawdown per one log cycle	0.19	feet
t_o	Zero drawdown/recovery intercept of straight line to time of zero drawdown	0.05	days
b	Aquifer thickness	20	feet

TRANSMISSIVITY (T)

T = 264 X Q / Δs
T = 264 X 1.5 / 0.19
T = 2084 gallons per day / foot
T = 278.7 square feet / day

HYDRAULIC CONDUCTIVITY

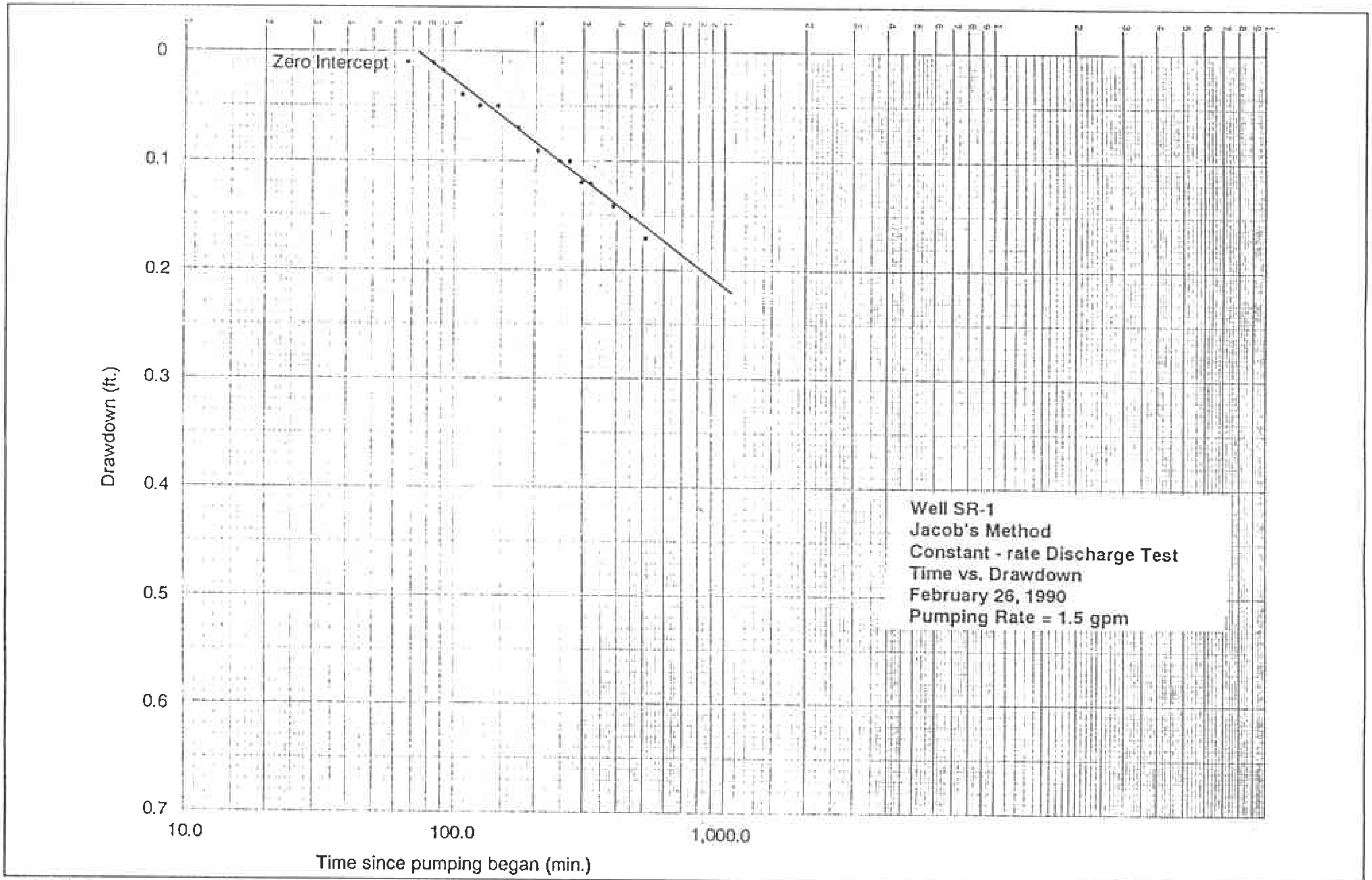
K = T/b
K = 2084 / 20 = 104.2 gallons per day / square foot
K = 278.7 / 20 = 13.93 feet / day
K = 13.93 X 0.0003527 = 0.0049141 cm / second

STORATIVITY (S)

S = 0.3 X T X t_o / r^2
S = 0.3 X 2084 X 0.05 / 9702.2
S = 0.0032219

Time (t) after which u < 0.05

t = 1.87 X r^2 X S / T X u
t = 1.87 (98.5 X 0.003222) / (2084 X 0.05)
t = 0.56 days 806 minutes



GeoStrategies Inc.

JOB NUMBER	REVIEWED BY RG/CEG	DATE	REVISED DATE	REVISED DATE
7632	[signature] 1262	4/90		

DATA SHEET: Modified Non-Equilibrium Method (Jacob, 1950)

PUMPING WELL SR-3

OBSERVATION WELL SR-2

Q	Average discharge rate	1.5	gpm
r	Distance from observation well to pumping well	79.4	feet
Δs	Change in drawdown per one log cycle	0.36	feet
t_o	Zero drawdown/recovery intercept of straight line to time of zero drawdown	0.03889	days
b	Aquifer thickness	20	feet

TRANSMISSIVITY (T)

$T = 264 \times Q / \Delta s$
$T = 264 \times 1.5 / 0.36$
T = 1100 gallons per day / foot
T = 147 square feet / day

HYDRAULIC CONDUCTIVITY

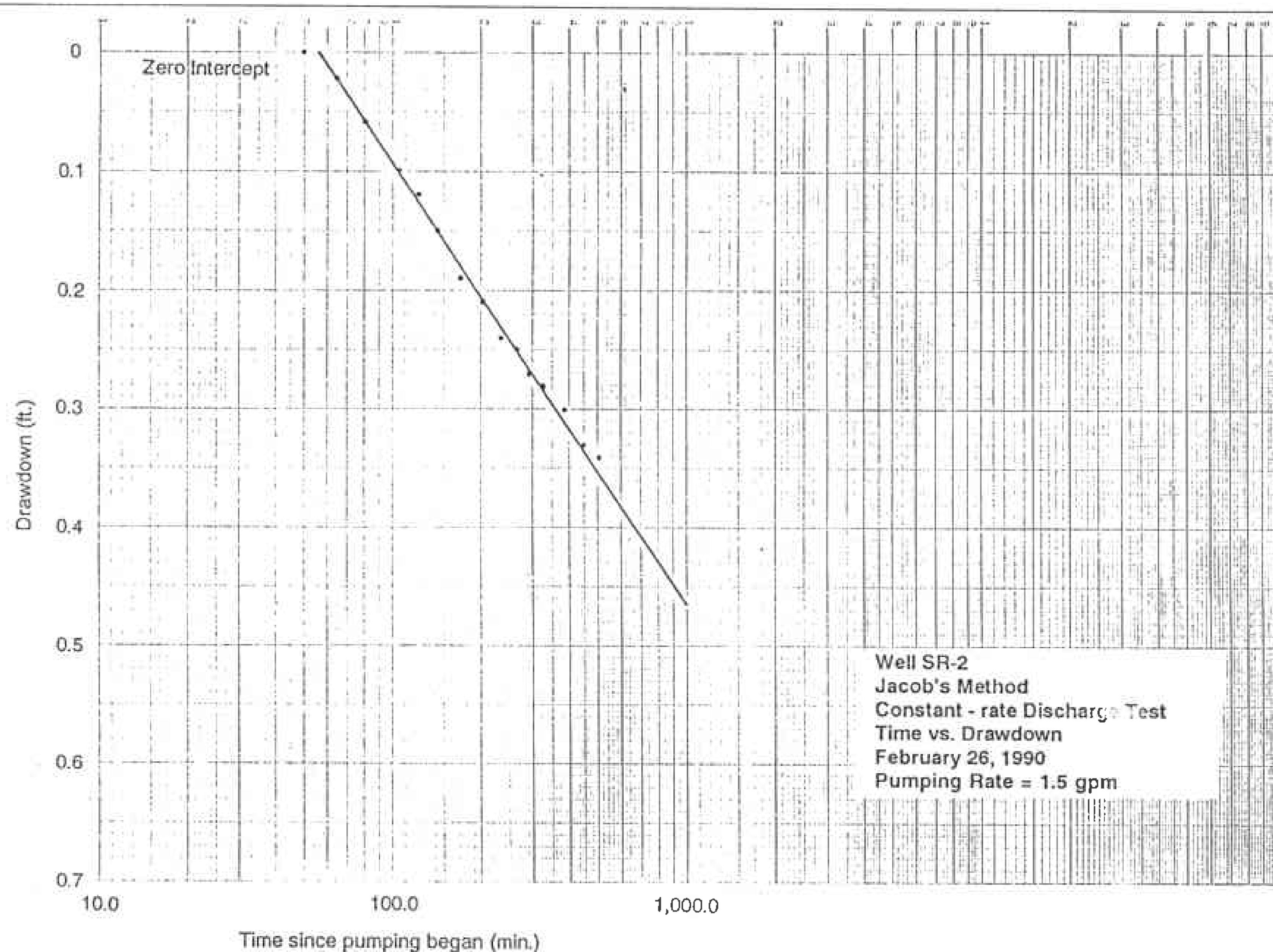
$K = T/b$
K = 1100 / 20 = 55 gallons per day / square foot
K = 147 / 20 = 7.35 feet / day
K = 7.35 X 0.0003527 = 0.0025935 cm / second

STORATIVITY (S)

$S = 0.3 \times T \times t_o / r^2$
$S = 0.3 \times 1100 \times 0.03889 / 6304$
$S = 0.0020356$

Time (t) after which u < 0.05

$t = 1.87 \times r^2 \times S / T \times u$
$t = 1.87 (79.4 \times 0.002036) / (1100 \times 0.05)$
t = 0.436 days = 628 minutes



GSI GeoStrategies Inc.

JOB NUMBER	REVIEWED BY RG/CEG	DATE	REVISED DATE	REVISED DATE
7632	CEG 1262	4/90		

DATA SHEET: Modified Non-Equilibrium Method (Jacob, 1950)

PUMPING WELL SR-3

OBSERVATION WELL S-2

Q	Average discharge rate	1.5 gpm
r	Distance from observation well to pumping well	10 feet
Δs	Change in drawdown per one log cycle	1.15 feet
t_0	Zero drawdown/recovery intercept of straight line to time of zero drawdown	0.005208 days
b	Aquifer thickness	20 feet

TRANSMISSIVITY (T)

T = 264 X Q / Δs
T = 264 X 1.5 / 1.15
T = 344 gallons per day / foot
T = 46 square feet / day

HYDRAULIC CONDUCTIVITY

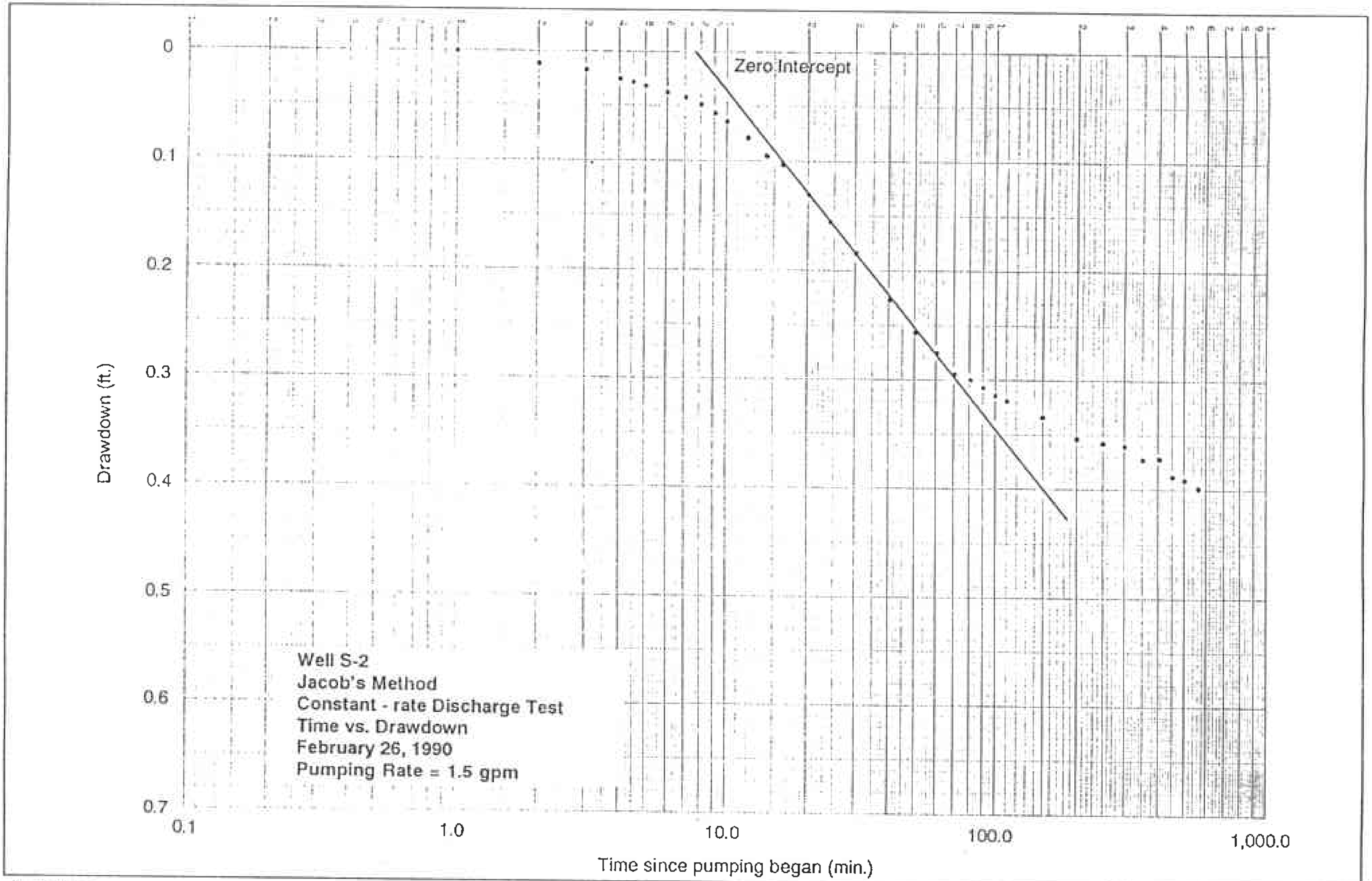
K = T/b
K = 344 / 20 = 17.2 gallons per day / square foot
K = 46 / 20 = 2.3 feet / day
K = 2.3 X 0.0003527 = 0.0008112 cm / second

STORATIVITY (S)

S = 0.3 X T X t_0 / r^2
S = 0.3 X 344 X 0.05208 / 100
S = 0.053746

Time (t) after which u < 0.05

t = 1.87 X r^2 X S / T X u
t = 1.87 (10 X 0.0199987) / (344 X 0.05)
t = 0.5843 days = 841 minutes



GeoStrategies Inc.

JOB NUMBER	REVIEWED BY RG/CEG	DATE	REVISED DATE	REVISED DATE
7632	[signature]	4/90		

DATA SHEET: Modified Non-Equilibrium Method (Jacob, 1950)

PUMPING WELL SR-3

OBSERVATION WELL S-4

Q	Average discharge rate	1.5	gpm
r	Distance from observation well to pumping well	82.4	feet
Δs	Change in drawdown per one log cycle	0.37	feet
t_o	Zero drawdown/recovery intercept of straight line to time of zero drawdown	0.0597	days
b	Aquifer thickness	20	feet

TRANSMISSIVITY (T)

$T = 264 \times Q / \Delta s$
$T = 264 \times$ 1.5 / 0.37
T = 1070 gallons per day / foot
T = 143 square feet / day

HYDRAULIC CONDUCTIVITY

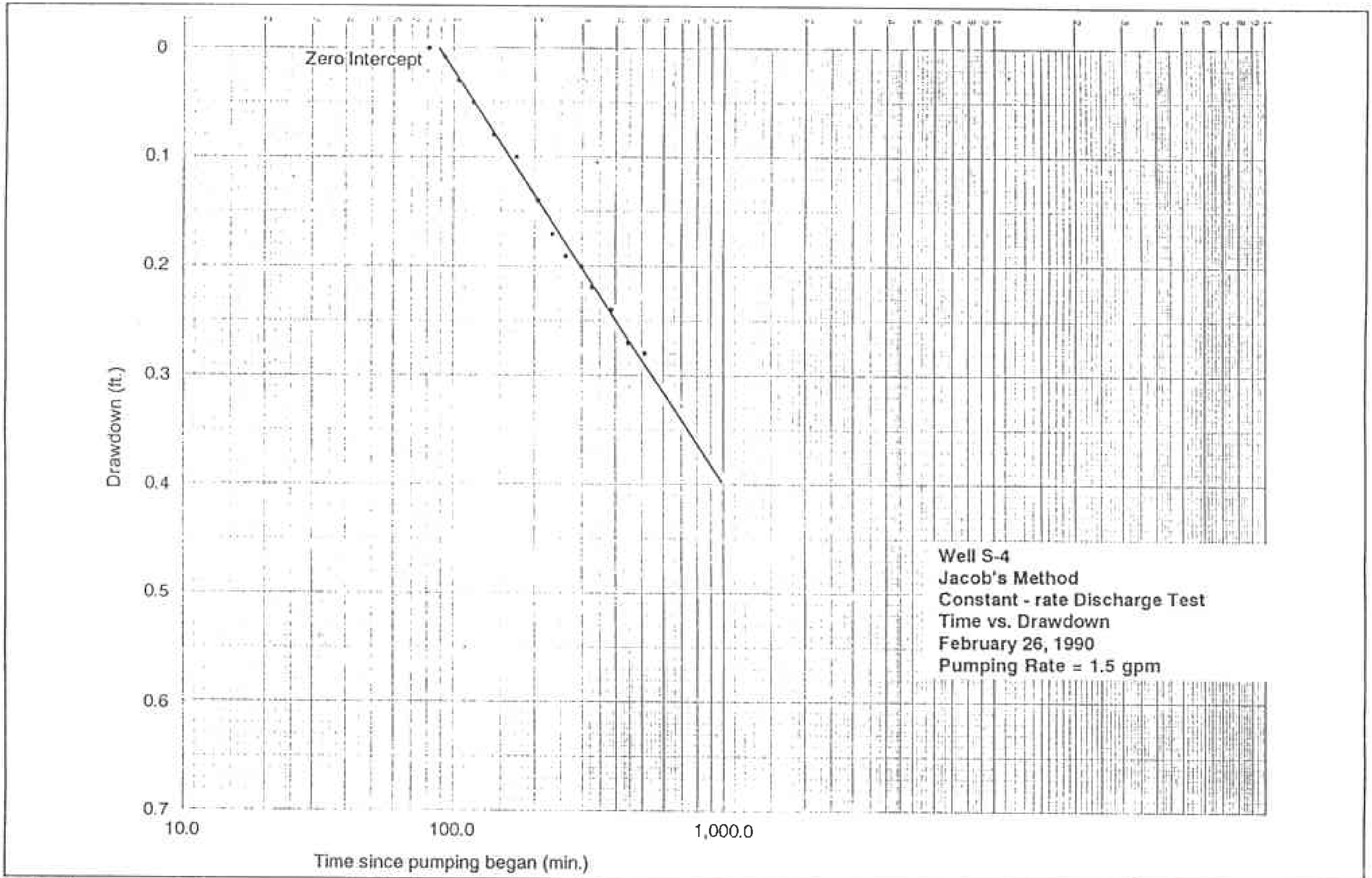
K = T/b
K = 1070 / 20 = 53.5 gallons per day / square foot
K = 143 / 20 = 7.155 feet / day
K = 7.155 X 0.0003527 = 0.0025234 cm / second

STORATIVITY (S)

$S = 0.3 \times T \times t_o / r^2$
S = 0.3 X 1070 X 0.0597 / 6789.8
S = 0.0028224

Time (t) after which u < 0.05

$t = 1.87 \times r^2 \times S / T \times u$
t = 1.87 (82.4 X 0.0028224) / (1070 X 0.05)
t = 0.6698 days 964.5 minutes



GeoStrategies Inc.

JOB NUMBER	REVIEWED BY RG/CEG	DATE	REVISED DATE	REVISED DATE
7632	CWP CEG 1262	4/90		

DATA SHEET: Modified Non-Equilibrium Method (Jacob, 1950)

PUMPING WELL SR-3

OBSERVATION WELL S-5

Q	Average discharge rate	1.5	gpm
r	Distance from observation well to pumping well	121	feet
Δs	Change in drawdown per one log cycle	0.07	feet
t_o	Zero drawdown/recovery intercept of straight line to time of zero drawdown	0.0583	days
b	Aquifer thickness	121	feet

TRANSMISSIVITY (T)

$T = 264 \times Q / \Delta s$
$T = 264 \times 1.5 / 0.07$
T = 5657 gallons per day / foot
T = 756 square feet / day

HYDRAULIC CONDUCTIVITY

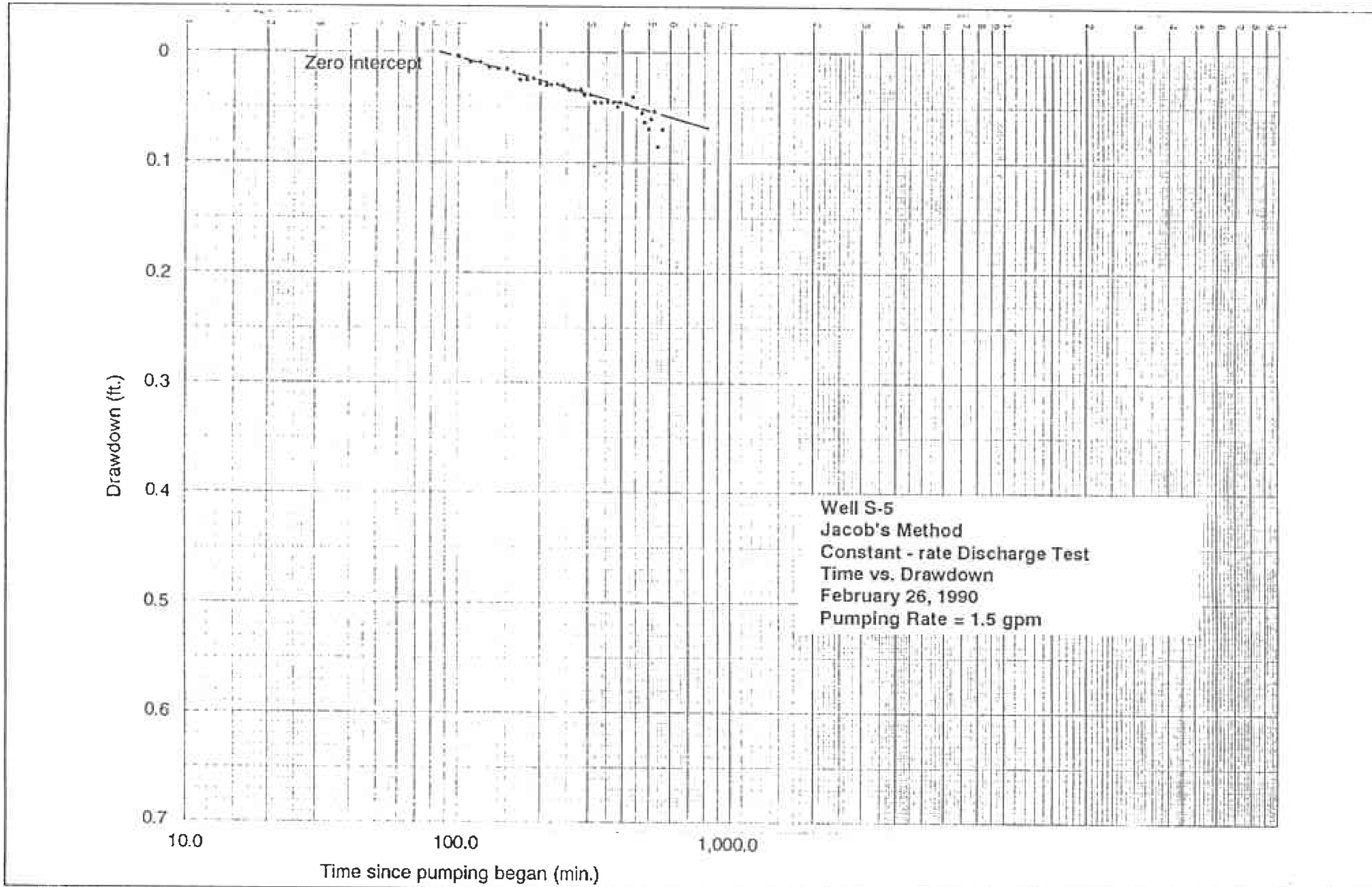
$K = T/b$
K = 5657 / 20 = 283 gallons per day / square foot
K = 756 / 20 = 37.8 feet / day
K = 37.8 X 0.0003527 = 0.0133413 cm / second

STORATIVITY (S)

$S = 0.3 \times T \times t_o / r^2$
$S = 0.3 \times 5657 \times 0.0583 / 14641$
$S = 0.0067616$

Time (t) after which $u < 0.05$

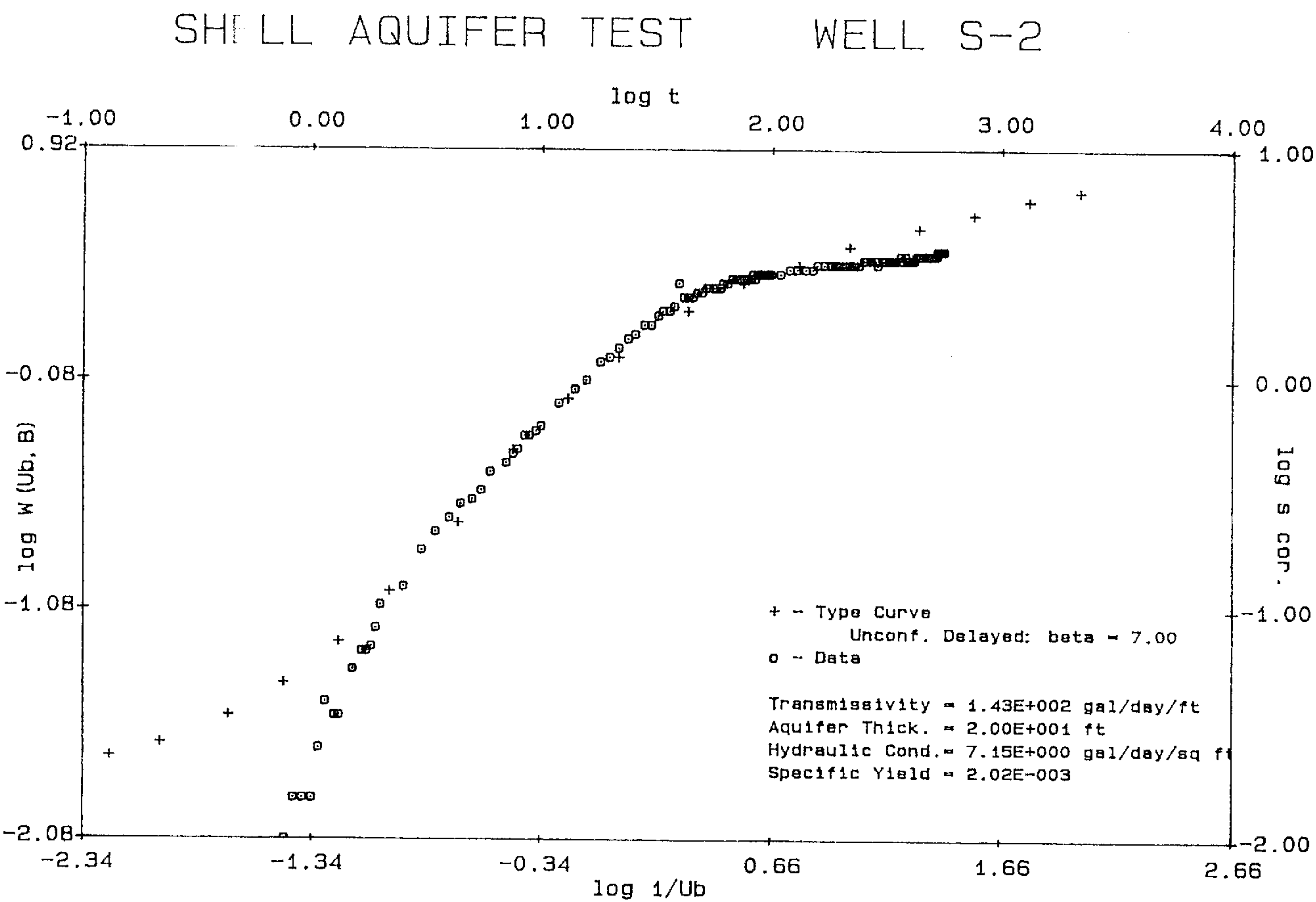
$t = 1.87 \times r^2 \times S / T \times u$
$t = 1.87 (121 \times 0.0067616) / (5657 \times 0.05)$
t = 0.65449 days = 942 minutes



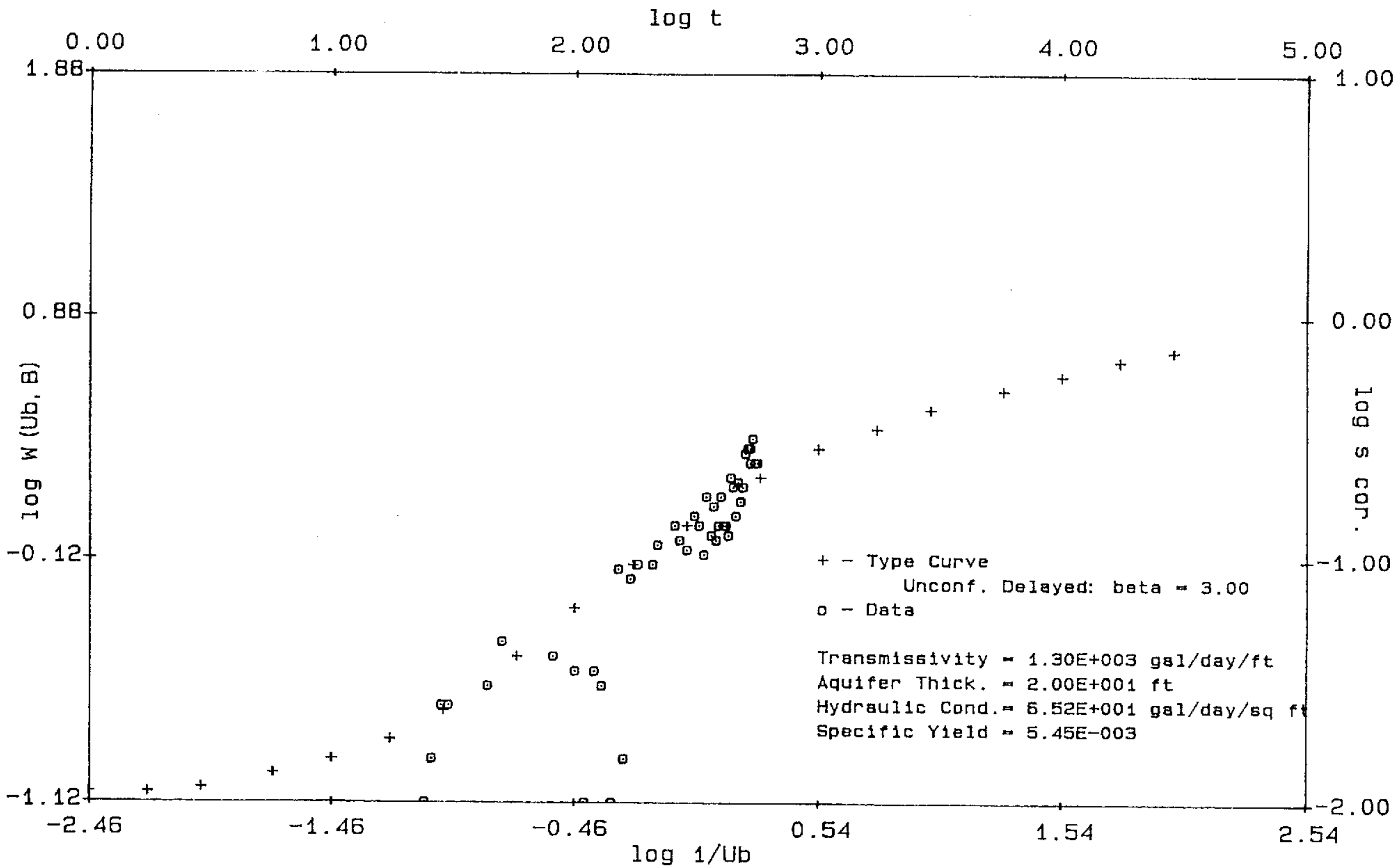
GeoStrategies Inc.

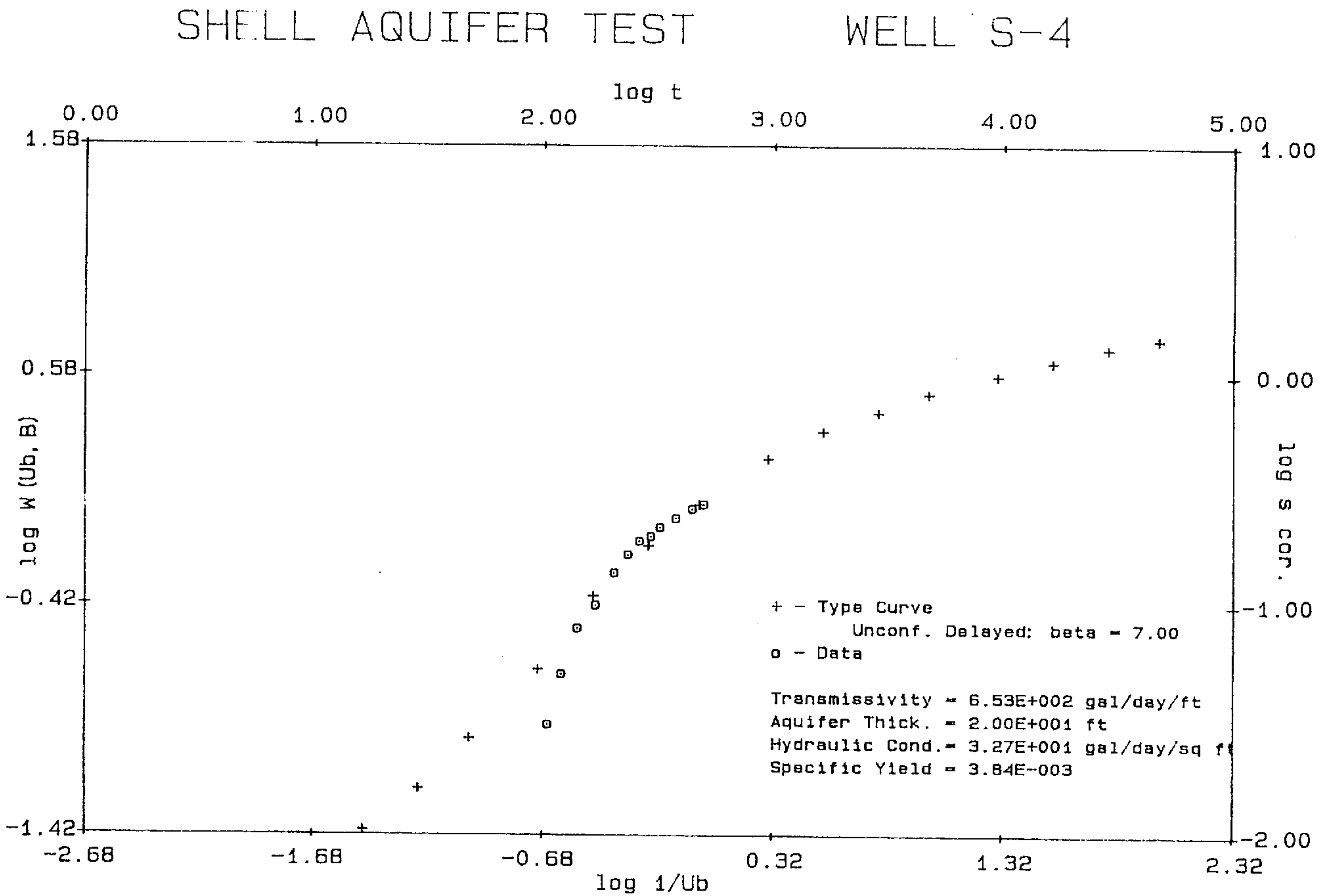
JOB NUMBER	REVIEWED BY RG/CEG	DATE	REVISED DATE	REVISED DATE
7632	BWP CEG 1262	4/90		

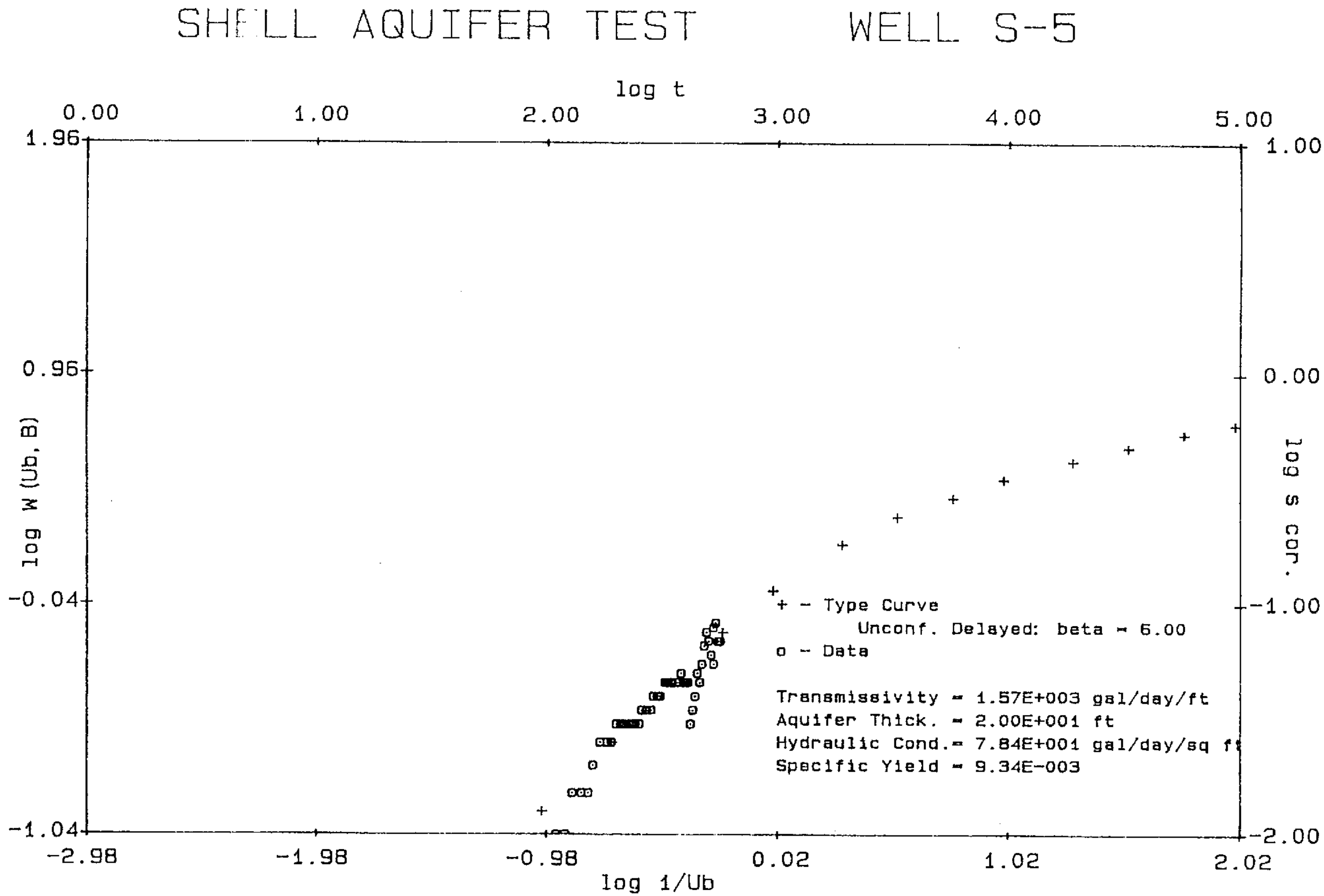
APPENDIX C
CONSTANT-RATE GWAP PLOTS


SHELL AQUIFER TEST WELL S-2
log t
-1.00
0.00
1.00
2.00
3.00
4.00
0.92
-0.08
-1.08
-2.08
1.00
0.00
-1.00
-2.00
log W (Ub, B)
log s cor.
-2.34
-1.34
-0.34
0.66
1.66
2.66
log 1/Ub
+ - Type Curve
Unconf. Delayed: beta = 7.00
o - Data
Transmissivity = 1.43E+002 gal/day/ft
Aquifer Thick. = 2.00E+001 ft
Hydraulic Cond.= 7.15E+000 gal/day/sq ft
Specific Yield = 2.02E-003

SHELL AQUIFER TEST WELL S-3

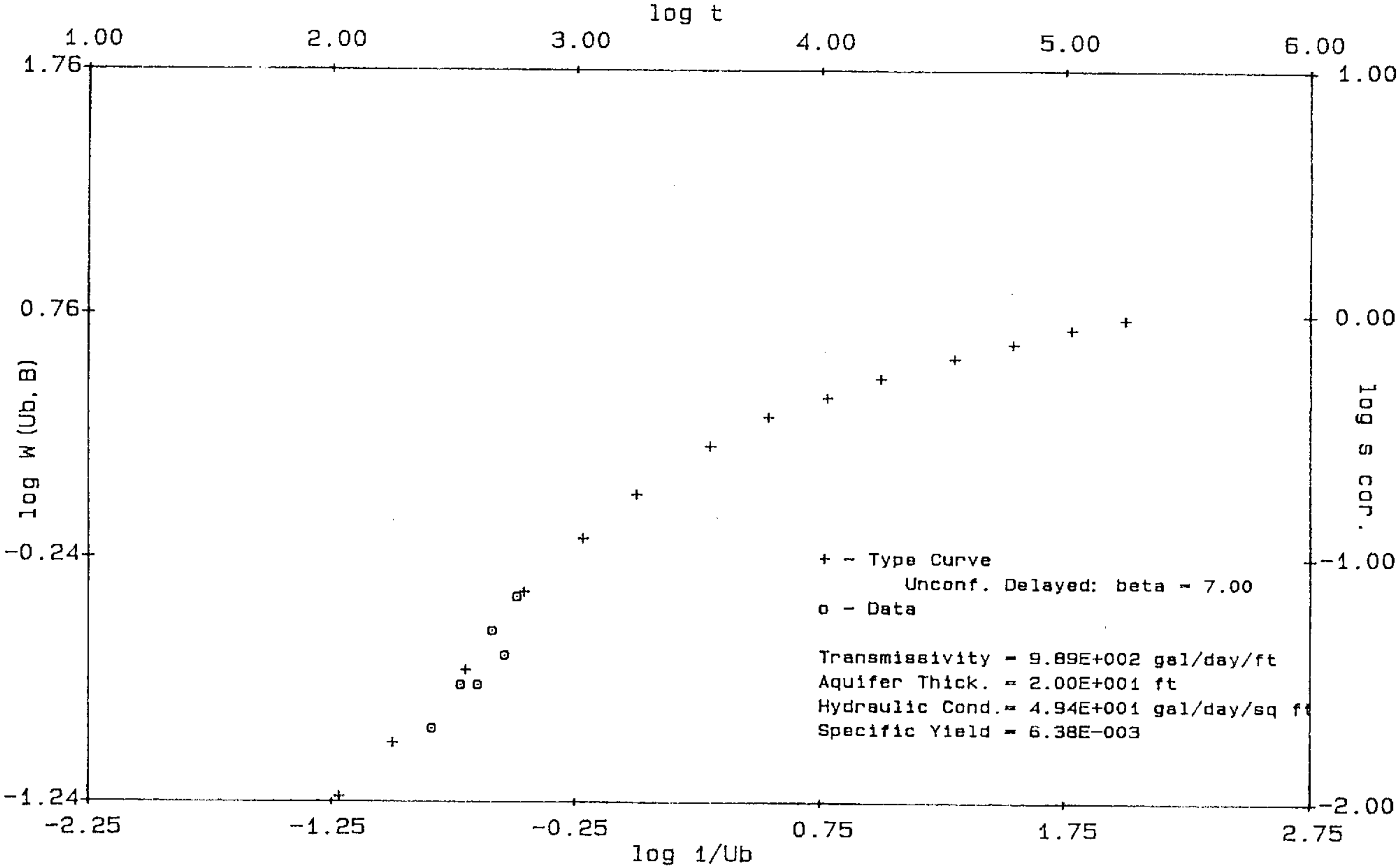


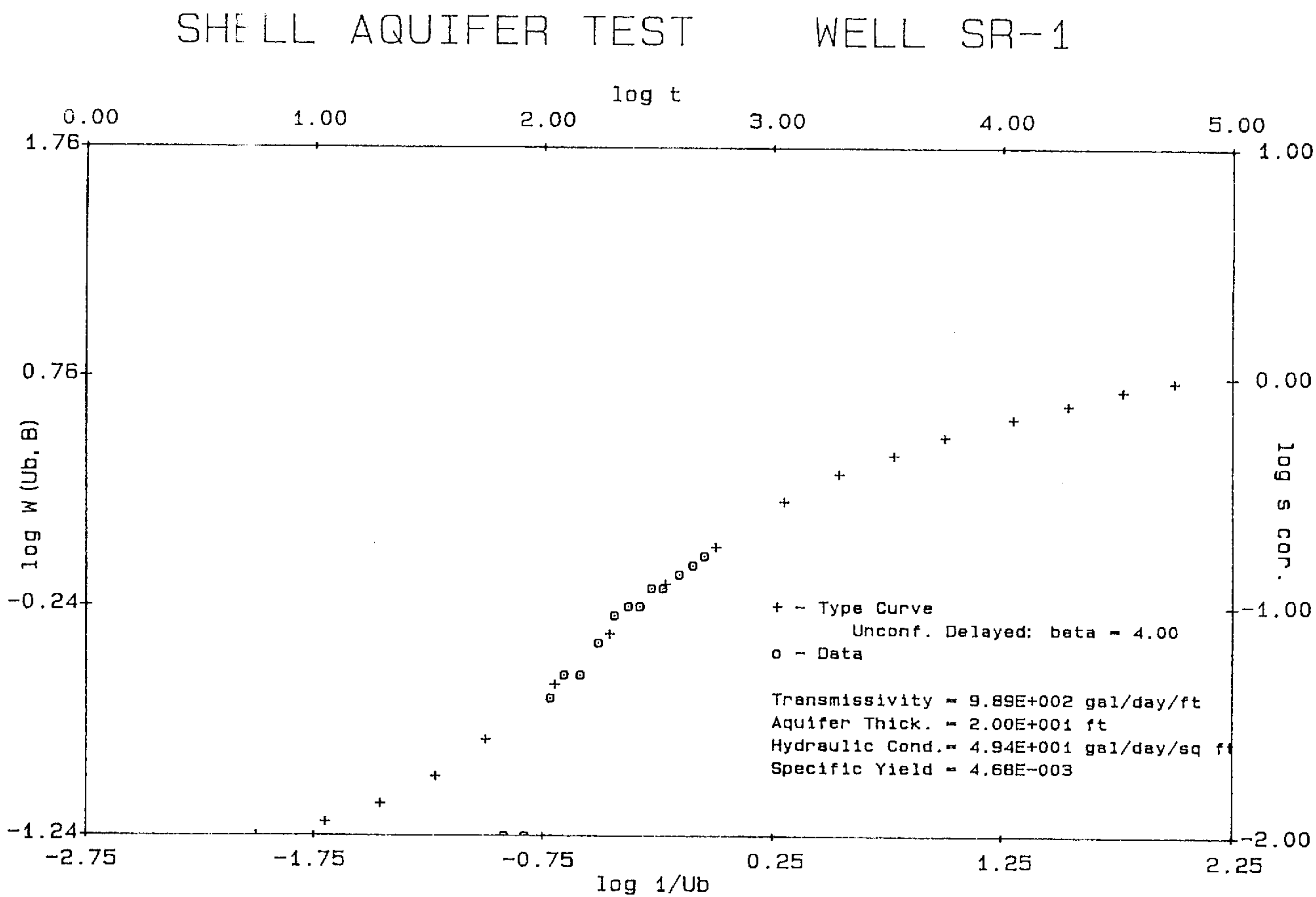

SHELL AQUIFER TEST WELL S-4
log t
0.00
1.00
2.00
3.00
4.00
5.00
1.58
0.58
-0.42
-1.42
1.00
0.00
-1.00
-2.00
log W (Ub, B)
log s cor.
-2.68
-1.68
-0.68
0.32
1.32
2.32
log 1/Ub
+ - Type Curve
Unconf. Delayed: beta = 7.00
o - Data
Transmissivity = 6.53E+002 gal/day/ft
Aquifer Thick. = 2.00E+001 ft
Hydraulic Cond.= 3.27E+001 gal/day/sq ft
Specific Yield = 3.84E-003



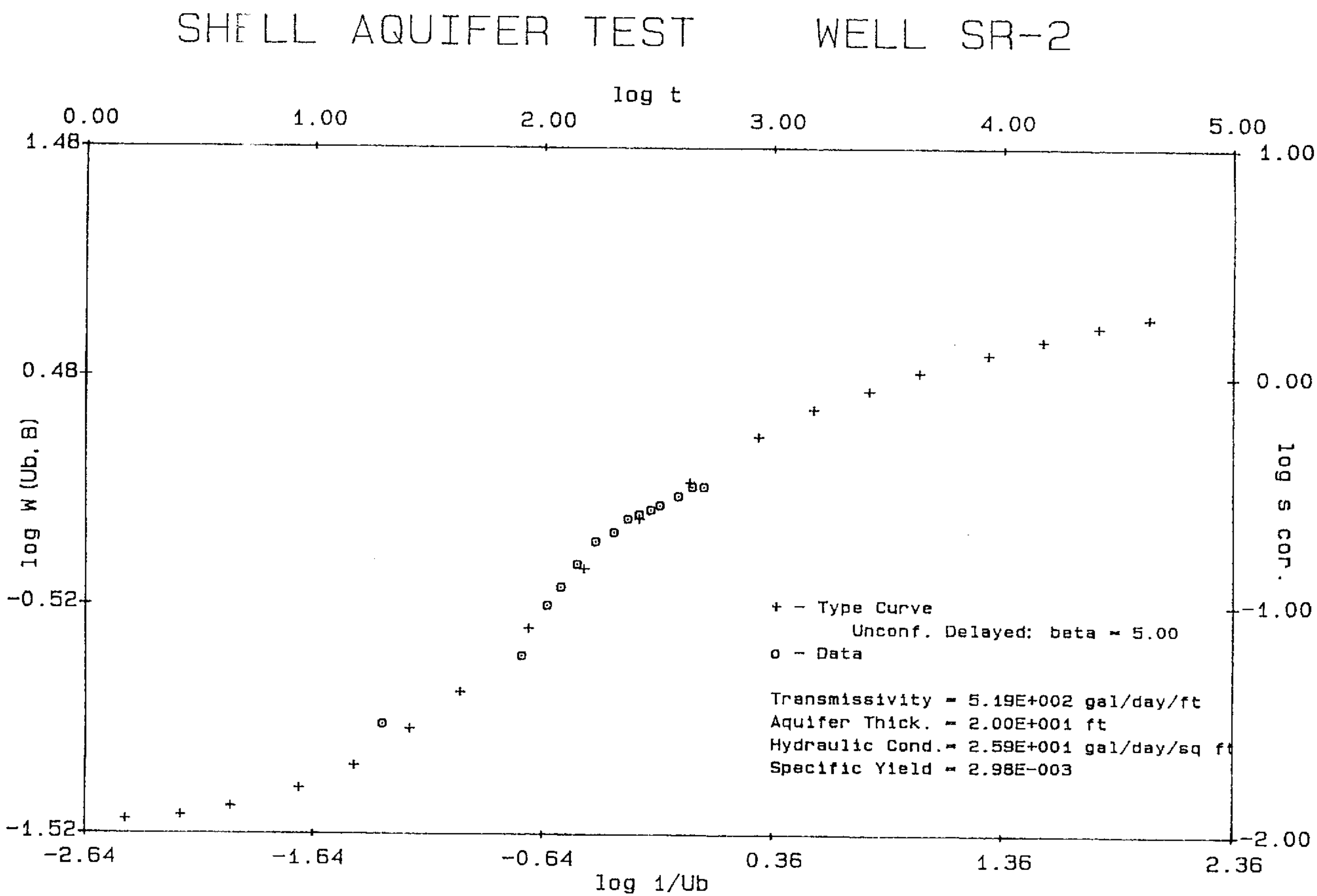
SHELL AQUIFER TEST WELL S-5
log t
0.00
1.00
2.00
3.00
4.00
5.00
1.96
0.96
-0.04
-1.04
1.00
0.00
-1.00
-2.00
log W (Ub, B)
log s cor.
-2.98
-1.98
-0.98
0.02
1.02
2.02
log 1/Ub
+ - Type Curve
Unconf. Delayed: beta = 6.00
o - Data
Transmissivity = 1.57E+003 gal/day/ft
Aquifer Thick. = 2.00E+001 ft
Hydraulic Cond.= 7.84E+001 gal/day/sq ft
Specific Yield = 9.34E-003

SHELL AQUIFER TEST   WELL S-6





SHELL AQUIFER TEST WELL SR-1
log t
0.00
1.00
2.00
3.00
4.00
5.00
1.76
0.76
-0.24
-1.24
1.00
0.00
-1.00
-2.00
log W (Ub, B)
log s cor.
+ - Type Curve
Unconf. Delayed: beta = 4.00
o - Data
Transmissivity = 9.89E+002 gal/day/ft
Aquifer Thick. = 2.00E+001 ft
Hydraulic Cond.= 4.94E+001 gal/day/sq ft
Specific Yield = 4.68E-003
-2.75
-1.75
-0.75
0.25
1.25
2.25
log 1/Ub


SHELL AQUIFER TEST WELL SR-2
log t
0.00
1.00
2.00
3.00
4.00
5.00
1.48
0.48
-0.52
-1.52
1.00
0.00
-1.00
-2.00
log W(Ub,B)
log s cor.
-2.64
-1.64
-0.64
0.36
1.36
2.36
log 1/Ub
+ - Type Curve
Unconf. Delayed: beta = 5.00
o - Data
Transmissivity = 5.19E+002 gal/day/ft
Aquifer Thick. = 2.00E+001 ft
Hydraulic Cond.= 2.59E+001 gal/day/sq ft
Specific Yield = 2.98E-003

APPENDIX D
DISTANCE-DRAWDOWN
AND
RECOVERY DATA PLOTS

DATA SHEET: Distance-Drawdown Method

PUMPING WELL	SR-3	DISTANCE TO PUMPING WELL (FEET)
OBSERVATION WELL	S-2	10.
	SR-1	98.5
	S-5	121.
	S-6	155

Q	Average discharge rate	1.5 gpm
r_o	Radius of influence intercept of extended straight line at zero drawdown	130. feet
Δs	Change in drawdown per one log cycle	3.5 feet
t	Time since pumping started	0.004 days
C	Calculated drawdown intercept of extended straight line to casing radius	10.1 feet
D	Observed drawdown in pumping well	10.9 feet

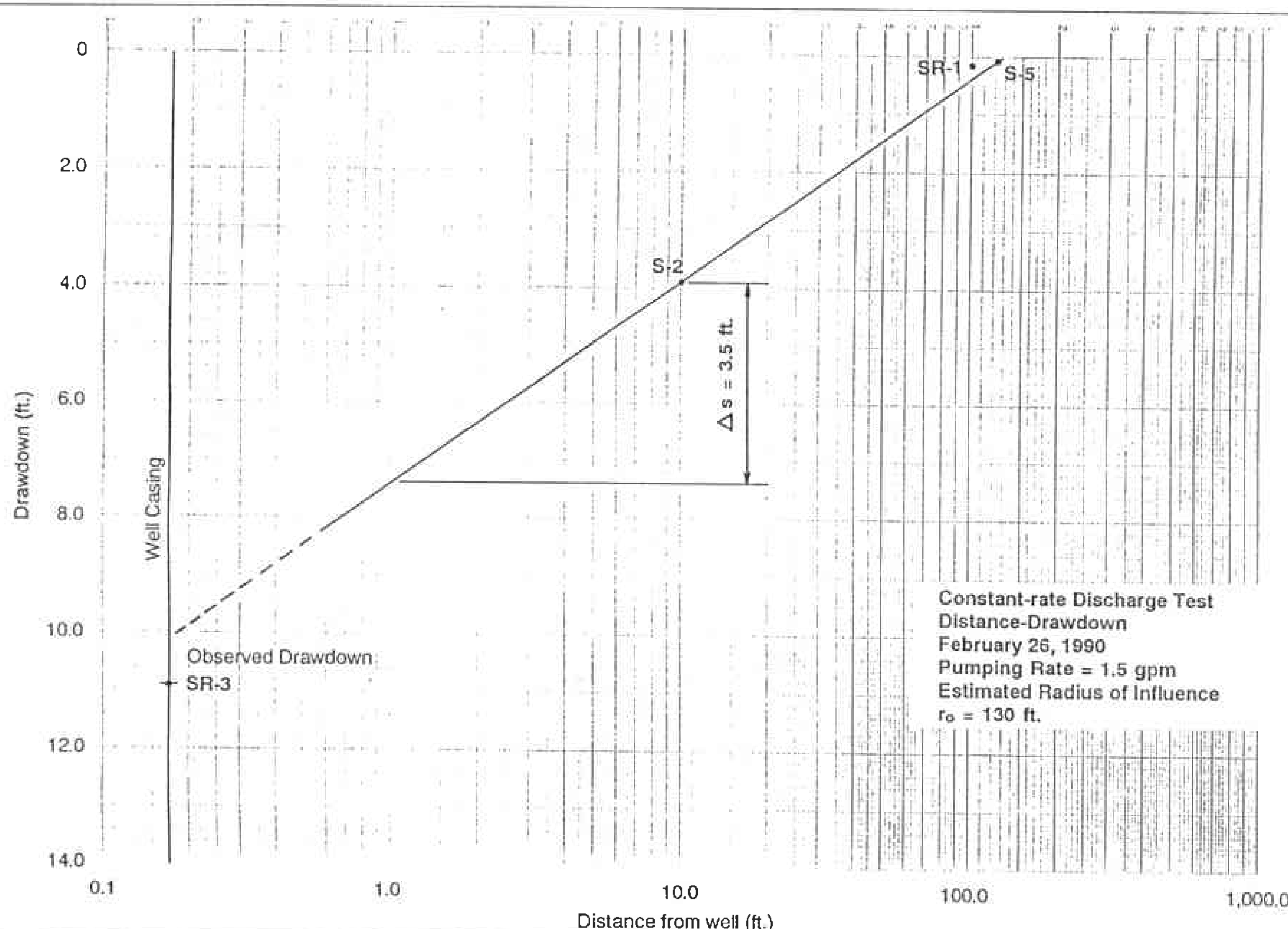
TRANSMISSIVITY (T)

$T = 528 \times Q / \Delta s$
$T = 528 \times 1.5 / 3.5$
T = 226 gallons per day / foot

STORATIVITY (S)

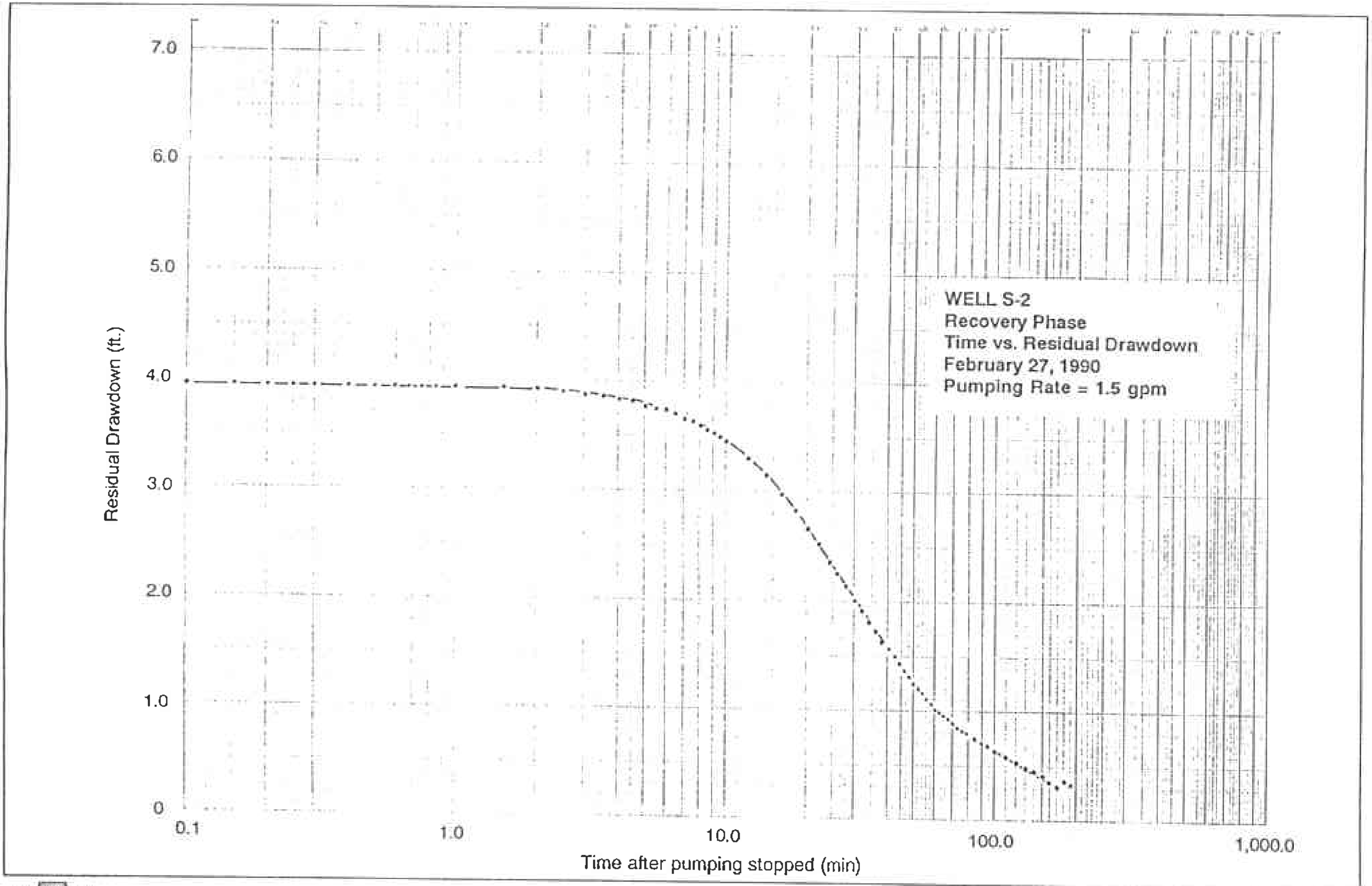
$S = 0.3 \times T \times t / r_o^2$

$S = 0.3 \times 226 \times .347 / 130^2$
$S = 0.0013921$



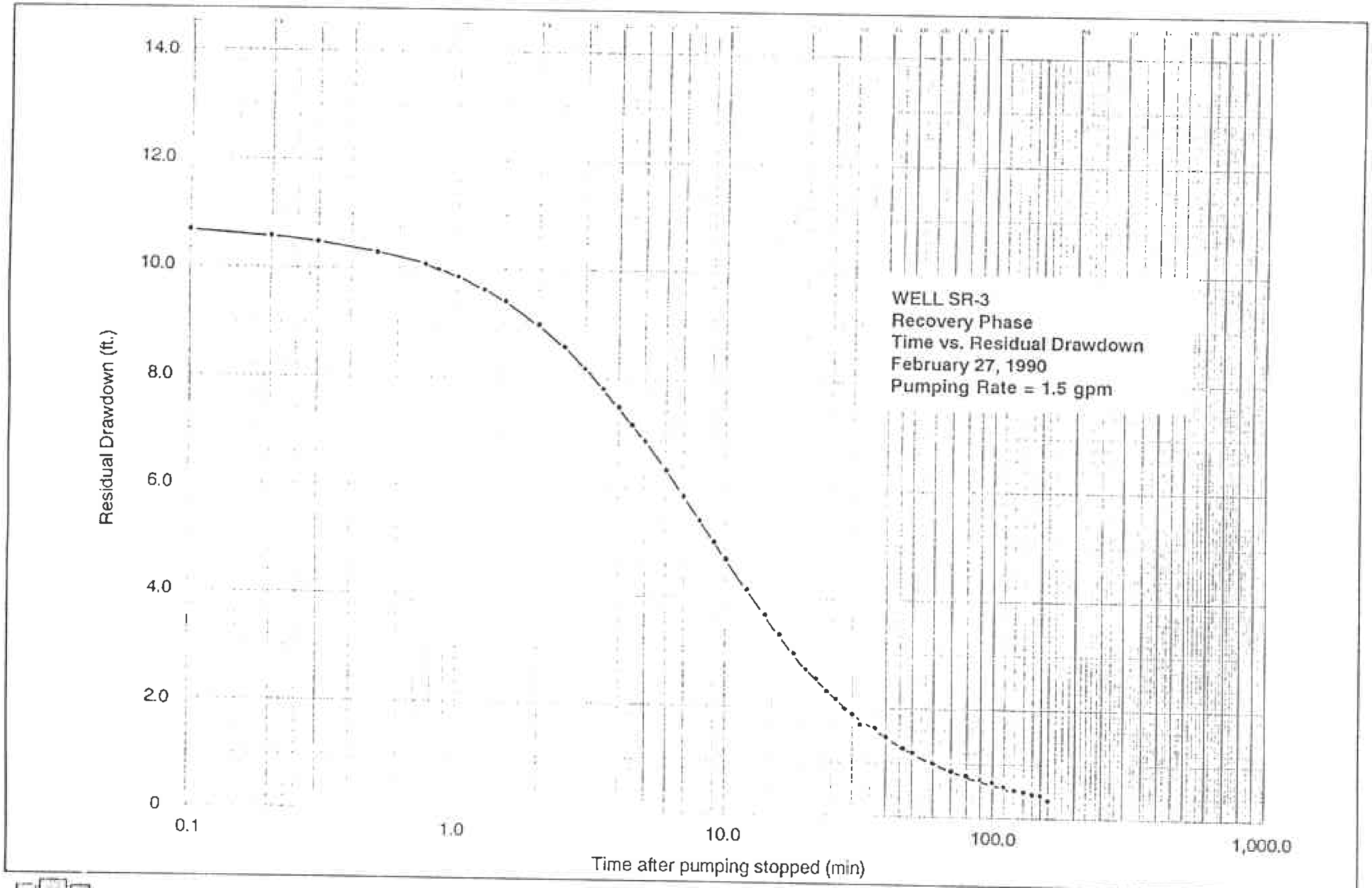
GSI GeoStrategies Inc.

JOB NUMBER	REVIEWED BY RG/CEG	DATE	REVISED DATE	REVISED DATE
7632	CMP CEG 1262	4/90		



GeoStrategies Inc.

JOB NUMBER	REVIEWED BY RG/CEG	DATE	REVISED DATE	REVISED DATE
7632	CMP CEG 1262	4/90		



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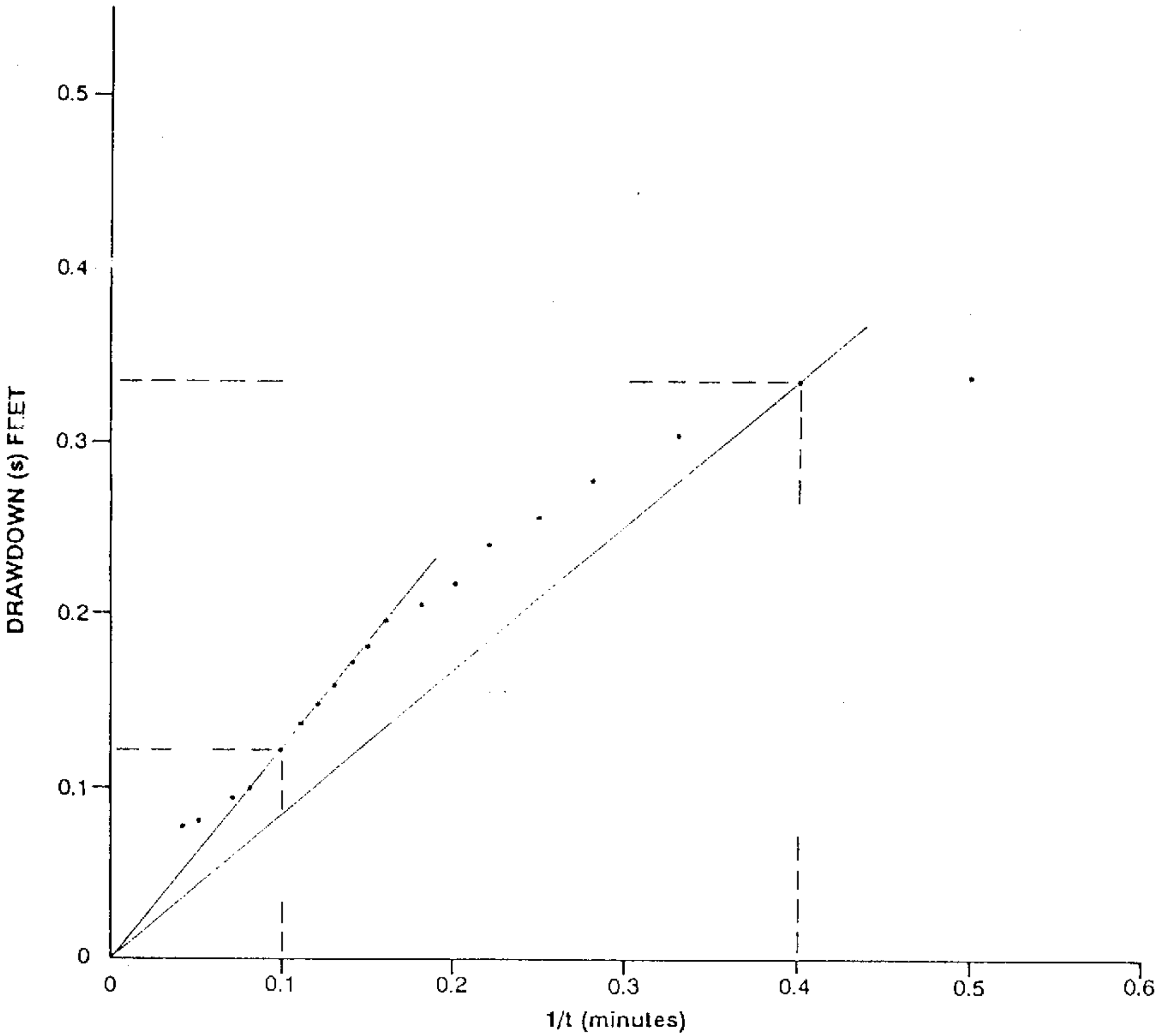
JOB NUMBER	REVIEWED BY RG/CEG	DATE	REVISED DATE	REVISED DATE
7632	CMP CEG 1262	4/90		

APPENDIX E
SLUG TEST FIELD DATA PLOTS



Slug Test

Date February 22, 1990

Well SR-3

Slug- in

V = 0.82 gals

$$T = \frac{114.6\ (V)\ (1/t)}{S}$$

$$T_E = \frac{114.6\ (0.82)\ (0.4)}{0.335}$$

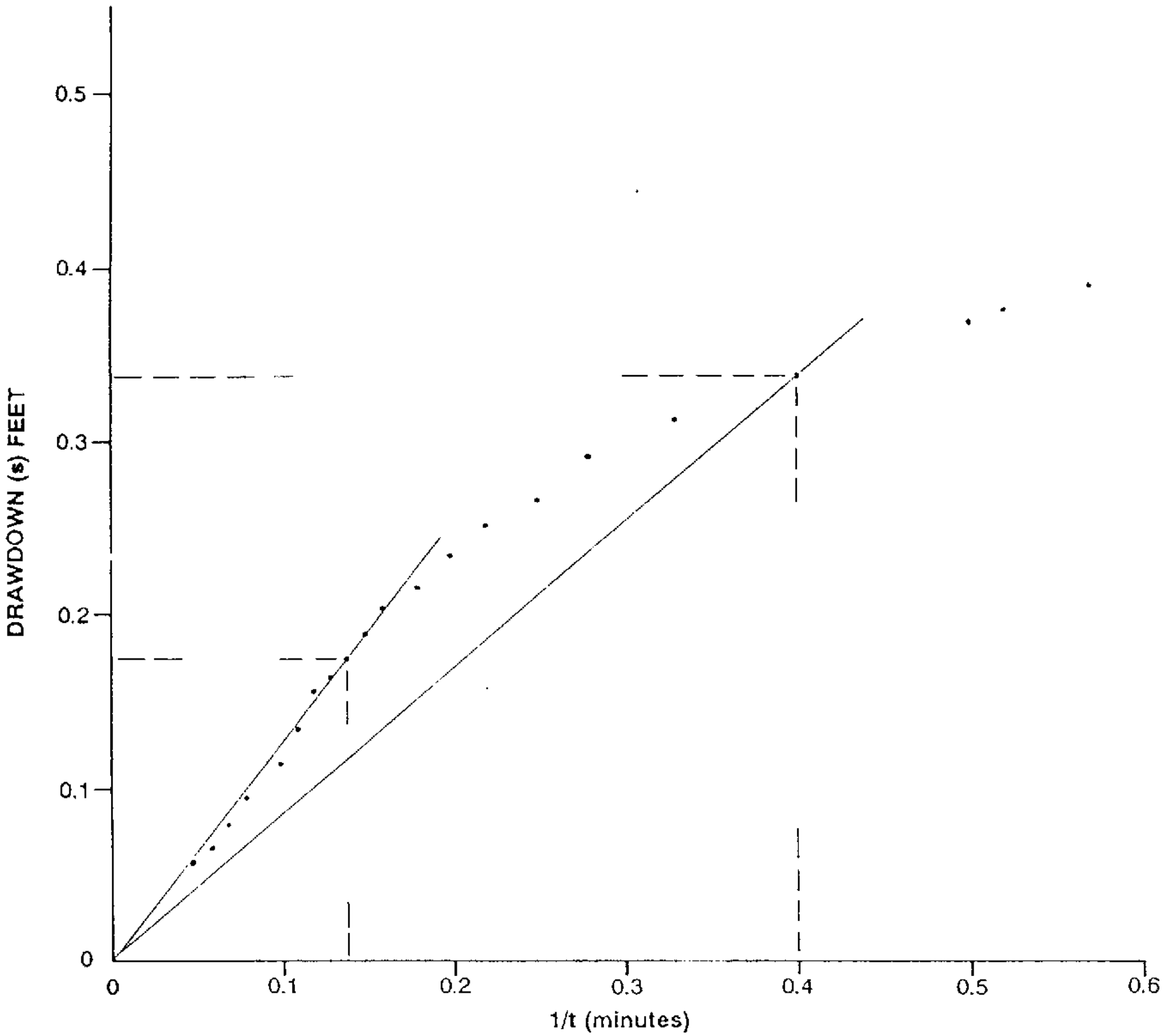
T_E = 112.21 gpd/ft

$$T_L = \frac{114.6\ (0.82)\ (0.1)}{0.120}$$

T_L = 78.31 gpd/ft

GeoStrategies Inc.

JOB NUMBER	REVIEWED BY RG / CEG	DATE	REVISED DATE	REVISED DATE
7632	CMP CEG 1262	4/90		



Slug Test

Date February 22, 1990

Well SR-3

Slug-out

V = 0.82 gals

$$T = \frac{114.6\,(V)\,(1/t)}{S}$$

$$T_E = \frac{114.6\ (0.82)\ (0.4)}{0.34}$$

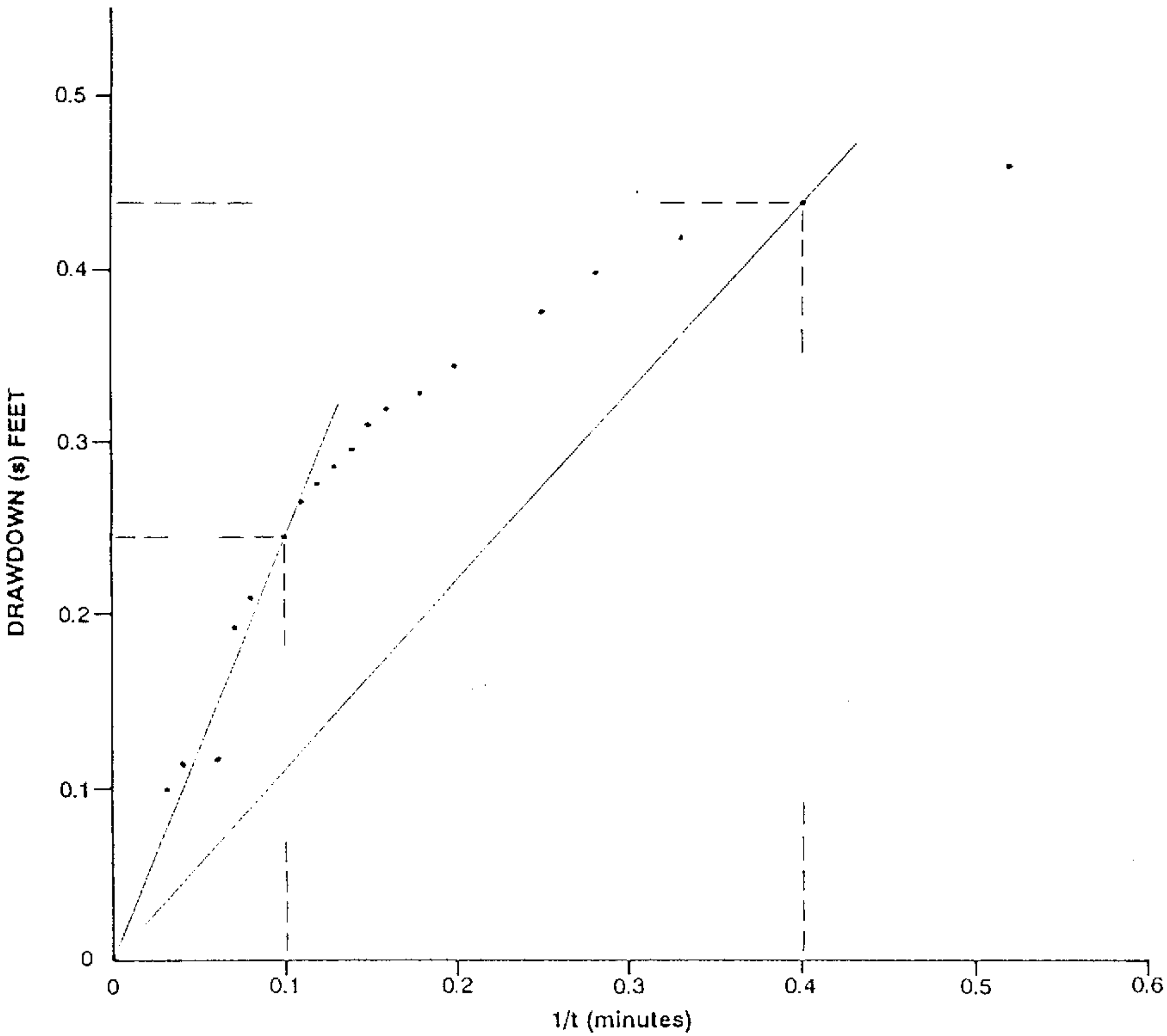
T_E = 110.55 gpd/ft

$$T_L = \frac{114.6\ (0.82)\ (0.14)}{0.177}$$

T_L = 74.33 gpd/ft

GeoStrategies Inc.

JOB NUMBER	REVIEWED BY RG/CEG	DATE	REVISED DATE	REVISED DATE
7632	CMP CEG 1262	4/90		



Slug Test

Date February 22, 1990

Well S-2

Slug- out

V = 0.458 gals

$$T = \frac{114.6\ (V)\ (1/t)}{S}$$

$$T_E = \frac{114.6\ (0.458)\ (0.4)}{0.44}$$

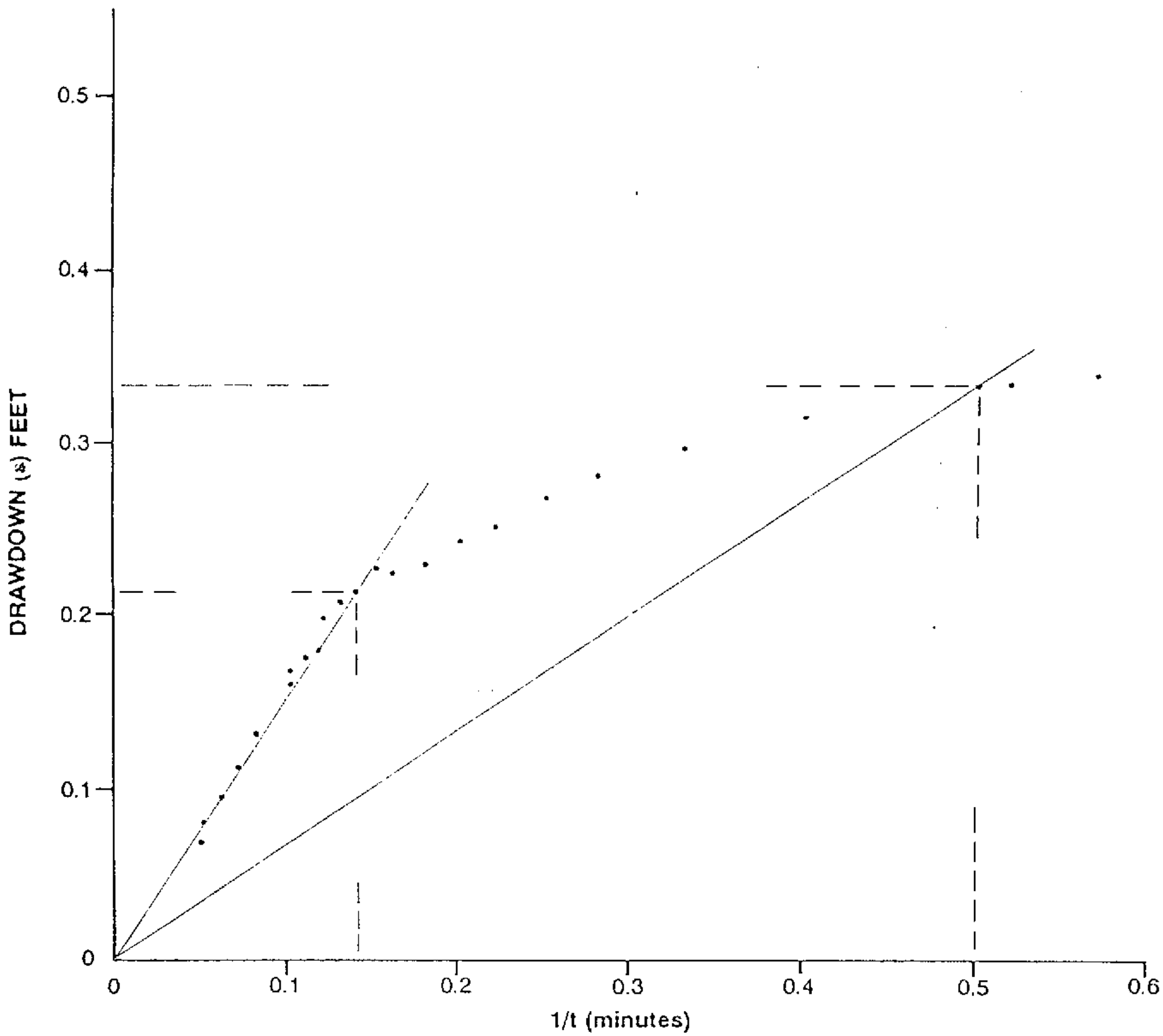
T_E = 47.71 gpd/ft

$$T_L = \frac{114.6\ (0.458)\ (0.1)}{0.239}$$

T_L = 21.96 gpd/ft

GeoStrategies Inc.

JOB NUMBER	REVIEWED BY RG/CEG	DATE	REVISED DATE	REVISED DATE
7632	CMP CEG 1262	4/90		



Slug Test

Date February 22, 1990

Well S-2

Slug-in

V = 0.458 gals

$$T = \frac{114.6\ (V)\ (1/t)}{S}$$

$$T_E = \frac{114.6\ (0.458)\ (0.5)}{0.34}$$

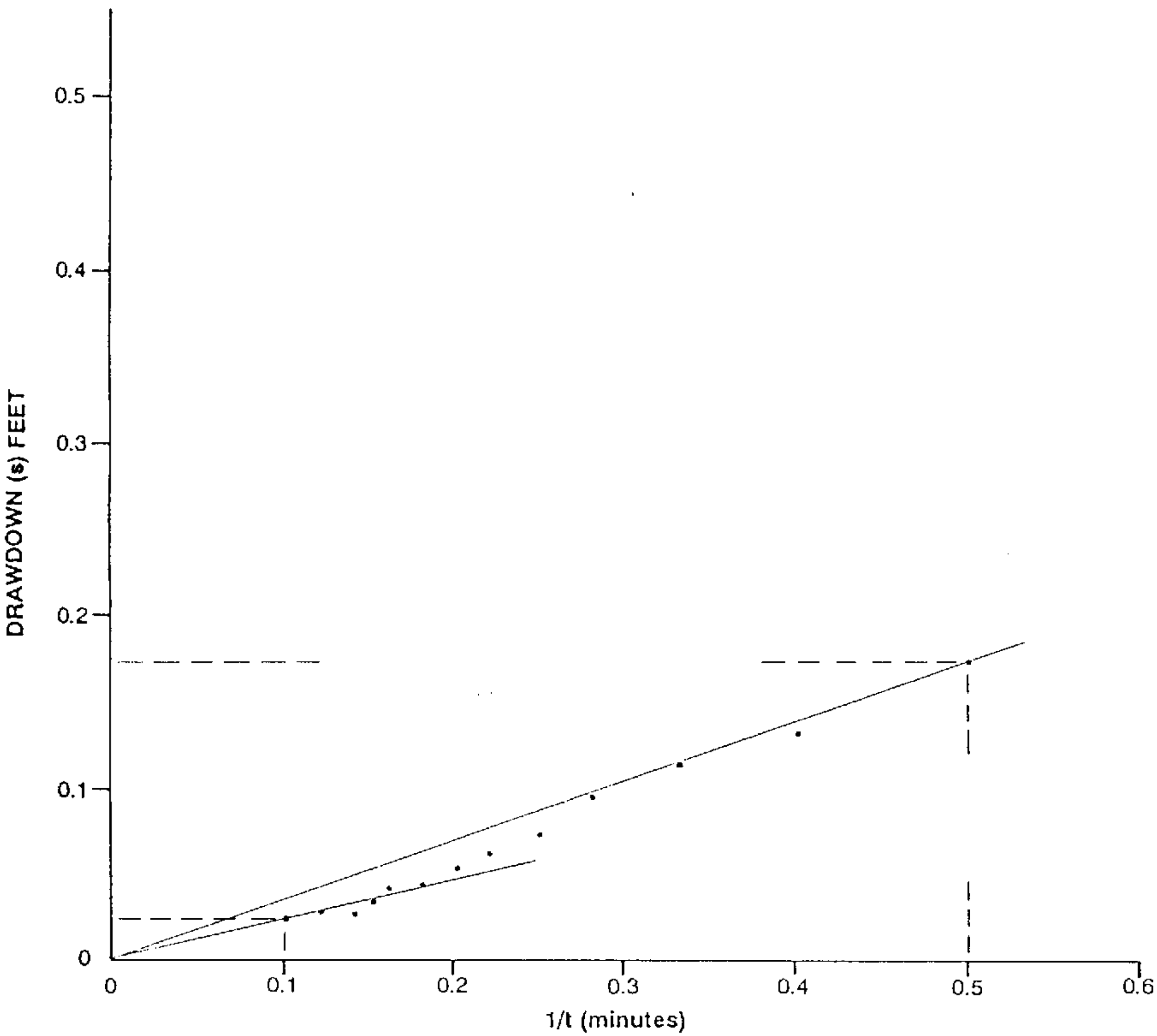
T_E = 77.18 gpd/ft

$$T_L = \frac{114.6\ (0.458)\ (0.14)}{0.22}$$

T_L = 33.4 gpd/ft

GeoStrategies Inc.

JOB NUMBER	REVIEWED BY RG/CEG	DATE	REVISED DATE	REVISED DATE
7632	CMP CEG 1262	4/90		



Slug Test

Date February 22, 1990

Well S-3

Slug-in

V = 0.458 gals

$$T = \frac{114.6\ (V)\ (1/t)}{S}$$

$$T_E = \frac{114.6\ (0.458)\ (0.5)}{0.175}$$

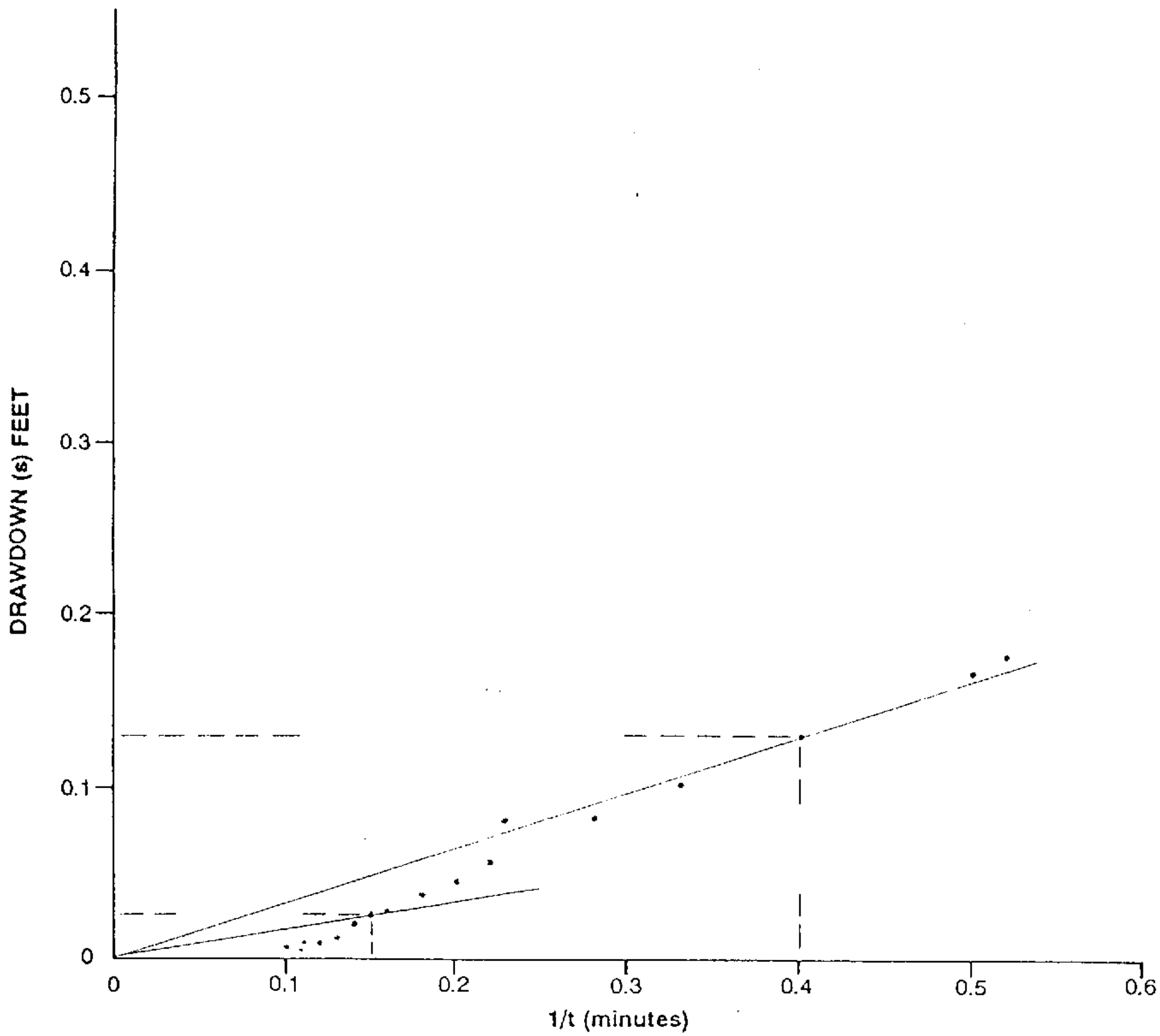
T_E = 149.96 gpd/ft

$$T_L = \frac{114.6\ (0.458)\ (0.1)}{0.025}$$

T_L = 209.95 gpd/ft

GSI GeoStrategies Inc.

JOB NUMBER	REVIEWED BY RG/CEG	DATE	REVISED DATE	REVISED DATE
7632	QMD CEG 1262	4/90		



Slug Test

Date February 22, 1990

Well S-3

Slug-out

V = 0.458 gals

$$T = \frac{114.6\ (V)\ (1/t)}{S}$$

$$T_E = \frac{114.6\ (0.458)\ (0.4)}{0.13}$$

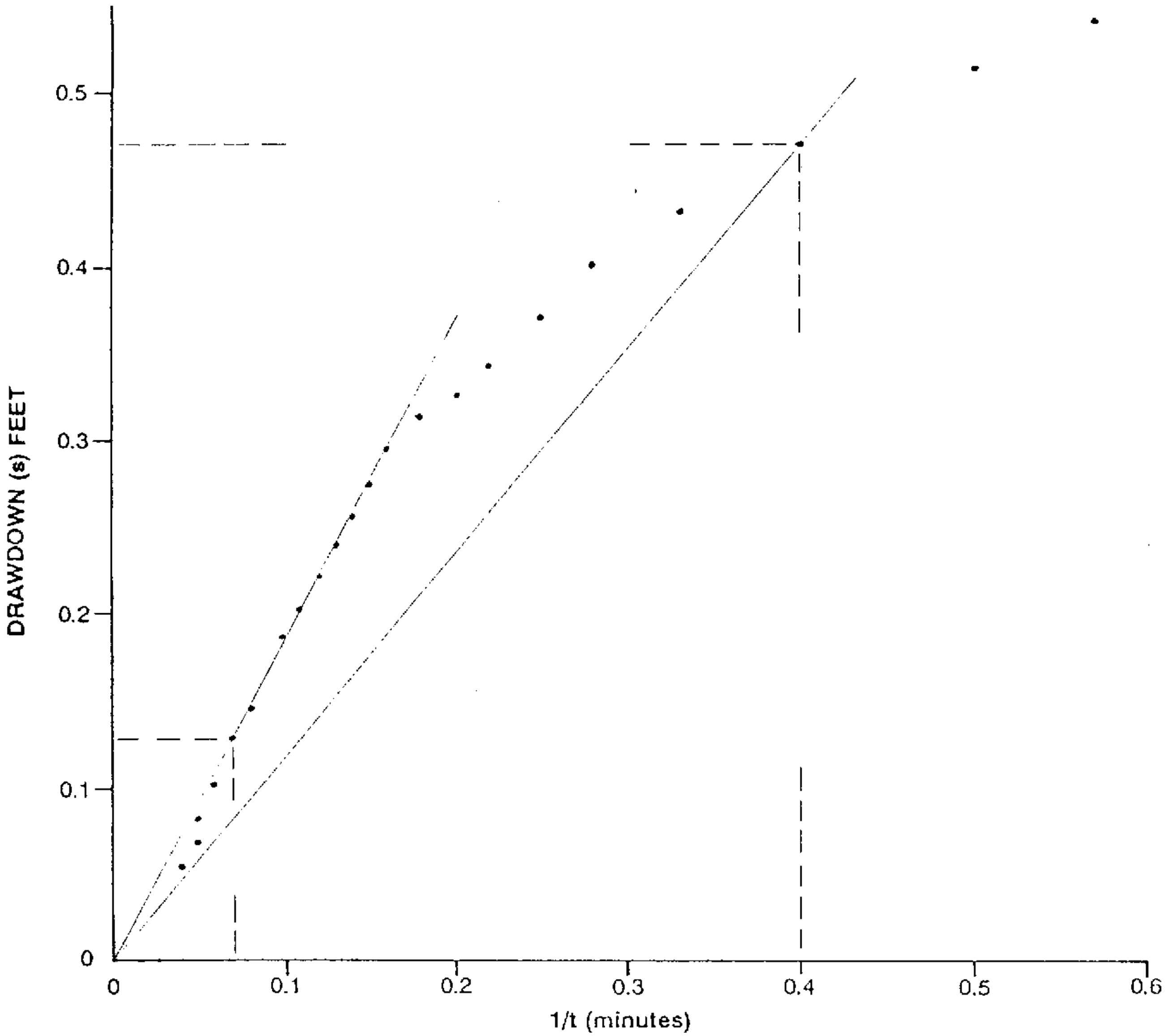
T_E = 161.50 gpd/ft

$$T_L = \frac{114.6\ (0.458)\ (0.4)}{0.13}$$

T_L = 302.81 gpd/ft

GSI GeoStrategies Inc.

JOB NUMBER	REVIEWED BY RG/CEG	DATE	REVISED DATE	REVISED DATE
7632	CWP CEG 1262	4/90		



Slug Test

Date February 23, 1990
Well S-5
Slug-in
V = 0.458 gals

$$T = \frac{114.6\ (V)\ (1/t)}{S}$$

$$T_E = \frac{114.6\ (0.458)\ (0.4)}{0.473}$$

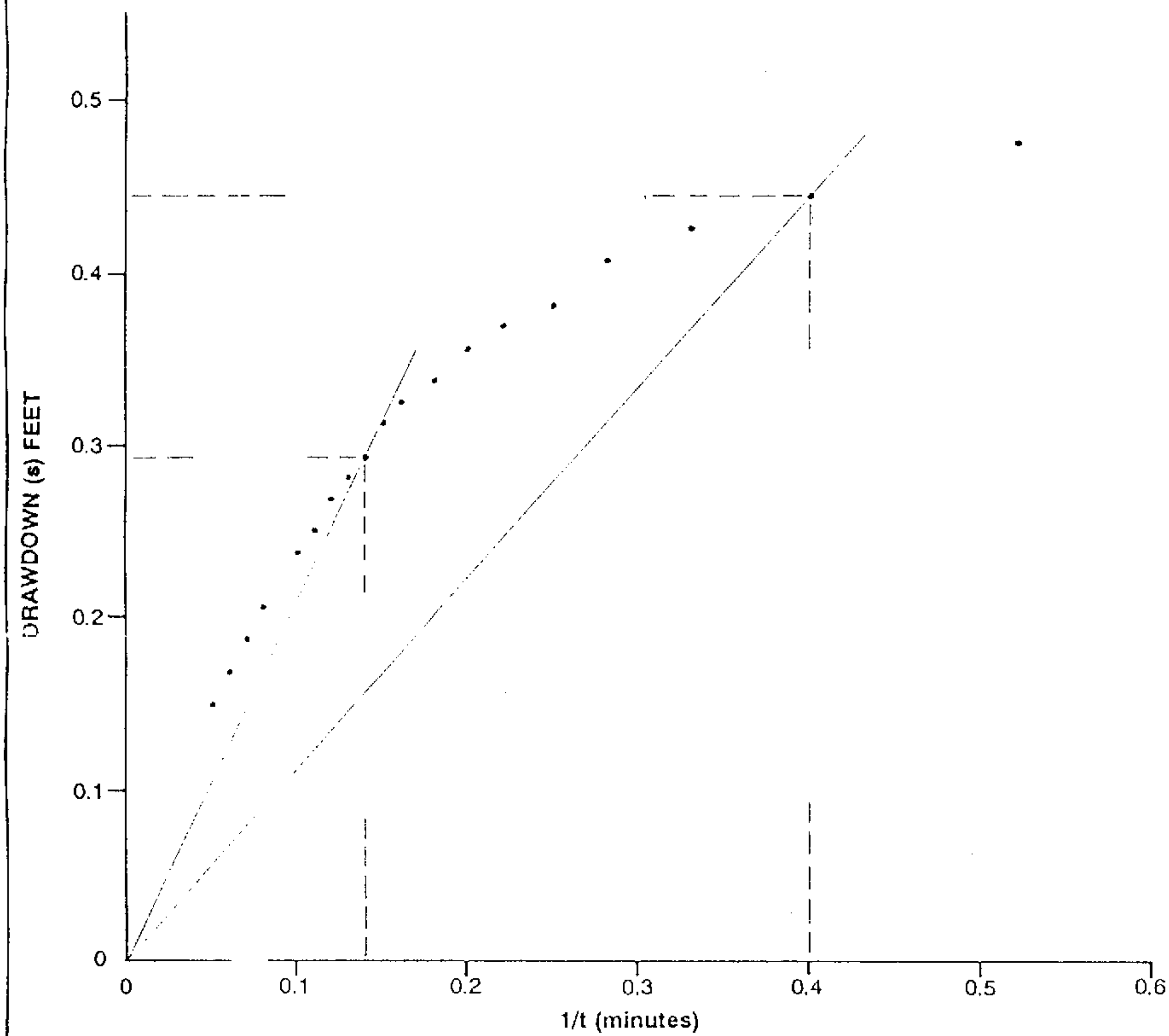
T_E = 44.38 gpd/ft

$$T_L = \frac{114.6\ (0.458)\ (0.07)}{0.129}$$

T_L = 28.48 gpd/ft

GSI GeoStrategies Inc.

JOB NUMBER	REVIEWED BY RG/CEG	DATE	REVISED DATE	REVISED DATE
7632	CMP CEG 1262	4/90		



Slug Test

Date February 23, 1990

Well S-5

Slug-out

V = 0.458 gals

$$T = \frac{114.6\ (V)\ (1/t)}{S}$$

$$T_E = \frac{114.6\ (0.458)\ (0.4)}{0.448}$$

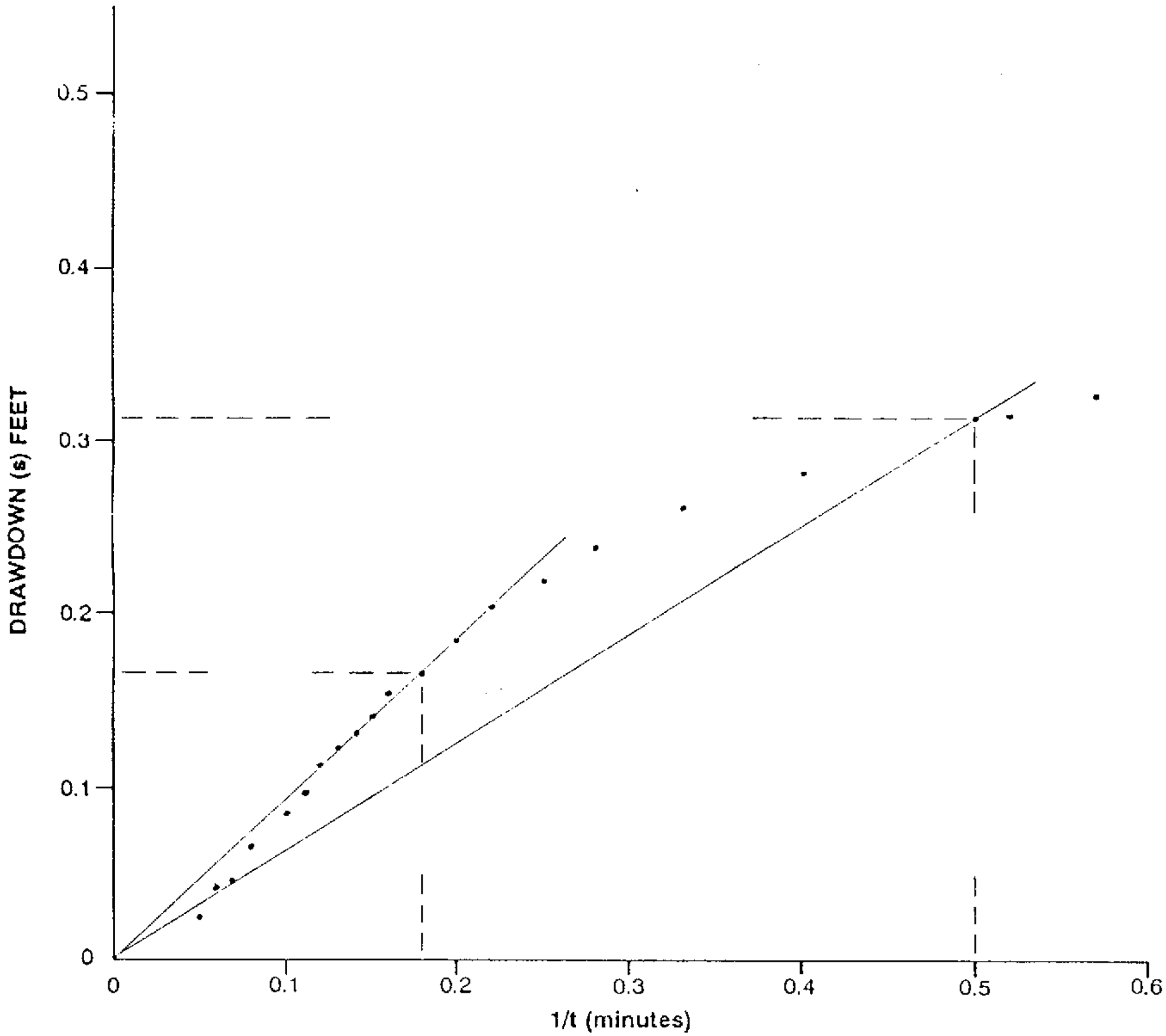
T_E = 46.86 gpd/ft

$$T_L = \frac{114.6\ (0.458)\ (0.14)}{0.297}$$

T_L = 24.74 gpd/ft

GSI GeoStrategies Inc.

JOB NUMBER	REVIEWED BY RG/CEG	DATE	REVISED DATE	REVISED DATE
7632	CMP CEG 1262	4/90		



Slug Test

Date February 23, 1990

Well S-7

Slug-in

V = 0.458 gals

$$T = \frac{114.6\ (V)\ (1/t)}{S}$$

$$T_E = \frac{114.6\ (0.458)\ (0.5)}{0.34}$$

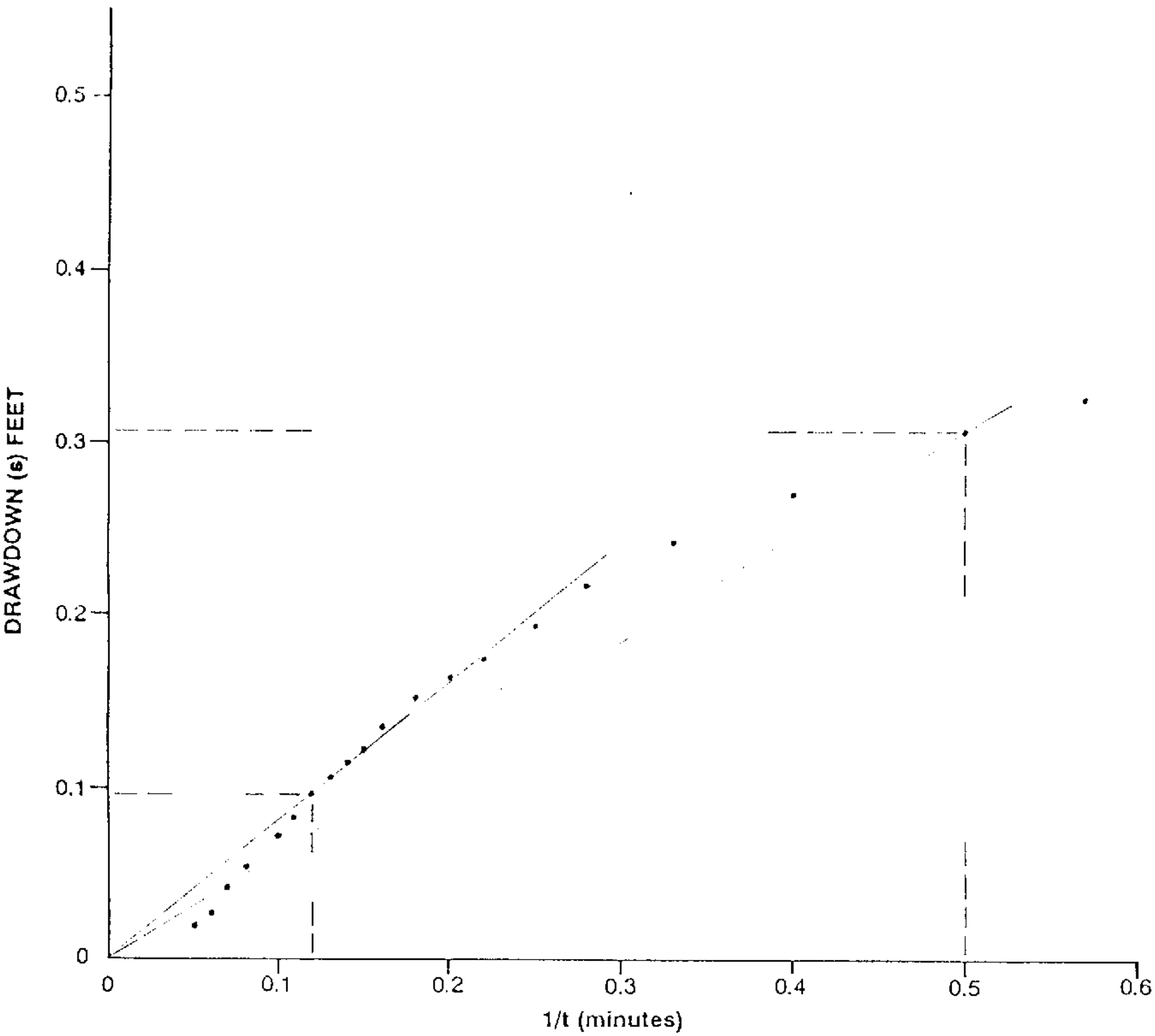
T_E = 77.18 gpd/ft

$$T_L = \frac{114.6\ (0.458)\ (0.18)}{0.167}$$

T_L = 56.57 gpd/ft

GeoStrategies Inc.

JOB NUMBER	REVIEWED BY RG/CEG	DATE	REVISED DATE	REVISED DATE
7632	CMP ceG1262	4/90		



Slug Test

Date February 23, 1990

Well S-7

Slug-out

V = 0.458 gals

$$T = \frac{114.6\ (V)\ (1/t)}{S}$$

$$T_E = \frac{114.6\ (0.458)\ (0.5)}{0.308}$$

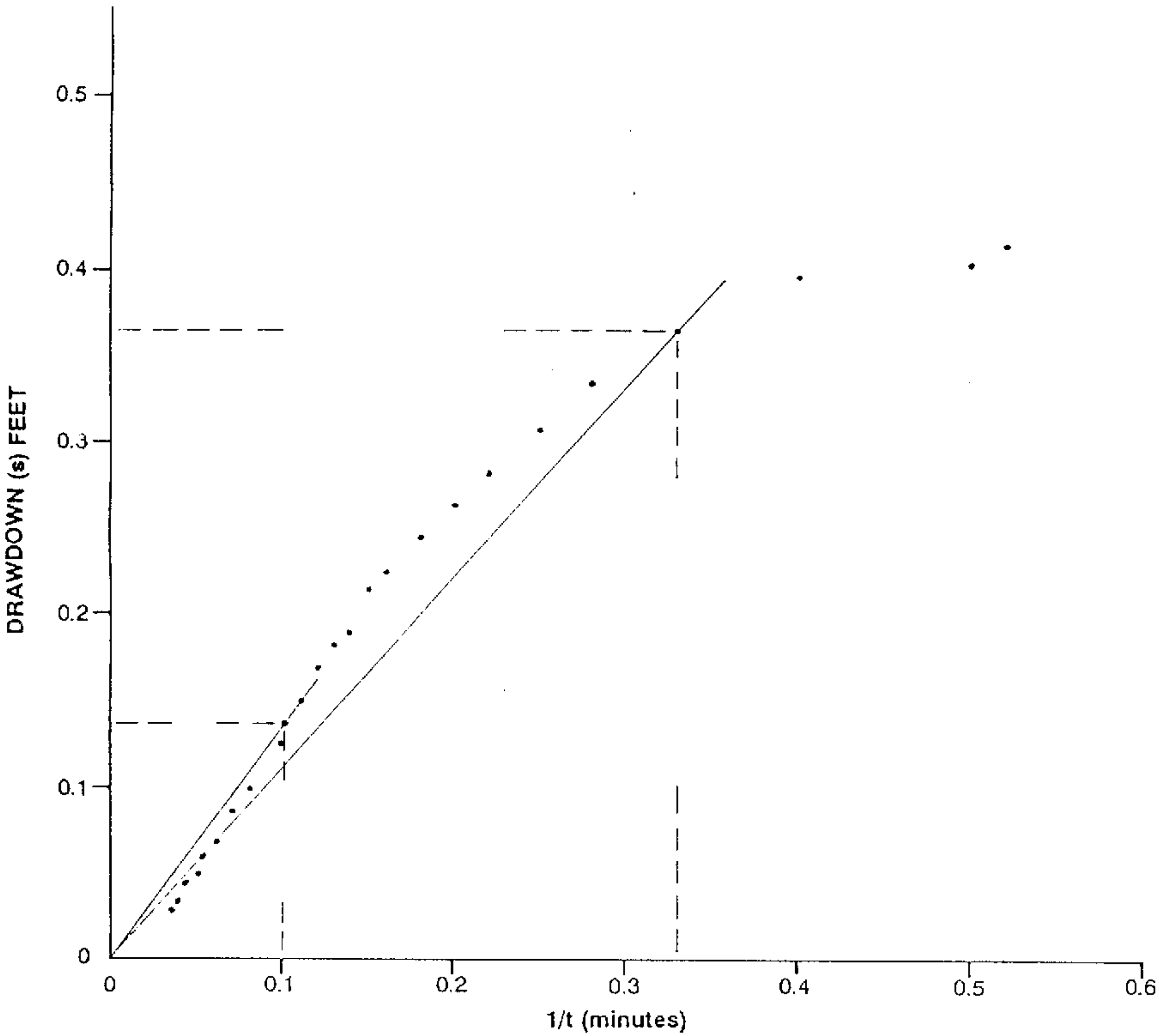
T_E = 85.21 gpd/ft

$$T_L = \frac{114.6\ (0.458)\ (0.097)}{0.12}$$

T_L = 42.43 gpd/ft

GSI GeoStrategies Inc.

JOB NUMBER	REVIEWED BY RG/CEG	DATE	REVISED DATE	REVISED DATE
7632	CMP CEG 1262	4/90		



Slug Test

Date February 23, 1990
Well S-8
Slug-out
V = 0.458 gals

$$T = \frac{114.6\ (V)\ (1/t)}{S}$$

$$T_E = \frac{114.6\ (0.458)\ (0.33)}{0.366}$$

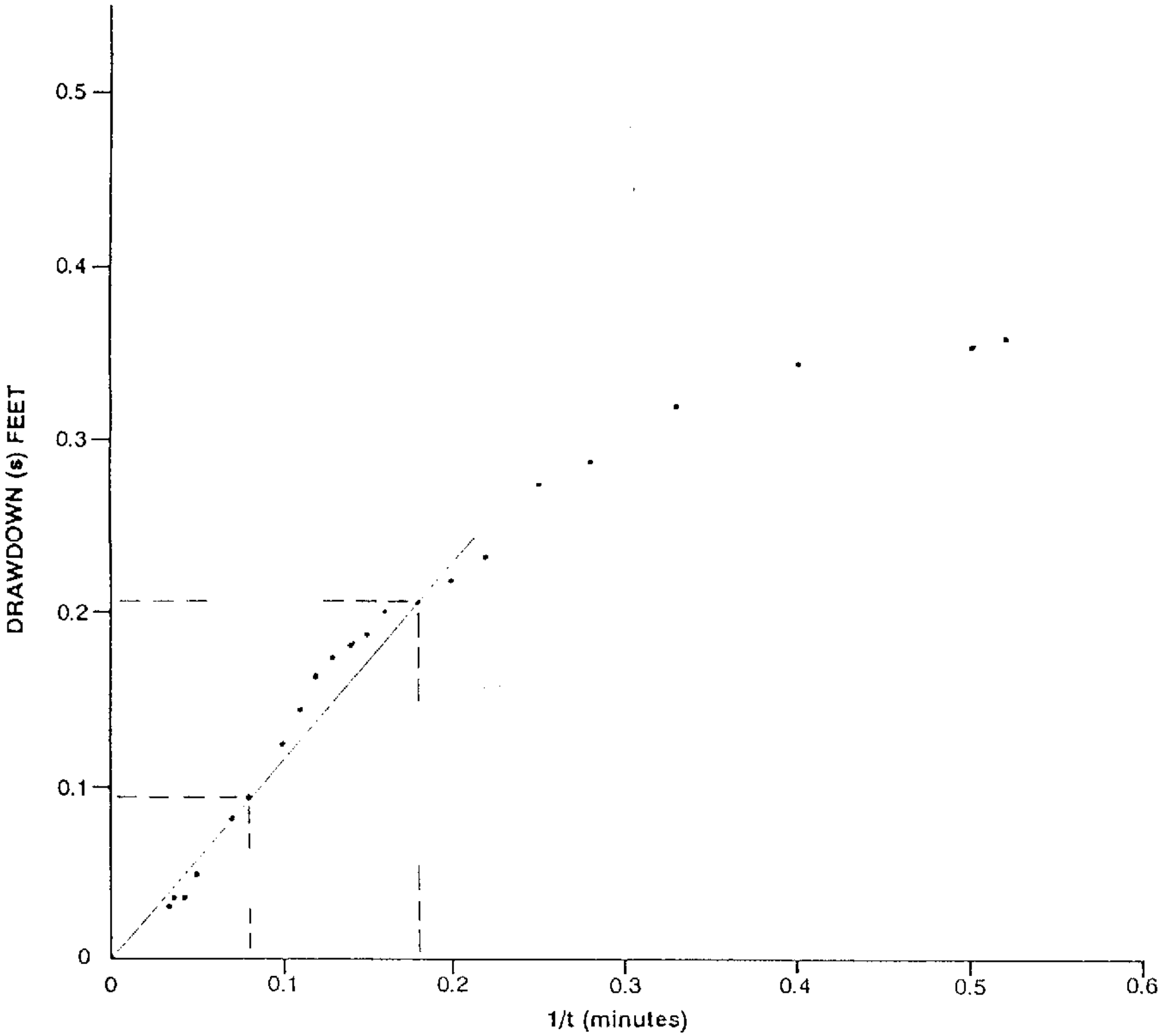
T_E = 47.32 gpd/ft

$$T_L = \frac{114.6\ (0.458)\ (0.1)}{0.14}$$

T_L = 37.49 gpd/ft

GSI GeoStrategies Inc.

JOB NUMBER	REVIEWED BY RG/CEG	DATE	REVISED DATE	REVISED DATE
7632	(signature) CEG 1262	4/90		



Slug Test

Date February 23, 1990
Well S-8
Slug-in
V = 0.458 gals

$$T = \frac{114.6\ (V)\ (1/t)}{S}$$

$$T_E = \frac{114.6\ (0.458)\ (0.18)}{0.208}$$

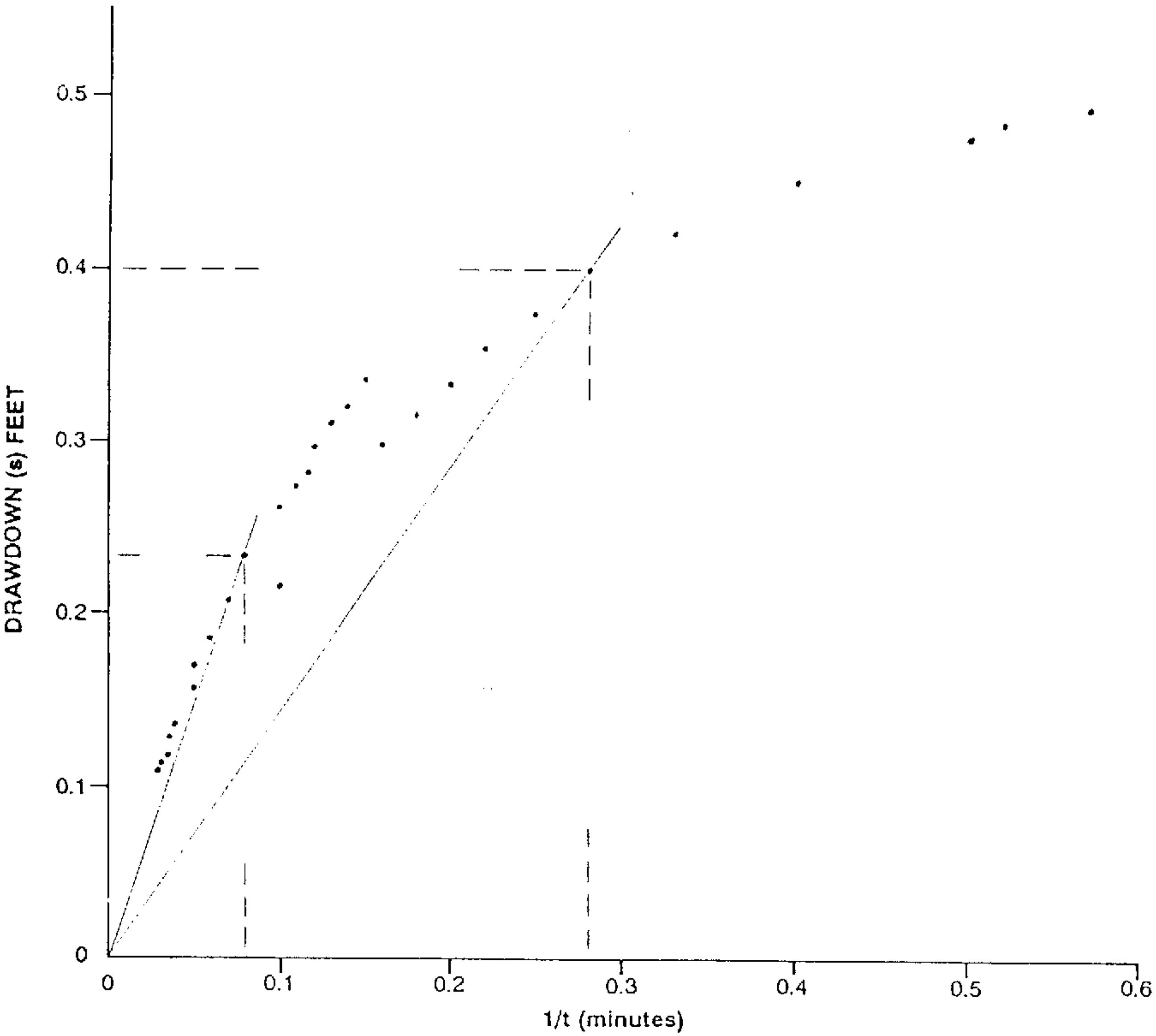
T_E = 45.42 gpd/ft

$$T_L = \frac{114.6\ (0.458)\ (0.08)}{0.094}$$

T_L = 44.67 gpd/ft

GSI GeoStrategies Inc.

JOB NUMBER	REVIEWED BY RG/CEG	DATE	REVISED DATE	REVISED DATE
7632	CMP CEG 1262	4/90		



Slug Test

Date February 23, 1990

Well S-9

Slug-out

V = 0.458 gals

$$T = \frac{114.6\,(V)\,(1/t)}{S}$$

$$T_E = \frac{114.6\,(0.458)\,(0.28)}{0.4}$$

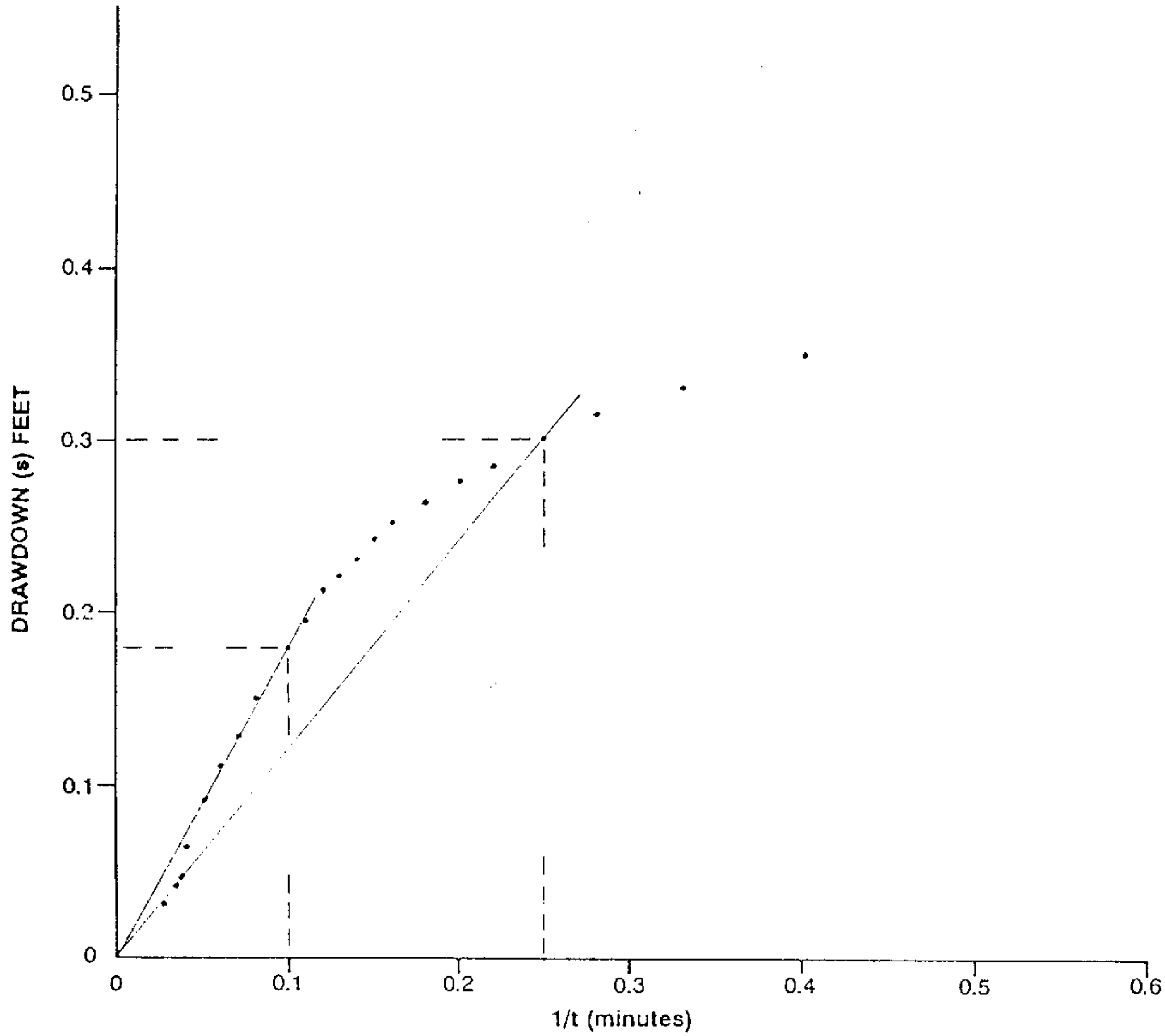
T_E = 36.74 gpd/ft

$$T_L = \frac{114.6\,(0.458)\,(0.08)}{0.233}$$

T_L = 18.02 gpd/ft

GeoStrategies Inc.

JOB NUMBER	REVIEWED BY RG/CEG	DATE	REVISED DATE	REVISED DATE
7632	[signature] CEG 1262	4/90		



Slug Test

Date February 23, 1990

Well S-9

Slug-in

V = 0.458 gals

$$T = \frac{114.6\ (V)\ (1/t)}{S}$$

$$T_E = \frac{114.6\ (0.458)\ (0.25)}{0.3}$$

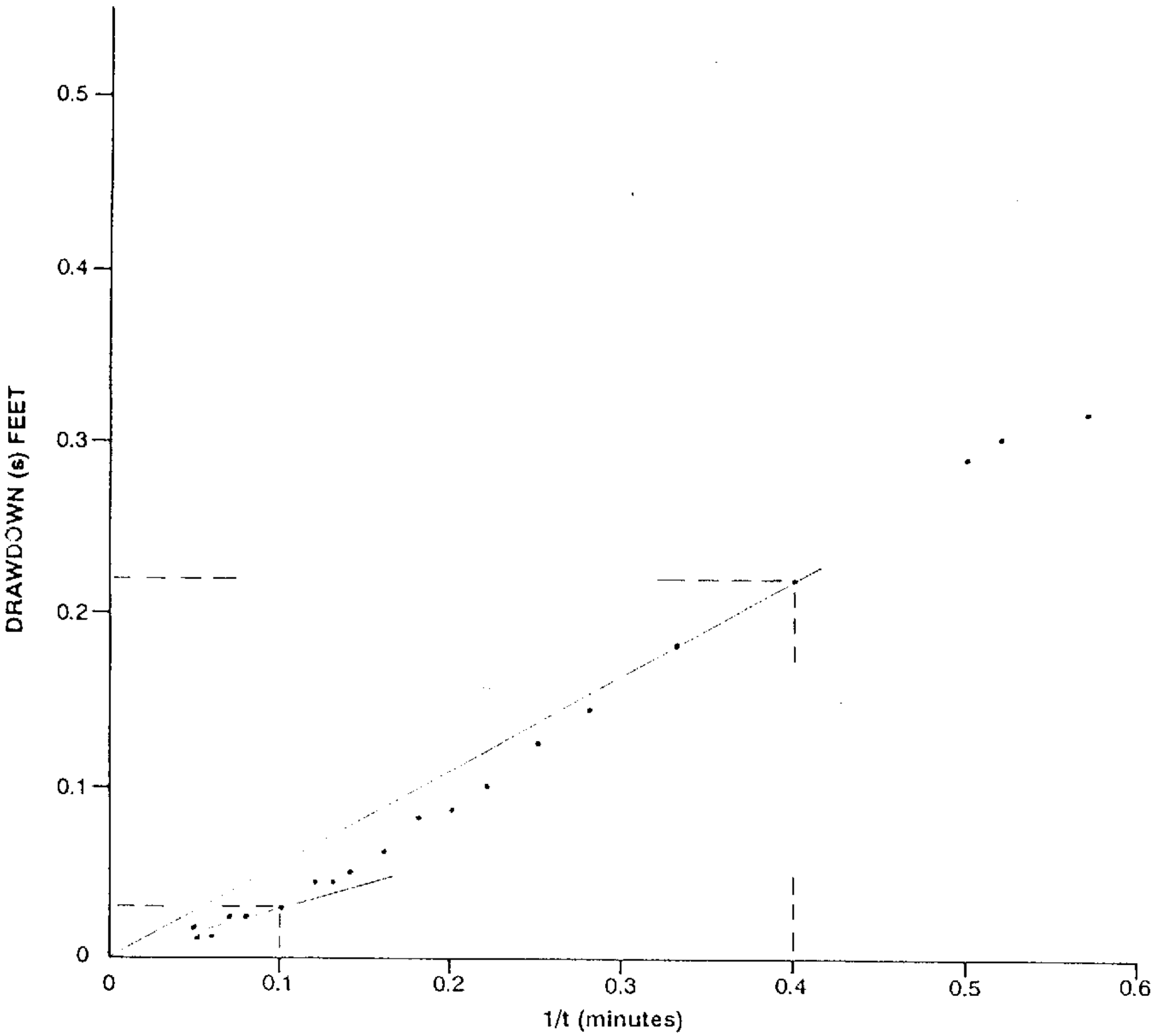
T_E = 43.74 gpd/ft

$$T_L = \frac{114.6\ (0.458)\ (0.1)}{0.179}$$

T_L = 29.32 gpd/ft

GeoStrategies Inc.

JOB NUMBER	REVIEWED BY RG/CEG	DATE	REVISED DATE	REVISED DATE
7632	[signature] CEG 1262	4/90		



Slug Test

Date February 23, 1990
Well S-10
Slug-out
V = 0.458 gals

$$T = \frac{114.6\ (V)\ (1/t)}{S}$$

$$T_E = \frac{114.6\ (0.458)\ (0.4)}{0.22}$$

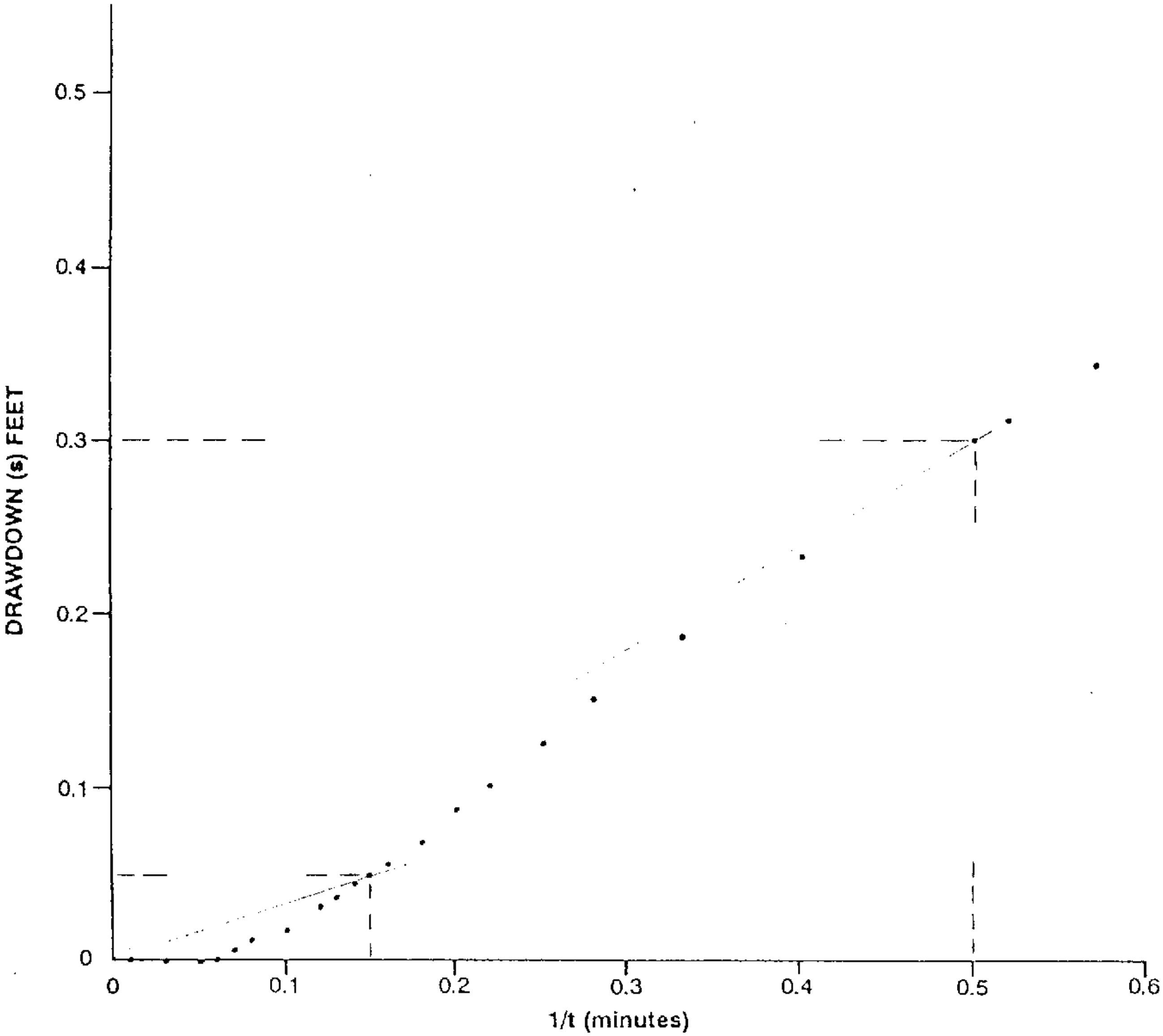
T_E = 95.43 gpd/ft

$$T_L = \frac{114.6\ (0.458)\ (0.1)}{0.03}$$

T_L = 174.96 gpd/ft

GeoStrategies Inc.

JOB NUMBER	REVIEWED BY RG/CEG	DATE	REVISED DATE	REVISED DATE
7632	[signature] CEG1262	4/90		



Slug Test

Date February 23, 1990
Well S-10
Slug-in
V = 0.458 gals

$$T = \frac{114.6\ (V)\ (1/t)}{S}$$

$$T_E = \frac{114.6\ (0.458)\ (0.5)}{0.3}$$

T_E = 87.48 gpd/ft

$$T_L = \frac{114.6\ (0.458)\ (0.15)}{0.05}$$

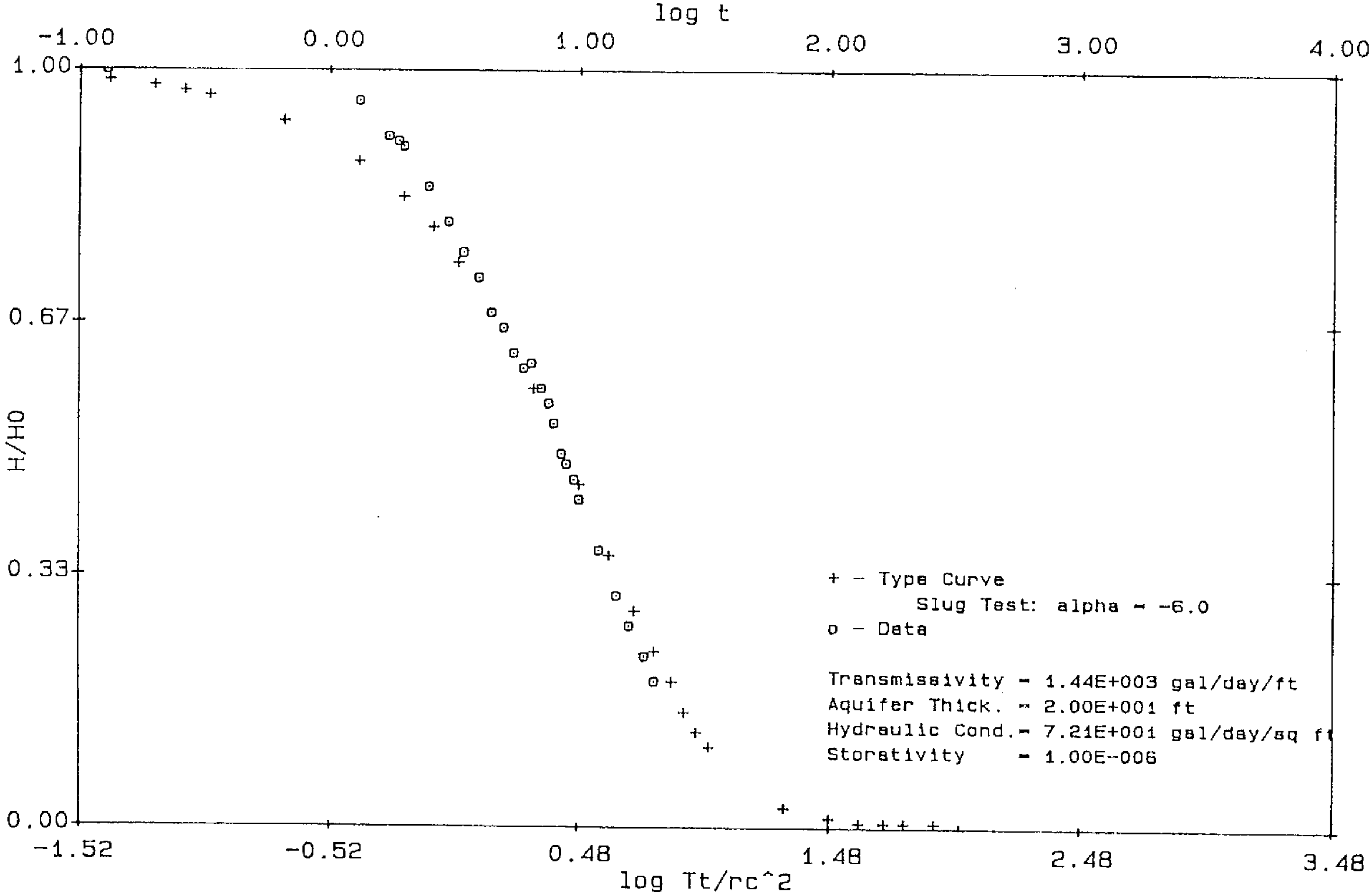
T_L = 157.46 gpd/ft

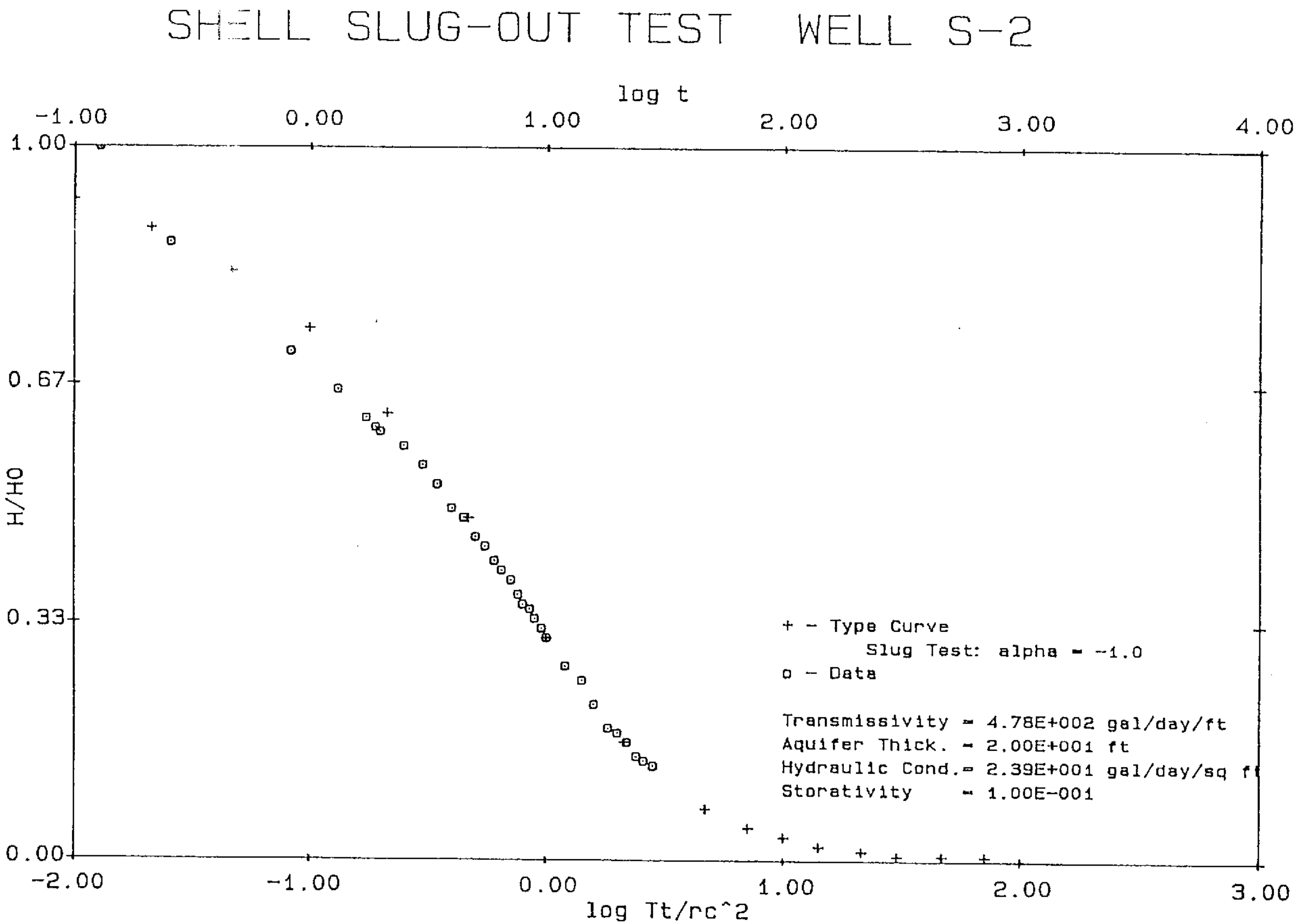
GSI GeoStrategies Inc.

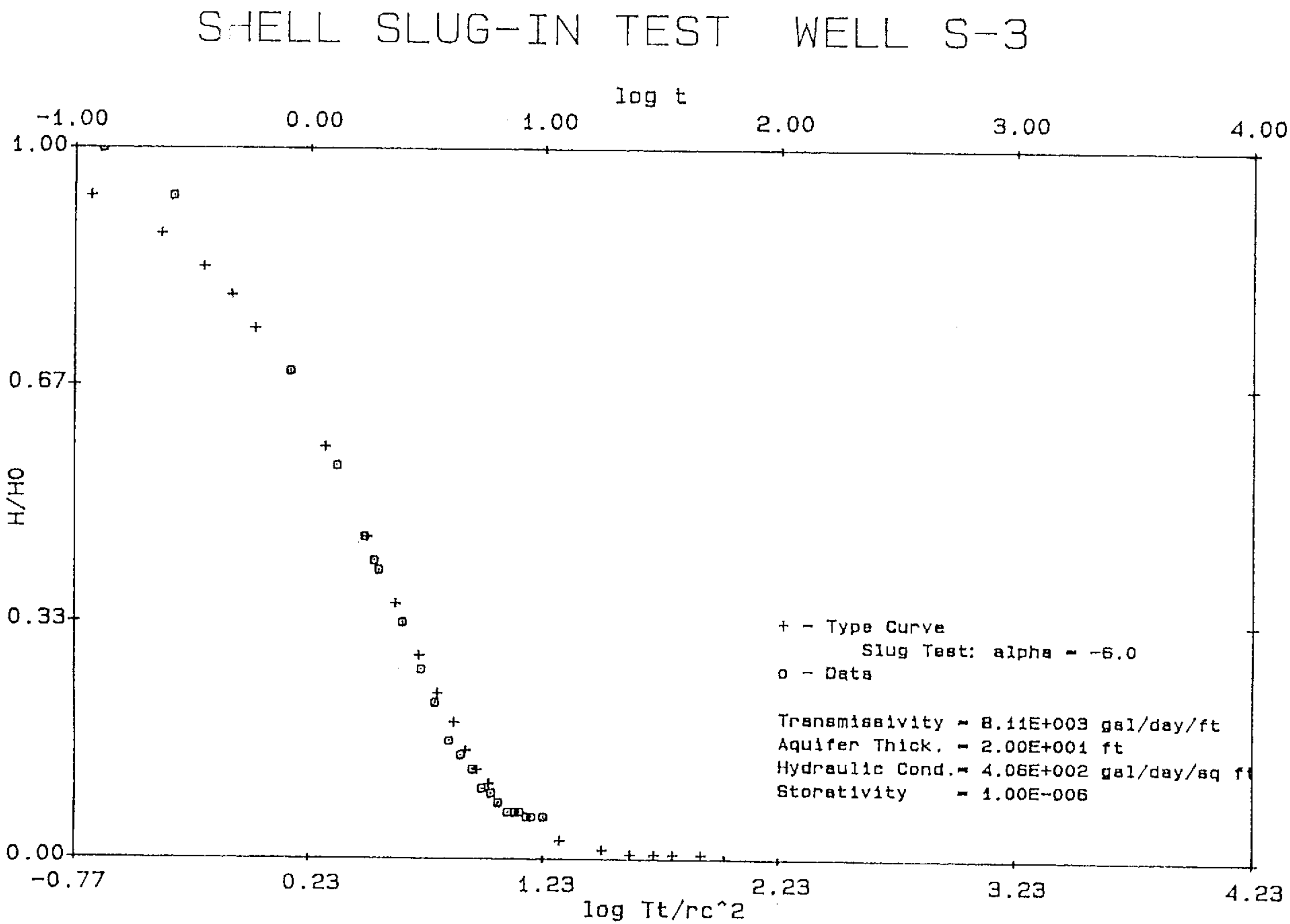
JOB NUMBER	REVIEWED BY RG/CEG	DATE	REVISED DATE	REVISED DATE
7632	CMP CEG 1262	4/90		

APPENDIX F
SLUG TEST GWAP DATA PLOTS

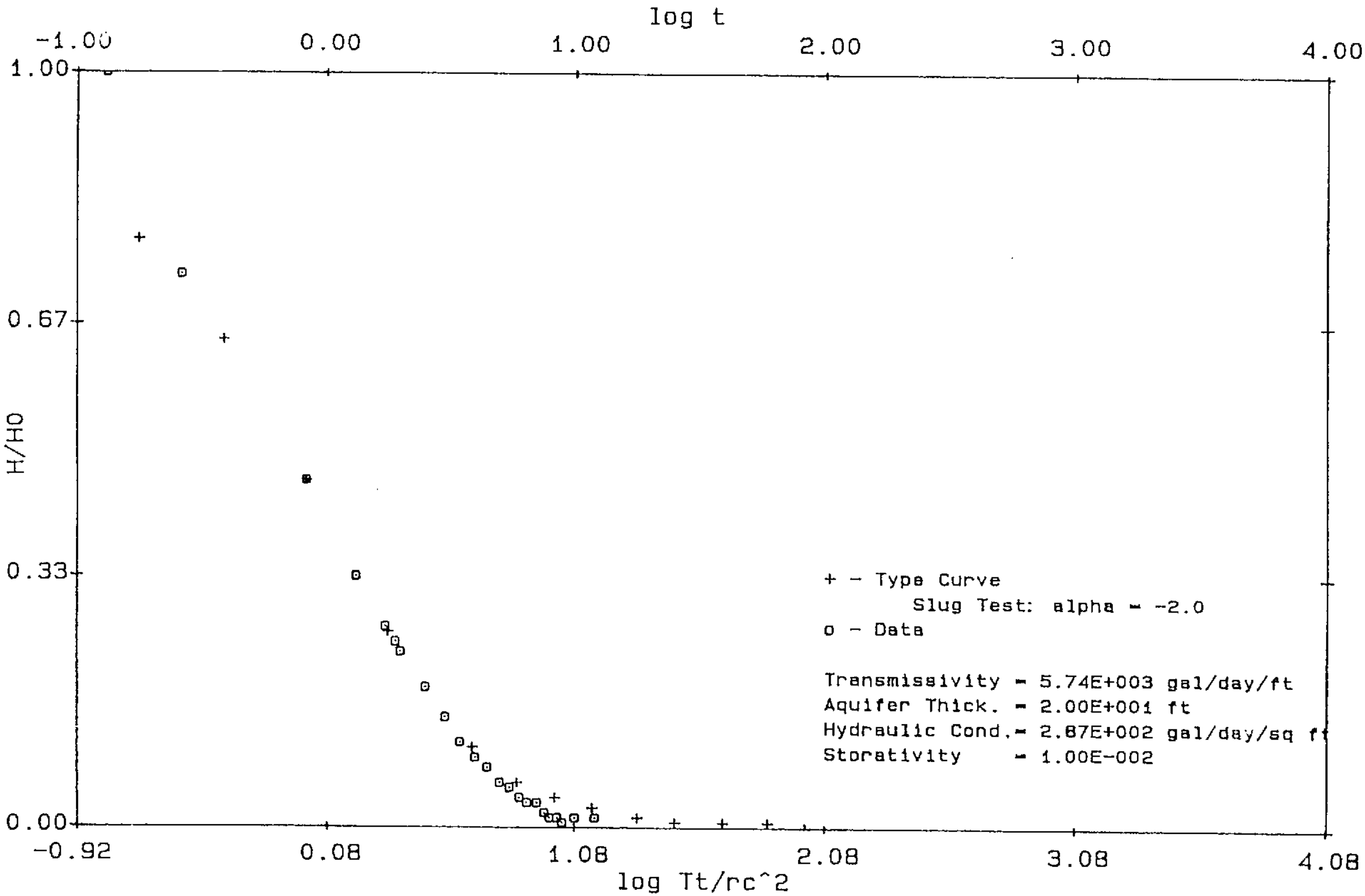
SHELL SLUG-IN TEST WELL S-2



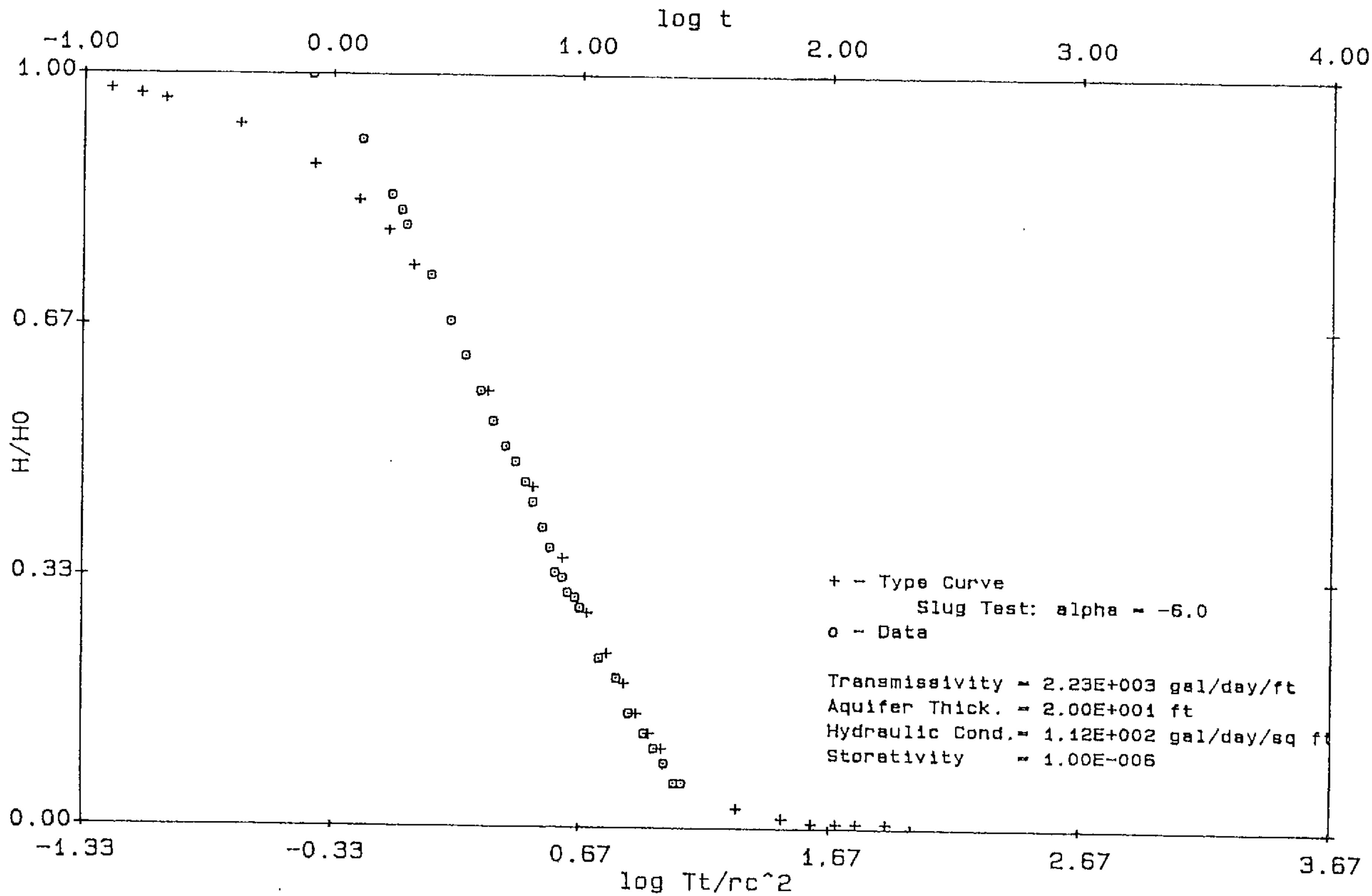

SHELL SLUG-OUT TEST WELL S-2
log t
-1.00
0.00
1.00
2.00
3.00
4.00
1.00
0.67
0.33
0.00
H/HO
-2.00
-1.00
0.00
1.00
2.00
3.00
log Tt/rc^2
+ - Type Curve
Slug Test: alpha = -1.0
o - Data
Transmissivity = 4.78E+002 gal/day/ft
Aquifer Thick. = 2.00E+001 ft
Hydraulic Cond.= 2.39E+001 gal/day/sq ft
Storativity = 1.00E-001

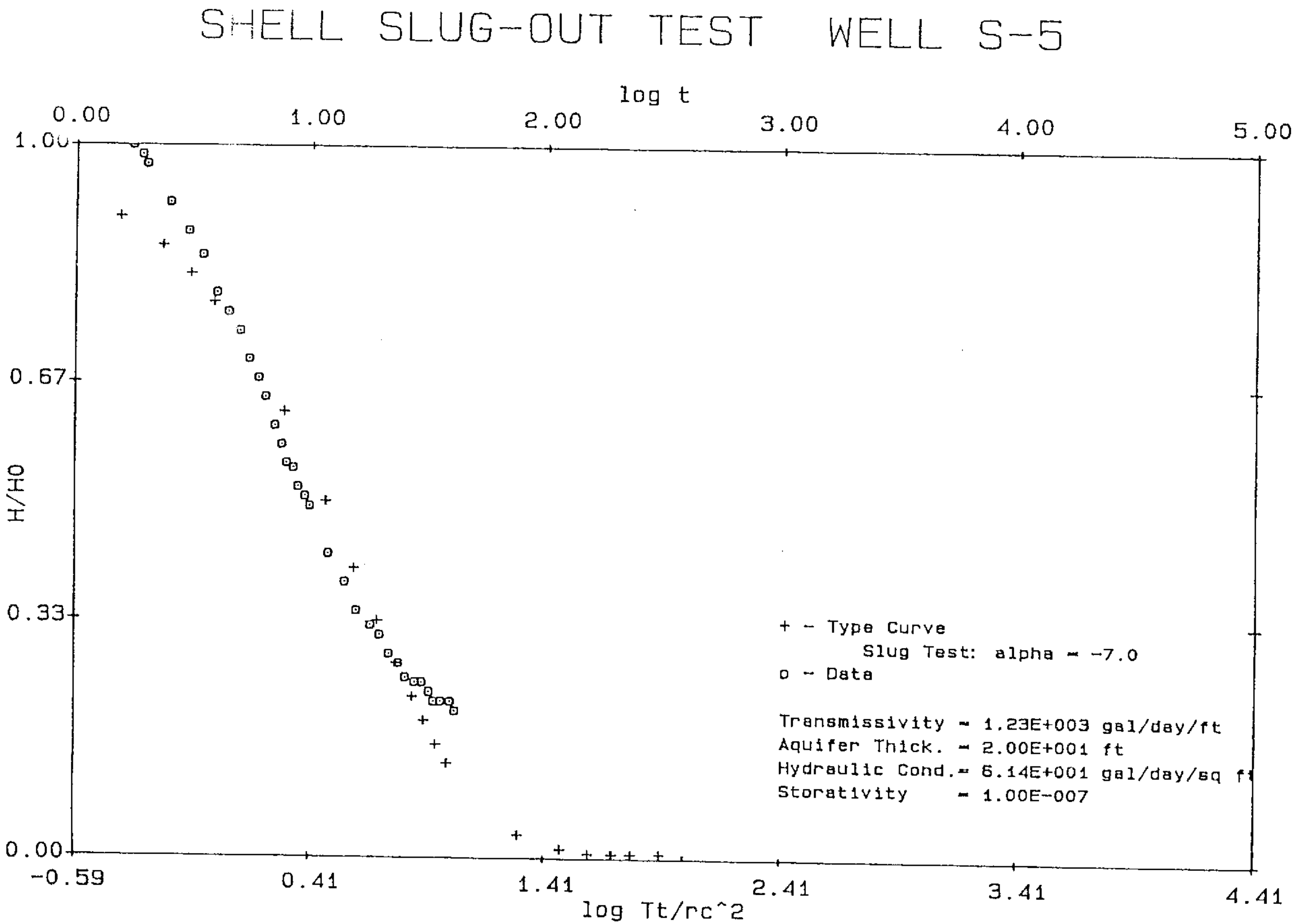

SHELL SLUG-IN TEST WELL S-3
log t
-1.00
0.00
1.00
2.00
3.00
4.00
1.00
0.67
0.33
0.00
H/HO
-0.77
0.23
1.23
2.23
3.23
4.23
log Tt/rc^2
+ - Type Curve
Slug Test: alpha = -6.0
o - Data
Transmissivity = 8.11E+003 gal/day/ft
Aquifer Thick. = 2.00E+001 ft
Hydraulic Cond.= 4.06E+002 gal/day/sq ft
Storativity = 1.00E-006

SHELL SLUG-OUT TEST WELL S-3

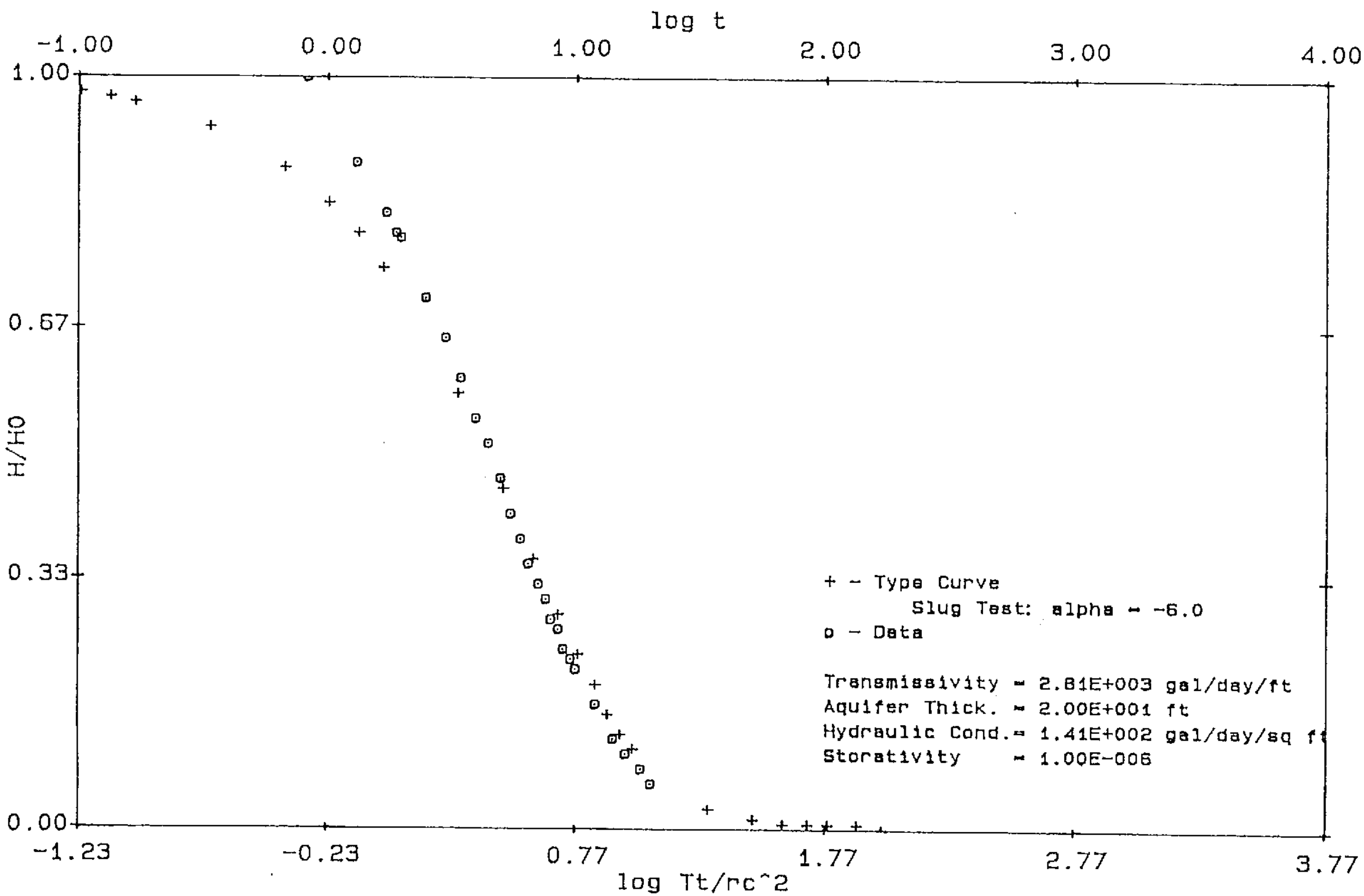


SHELL SLUG-IN TEST WELL S-5

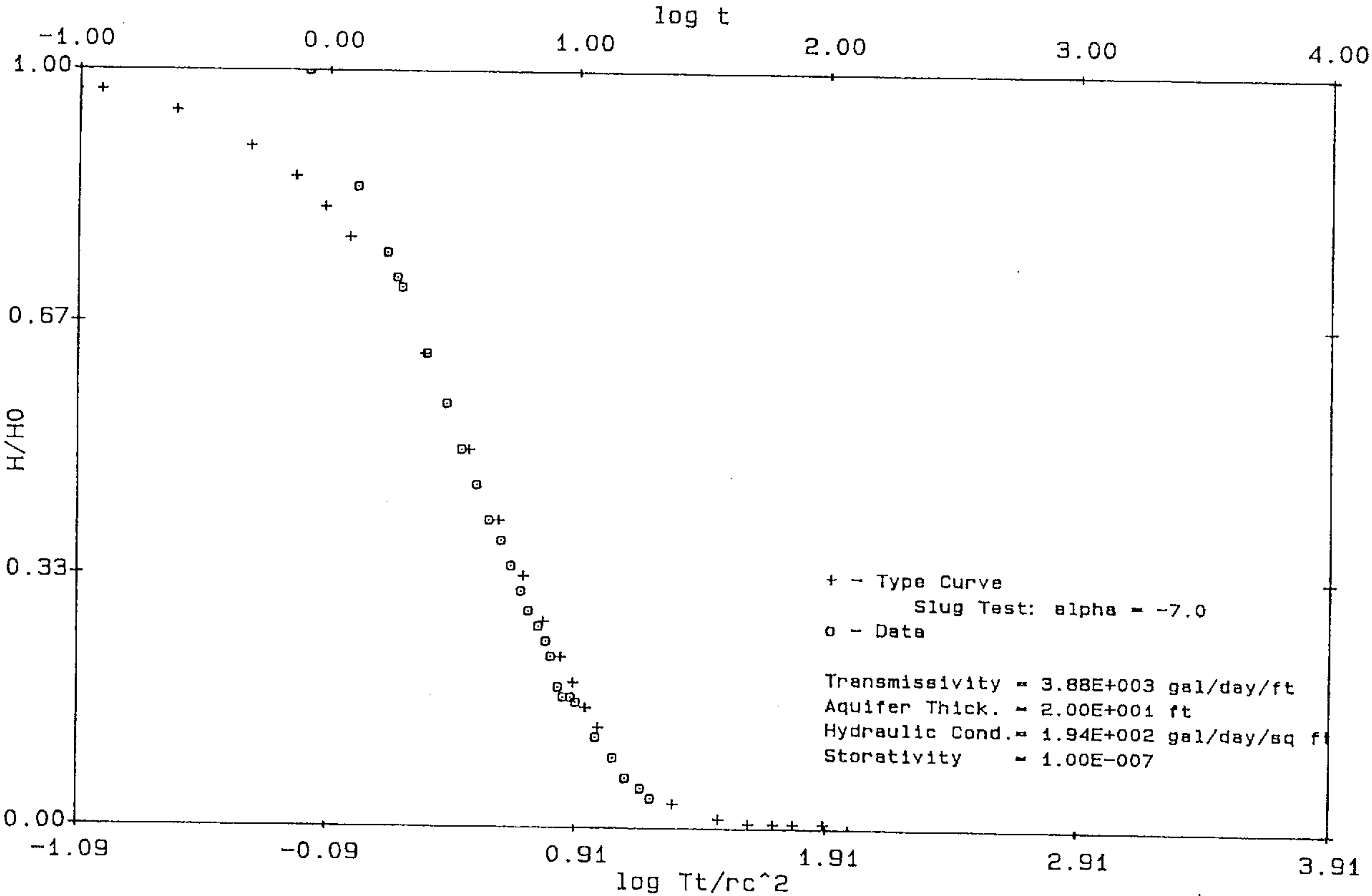


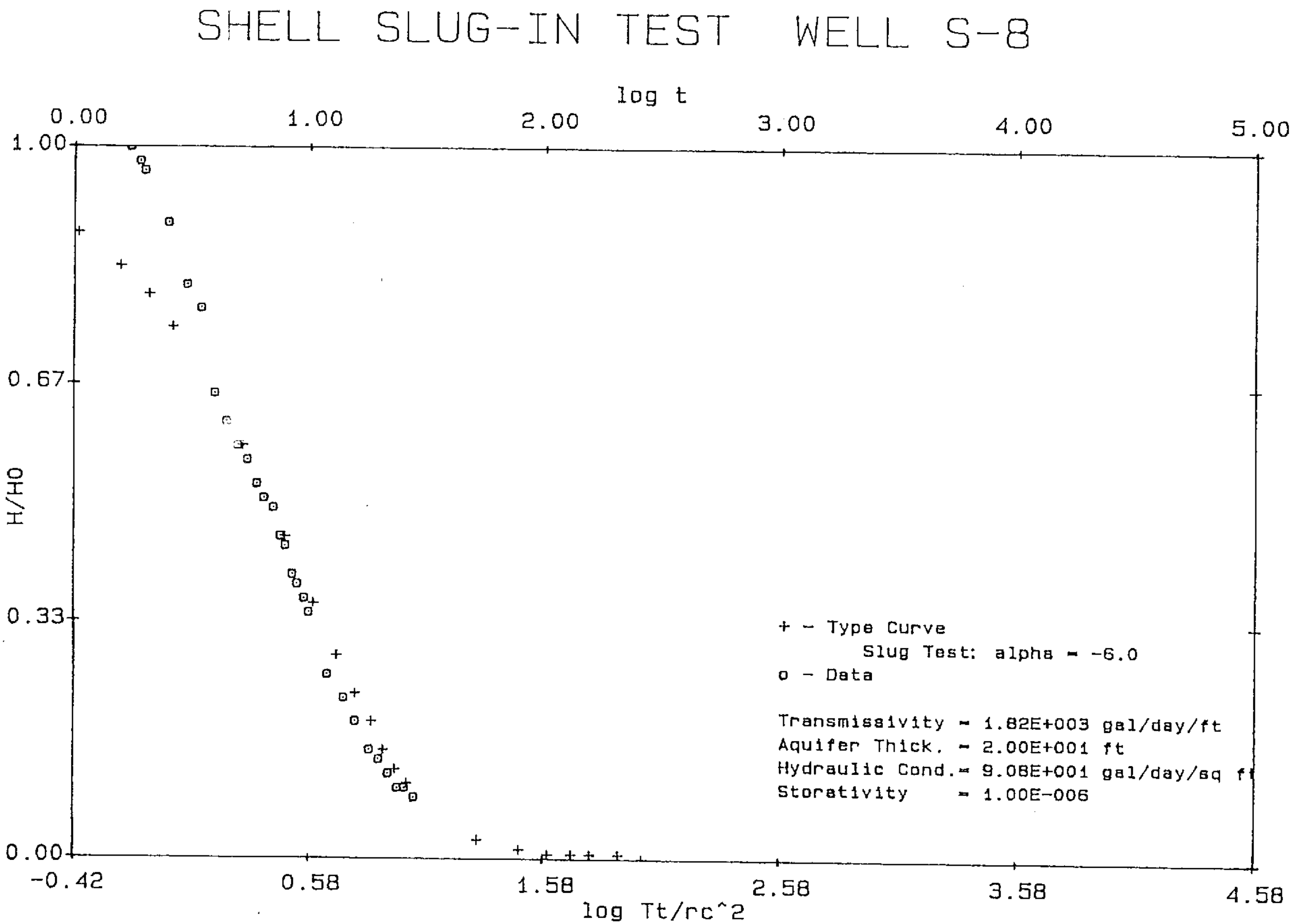

SHELL SLUG-OUT TEST WELL S-5
log t
0.00
1.00
2.00
3.00
4.00
5.00
1.00
0.67
0.33
0.00
H/HO
-0.59
0.41
1.41
2.41
3.41
4.41
log Tt/rc^2
+ - Type Curve
Slug Test: alpha = -7.0
o - Data
Transmissivity = 1.23E+003 gal/day/ft
Aquifer Thick. = 2.00E+001 ft
Hydraulic Cond.= 6.14E+001 gal/day/sq ft
Storativity = 1.00E-007

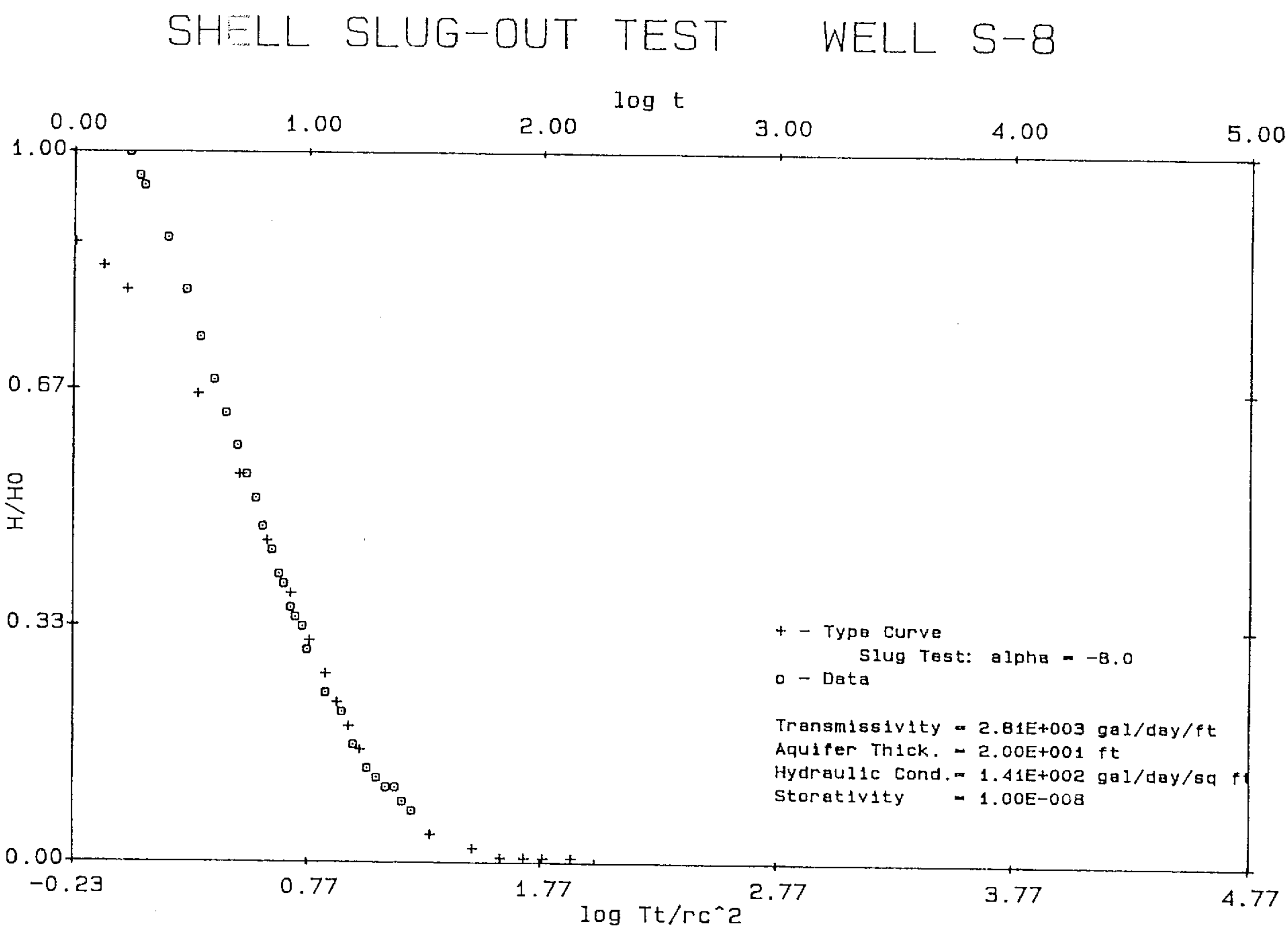
SHELL SLUG-IN TEST WELL S-7



SHELL SLUG-OUT TEST WELL S-7

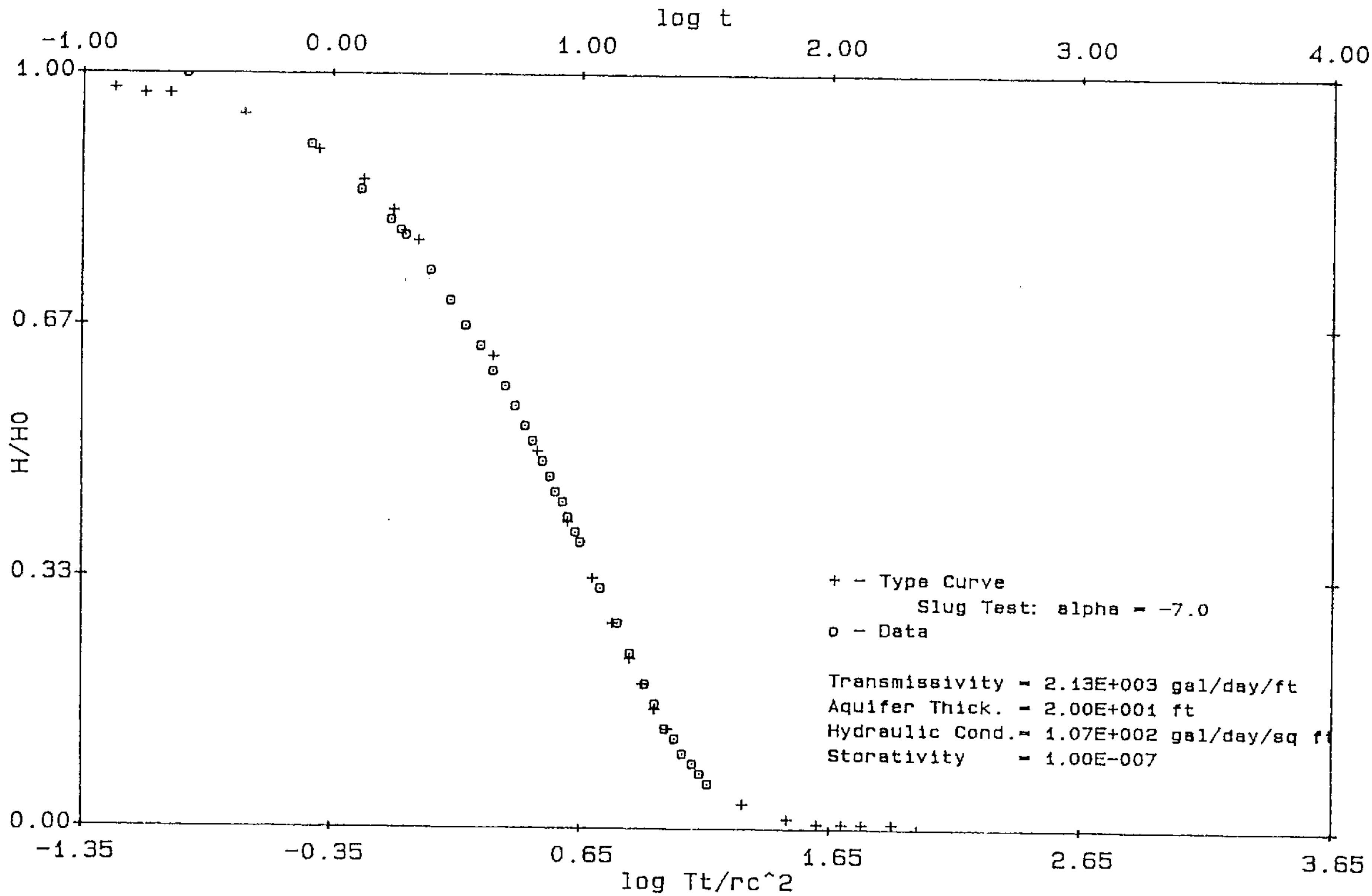



SHELL SLUG-IN TEST WELL S-8
log t
0.00
1.00
2.00
3.00
4.00
5.00
1.00
0.67
0.33
0.00
H/HO
-0.42
0.58
1.58
2.58
3.58
4.58
log Tt/rc^2
+ - Type Curve
Slug Test: alpha = -6.0
o - Data
Transmissivity = 1.82E+003 gal/day/ft
Aquifer Thick. = 2.00E+001 ft
Hydraulic Cond.= 9.08E+001 gal/day/sq ft
Storativity = 1.00E-006

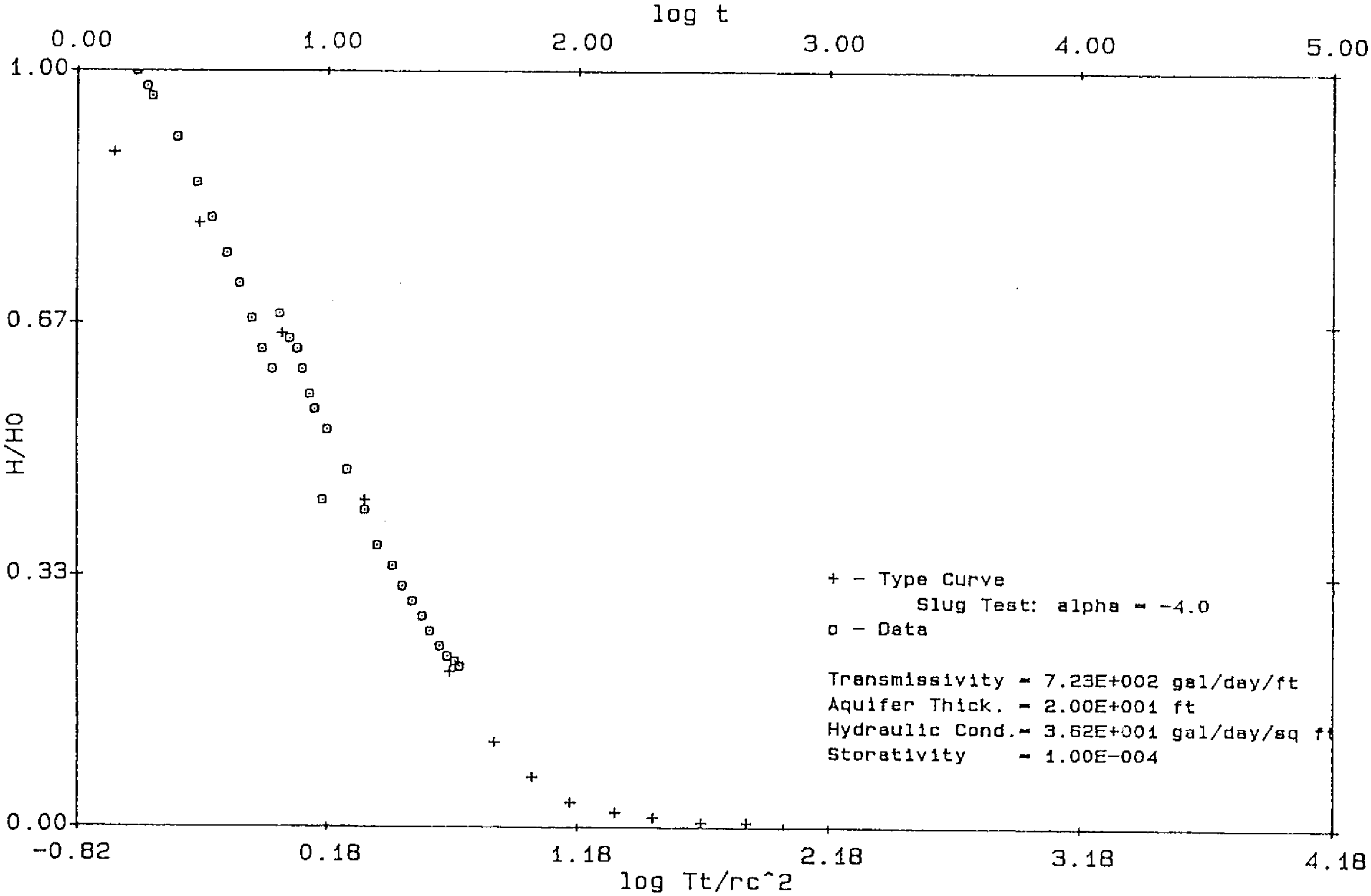


SHELL SLUG-OUT TEST WELL S-8
log t
0.00
1.00
2.00
3.00
4.00
5.00
1.00
0.67
0.33
0.00
H/HO
-0.23
0.77
1.77
2.77
3.77
4.77
log Tt/rc^2
+ - Type Curve
Slug Test: alpha = -8.0
o - Data
Transmissivity = 2.81E+003 gal/day/ft
Aquifer Thick. = 2.00E+001 ft
Hydraulic Cond.= 1.41E+002 gal/day/sq ft
Storativity = 1.00E-008

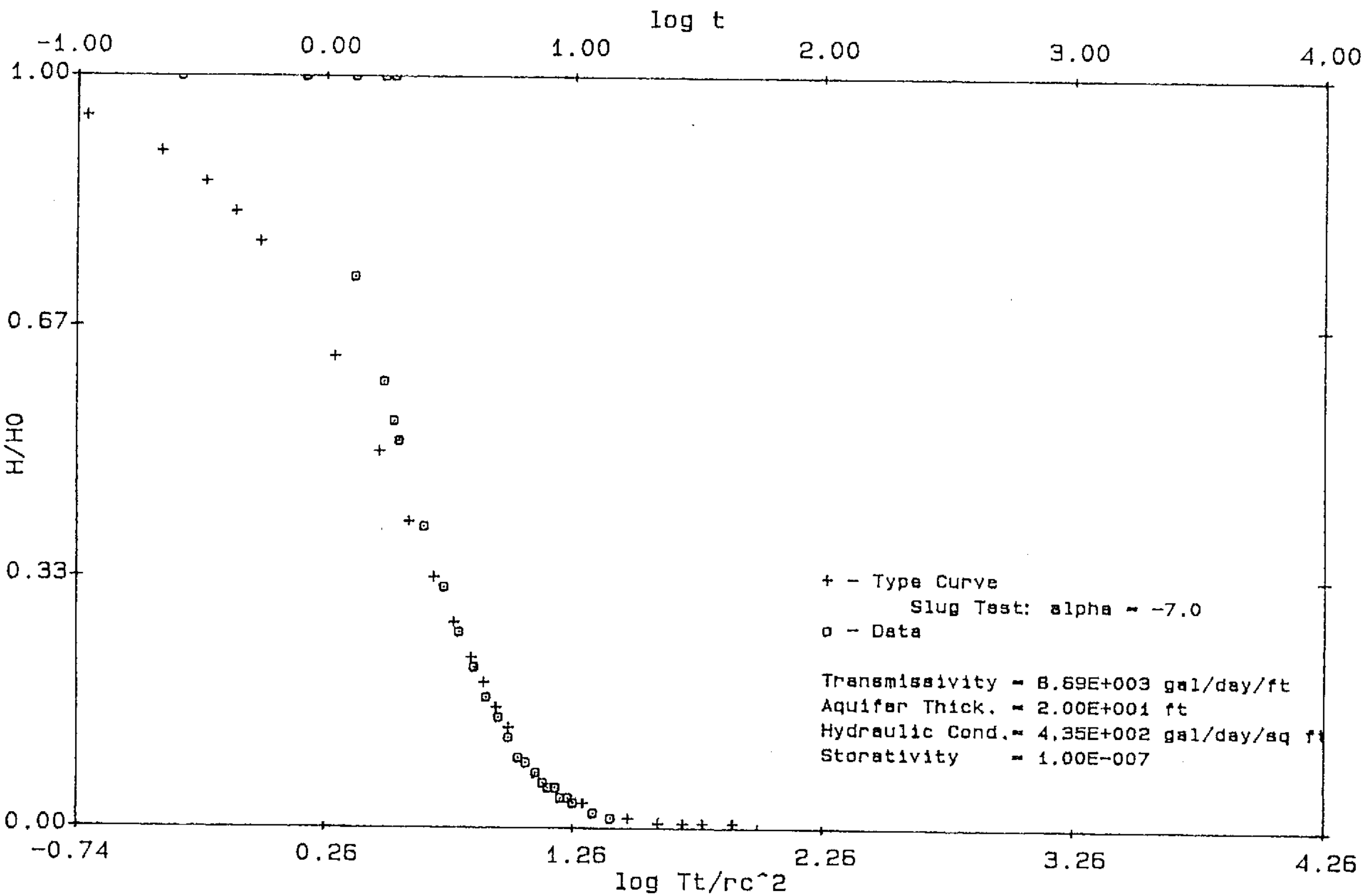
SHELL SLUG-IN TEST WELL S-9

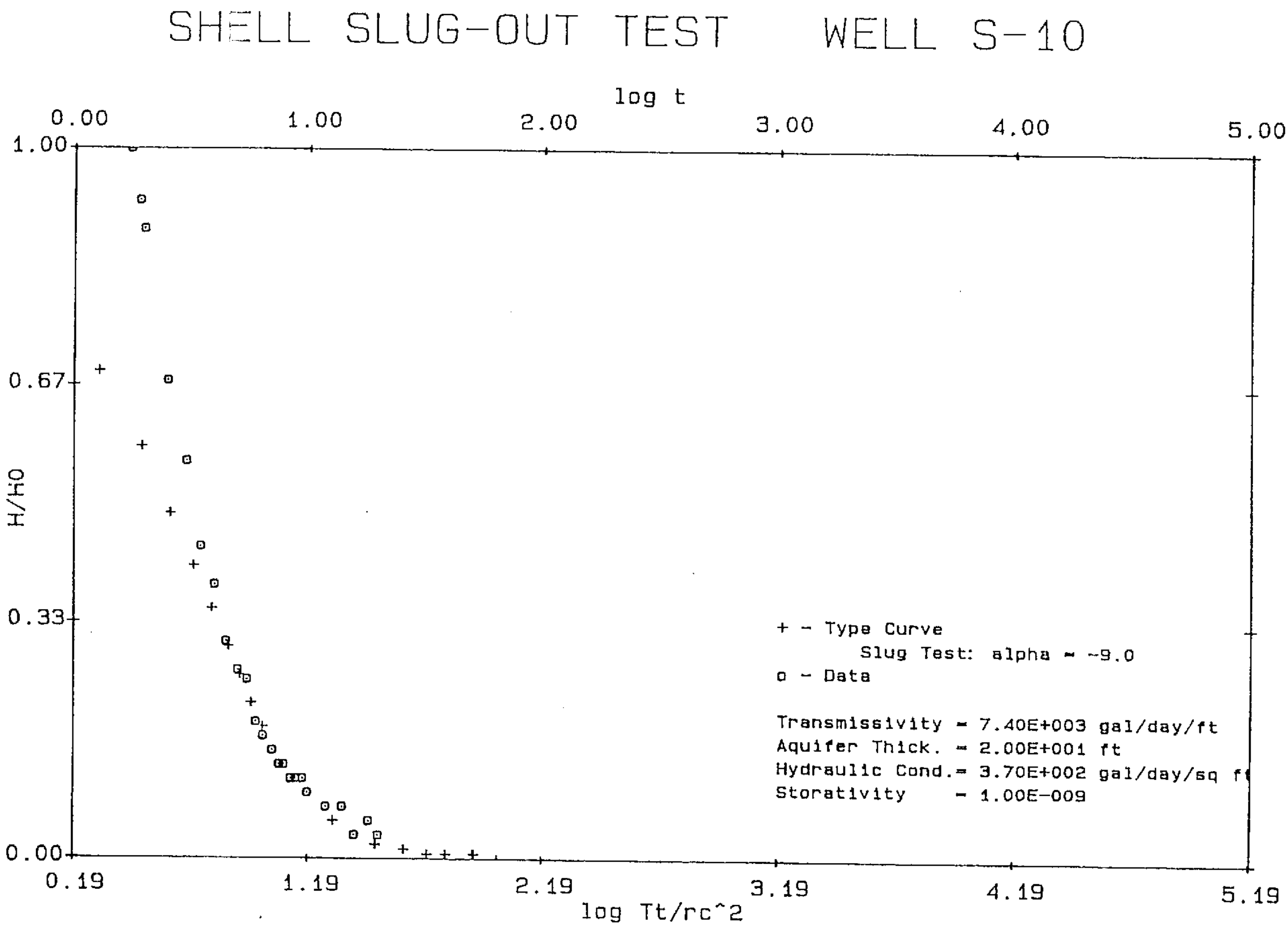


SHELL SLUG-OUT TEST WELL S-9

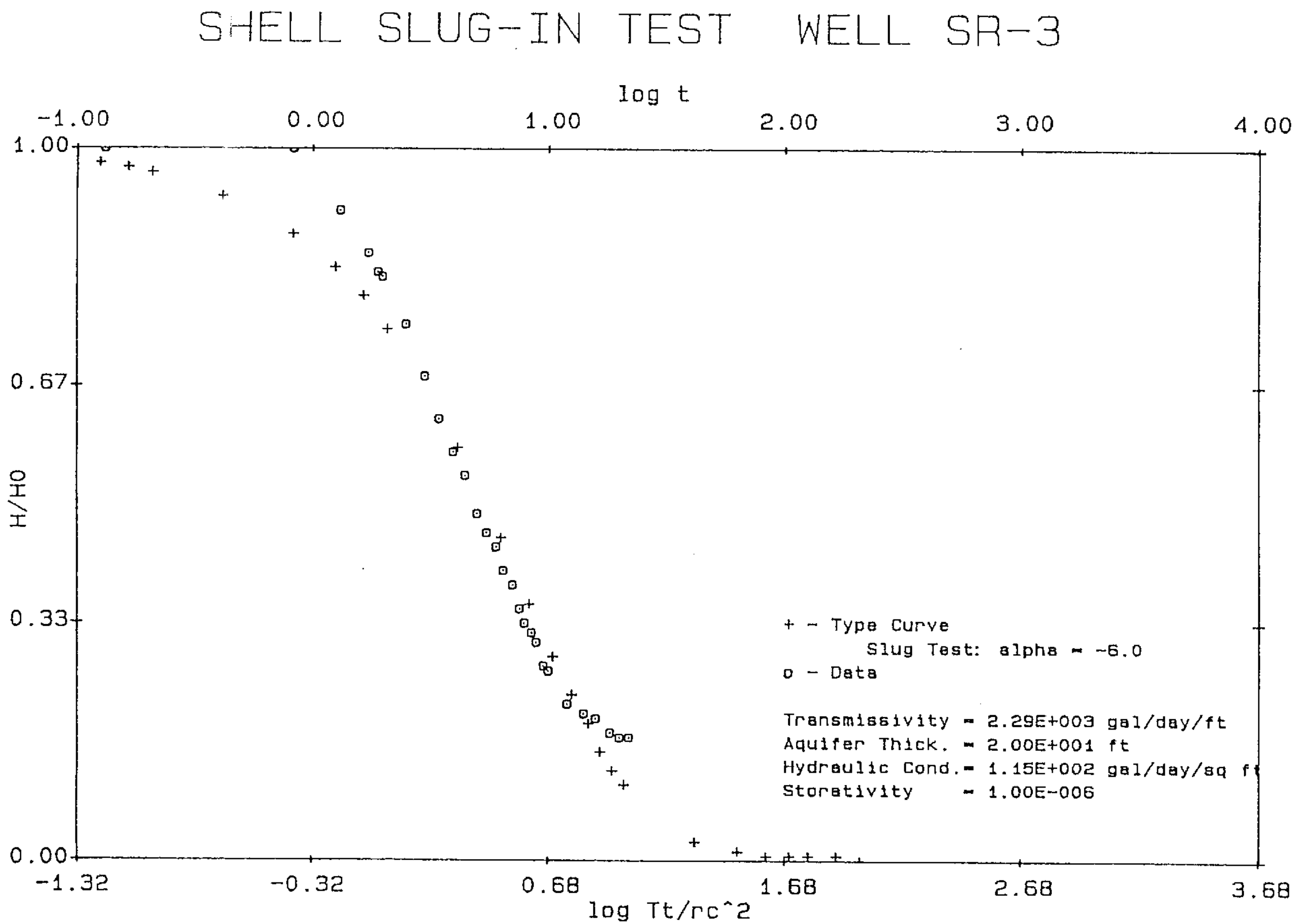


SHELL SLUG-IN TEST WELL S-10

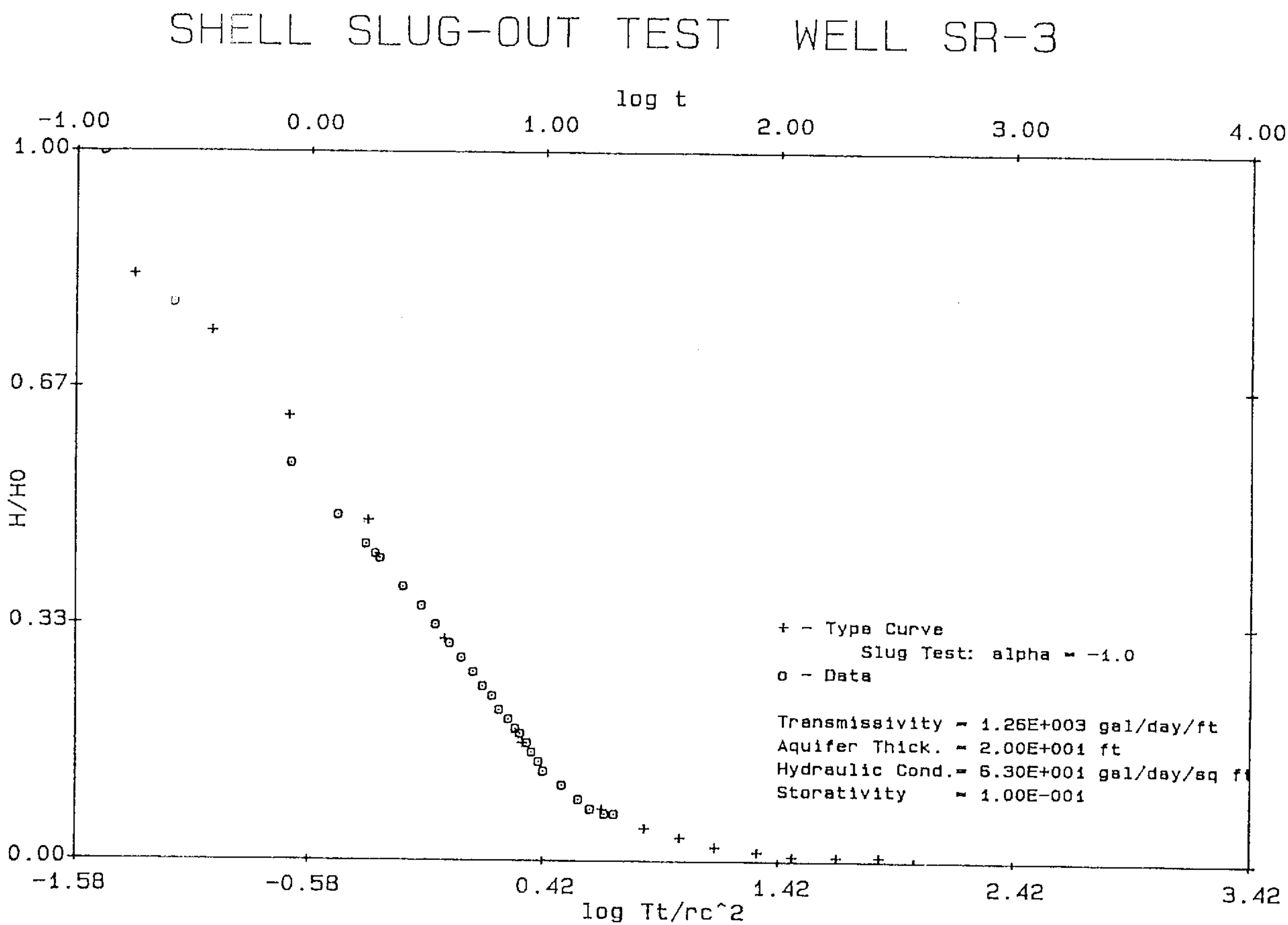




SHELL SLUG-OUT TEST WELL S-10
log t
0.00
1.00
2.00
3.00
4.00
5.00
1.00
0.67
0.33
0.00
H/HO
0.19
1.19
2.19
3.19
4.19
5.19
log Tt/rc^2
+ - Type Curve
Slug Test: alpha = -9.0
o - Data
Transmissivity = 7.40E+003 gal/day/ft
Aquifer Thick. = 2.00E+001 ft
Hydraulic Cond.= 3.70E+002 gal/day/sq ft
Storativity = 1.00E-009



SHELL SLUG-IN TEST WELL SR-3
log t
-1.00
0.00
1.00
2.00
3.00
4.00
1.00
0.67
0.33
0.00
H/HO
-1.32
-0.32
0.68
1.68
2.68
3.68
log Tt/rc^2
+ - Type Curve
Slug Test: alpha = -6.0
o - Data
Transmissivity = 2.29E+003 gal/day/ft
Aquifer Thick. = 2.00E+001 ft
Hydraulic Cond.= 1.15E+002 gal/day/sq ft
Storativity = 1.00E-006


SHELL SLUG-OUT TEST WELL SR-3
log t
-1.00
0.00
1.00
2.00
3.00
4.00
1.00
0.67
0.33
0.00
H/HO
-1.58
-0.58
0.42
1.42
2.42
3.42
log Tt/rc^2
+ - Type Curve
Slug Test: alpha = -1.0
o - Data
Transmissivity = 1.26E+003 gal/day/ft
Aquifer Thick. = 2.00E+001 ft
Hydraulic Cond.= 6.30E+001 gal/day/sq ft
Storativity = 1.00E-001

GeoStrategies Inc.

APPENDIX G
G-R GROUNDWATER SAMPLING REPORT
(MARCH, 1990)

gettler — ryan inc.

March 27, 1990

GROUNDWATER SAMPLING REPORT

Referenced Site: Shell Service Station
3790 Hopyard Road/Las Positas Boulevard
Pleasanton, California

Sampling Date: March 5 & 6, 1990

This report presents the results of the quarterly groundwater sampling and analytical program conducted by Gettler-Ryan Inc. on March 5 and 6, 1990 at the referenced location. The site is occupied by an operating service station located on the southwest corner of Hopyard Road and Los Positas Boulevard. The service station has underground storage tanks containing regular leaded, unleaded and super unleaded gasoline products and waste oil.

There are currently four groundwater monitoring wells on site, five off site, and three recovery wells at the locations shown on the attached site map. Prior to sampling, the wells were inspected for total well depth, water levels, and presence of separate phase product using an electronic interface probe. A clean acrylic bailer was used to visually detect the presence of separate phase product. Groundwater depths ranged from 12.51 to 17.56 feet below grade. Separate phase product was not observed in any of the monitoring wells.

The wells were then purged and sampled. The purge water was contained in drums for proper disposal. Standard sampling procedure calls for a minimum of four case volumes to be purged from each well. Each well was purged while pH, temperature, and conductivity measurements were monitored for stability. Details of the final well purging results are presented on the attached Table of Monitoring Data. In cases where a well dewatered or less than four case volumes were purged, groundwater samples were obtained after the physical parameters had stabilized. Under such circumstances the sample may not represent actual formation water due to low flow conditions.

Samples were collected, using Teflon bailers or bladder pumps, in properly cleaned and laboratory prepared containers. All sampling equipment was thoroughly cleaned after each well was sampled and steam cleaned upon completion of work at the site. The samples were labeled, stored on blue ice, and transported to the laboratory for analysis. A field blank (SF-8) and a trip blank, supplied by the laboratory, were included and analyzed to assess quality control. A duplicate sample (SD-2), was submitted without well designation, to assess laboratory performance. Analytical results for the blanks are included in the Certified Analytical Report (CAR's). Chain of custody records were established noting sample identification numbers, time, date, and custody signatures.

1992 national avenue • hayward, california 94545-1787 • (415) 783-7500

The samples were analyzed at International Technology Corporation - Santa Clara Valley Laboratory located at 2055 Junction Avenue, San Jose, California. The laboratory is assigned a California DHS-HMTL Certification number of 137. The results are presented as a Certified Analytical Report, a copy of which is attached to this report.

Tom Paulson
Sampling Manager

attachments

TABLE OF MONITORING DATA
GROUNDWATER WELL SAMPLING REPORT

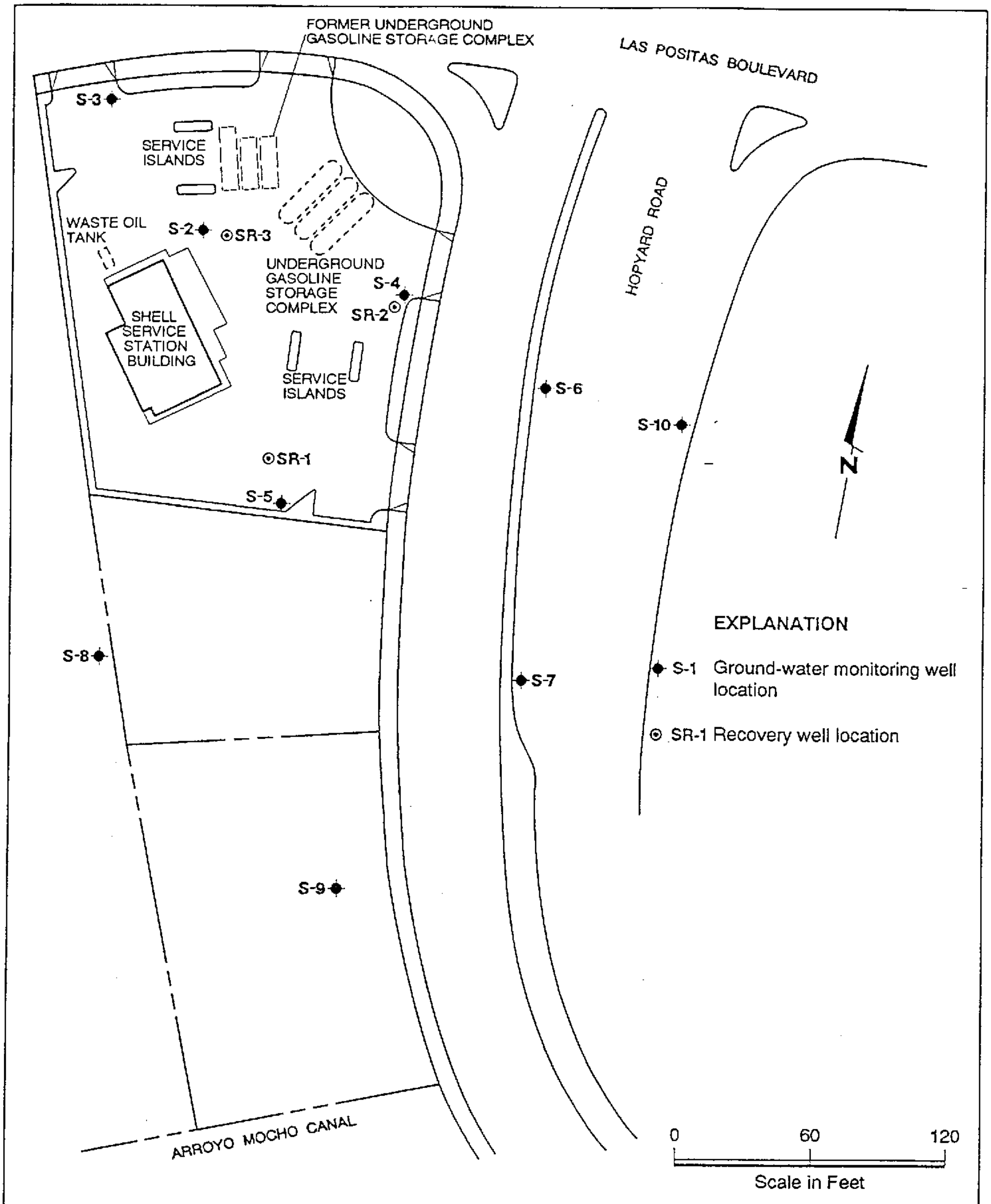
WELL I.D.	S-2 SD-2 3-05-90	S-3 3-05-90	S-4 3-05-90	S-5 3-05-90	S-6 3-06-90	S-7 3-06-90
Casing Diameter (inches)	3	3	3	3	3	3
Total Well Depth (feet)	33.8	34.6	35.6	34.3	34.2	34.9
Depth to Water (feet)	14.45	12.51	14.31	15.81	14.63	17.02
Free Product (feet)	none	none	none	none	none	none
Reason Not Sampled	----	----	----	----	----	----
Calculated 4 Case Vol.(gal.)	29.6	33.6	32.0	28.0	29.6	27.2
Did Well Dewater?	yes	no	yes	no	no	no
Volume Evacuated (gal.)	25	42	17	35	37	34.5
Purging Device	Suction	Suction	Suction	Bailer	Bladder	Bladder
Sampling Device	Bailer	Bailer	Bailer	Bailer	Bladder	Bladder
Time	16:09	15:33	15:55	12:14	10:48	09:48
Temperature (F)*	67.9	68.1	67.1	62.3	66.7	64.7
pH*	6.63	6.67	6.66	6.68	6.70	6.58
Conductivity (umhos/cm)*	4320	4240	4120	1906	2500	4070

* Indicates Stabilized Value

TABLE OF MONITORING DATA
GROUNDWATER WELL SAMPLING REPORT

WELL I.D.	S-8	S-9	S-10	SR-1	SR-2	SR-3
	3-05-90	3-06-90	3-06-90	3-05-90	3-05-90	3-05-90
Casing Diameter (inches)	3	3	3	4	4	4
Total Well Depth (feet)	33.5	34.8	34.4	35.2	35.2	35.0
Depth to Water (feet)	14.56	17.56	14.17	16.08	14.30	14.34
Free Product (feet)	none	none	none	none	none	none
Reason Not Sampled	----	----	----	----	----	----
Calculated 4 Case Vol.(gal.)	28.8	26.1	30.7	100.8	110.4	108.8
Did Well Dewater?	no	no	no	yes	yes	no
Volume Evacuated (gal.)	36.3	33.0	38.5	31.0	44.2	136.0
Purging Device	Bladder	Bladder	Bladder	Suction	Suction	Suction
Sampling Device	Bladder	Bladder	Bladder	Bailer	Bailer	Bailer
Time	14:48	08:30	12:02	16:22	15:48	12:55
Temperature (F)*	66.0	66.2	66.3	66.1	67.0	68.1
pH*	6.60	6.70	6.65	6.68	6.66	6.56
Conductivity (umhos/cm)*	4940	3970	2230	4700	4010	4400

* Indicates Stabilized Value



GSI GeoStrategies Inc.

Site Plan
Shell Service Station
3790 Hopyard Road
Pleasanton, California

PLATE

JOB NUMBER	REVIEWED BY RG/CEG	DATE	REVISED DATE	REVISED DATE
632				

INTERNATIONAL TECHNOLOGY CORPORATION

ANALYTICAL SERVICES

CERTIFICATE OF ANALYSIS

Shell Oil Company
Gettler-Ryan
2150 West Winton
Hayward, CA 94545
Tom Paulson

Date: 03/23/90

Work Order: T0-03-063

P.O. Number: MOH 880-021

This is the Certificate of Analysis for the following samples:

Client Work ID: GR3632,3790 Hopyard,Pleasantn
Date Received: 03/06/90
Number of Samples: 11
Sample Type: water

TABLE OF CONTENTS FOR ANALYTICAL RESULTS

Reviewed and Approved:

Michael Dean
Project Manager

Company: Shell Oil Company
Date: 03/23/90
Client Work ID: GR3632,3790 Hopyard,Pleasantn

IT ANALYTICAL SERVICES
SAN JOSE, CA

Work Order: T0-03-063

TEST NAME: **TPH Gas & BTEX**

SAMPLE ID: **S-2**
SAMPLE DATE: **03/05/90**
LAB SAMPLE ID: **T003063-01**
SAMPLE MATRIX: **aqueous**
RECEIPT CONDITION: **Cool pH < 2**
ANALYSIS DATE: **03/07/90**

RESULTS in Milligrams per Liter:

PARAMETER	DETECTION LIMIT	DETECTED
Low Boiling Hydrocarbons, calculated as Gasoline	0.050	**0.71**
Benzene	0.0005	**0.057**
Toluene	0.0005	**None**
Ethylbenzene	0.0005	**None**
Xylenes (total)	0.001	**0.088**

TEST NAME: **TPH Gas & BTEX**

SAMPLE ID: **S-3**
SAMPLE DATE: **03/05/90**
LAB SAMPLE ID: **T003063-02**
SAMPLE MATRIX: **aqueous**
RECEIPT CONDITION: **Cool pH < 2**
ANALYSIS DATE: **03/07/90**

RESULTS in Milligrams per Liter:

PARAMETER	DETECTION LIMIT	DETECTED
Low Boiling Hydrocarbons, calculated as Gasoline	0.050	**None**
Benzene	0.0005	**None**
Toluene	0.0005	**None**
Ethylbenzene	0.0005	**None**
Xylenes (total)	0.001	**None**

Company: Shell Oil Company
Date: 03/23/90
Client Work ID: GR3632,3790 Hopyard,Pleasantn

IT ANALYTICAL SERVICES
SAN JOSE, CA

Work Order: T0-03-063

TEST NAME: **TPH Gas & BTEX**

SAMPLE ID: **S-4**
SAMPLE DATE: **03/05/90**
LAB SAMPLE ID: T003063-03
SAMPLE MATRIX: aqueous
RECEIPT CONDITION: Cool pH < 2
ANALYSIS DATE: 03/07/90

RESULTS in Milligrams per Liter:

PARAMETER	DETECTION LIMIT	DETECTED
Low Boiling Hydrocarbons, calculated as Gasoline	0.050	0.35
Benzene	0.0005	0.043
Toluene	0.0005	None
Ethylbenzene	0.0005	0.024
Xylenes (total)	0.001	0.047

TEST NAME: **TPH Gas & BTEX**

SAMPLE ID: **S-5**
SAMPLE DATE: **03/05/90**
LAB SAMPLE ID: T003063-04
SAMPLE MATRIX: aqueous
RECEIPT CONDITION: Cool pH < 2
ANALYSIS DATE: 03/07/90

RESULTS in Milligrams per Liter:

PARAMETER	DETECTION LIMIT	DETECTED
Low Boiling Hydrocarbons, calculated as Gasoline	0.050	1.1
Benzene	0.0005	0.10
Toluene	0.0005	0.11
Ethylbenzene	0.0005	0.079
Xylenes (total)	0.001	0.24

IT ANALYTICAL SERVICES
SAN JOSE, CA

Company: Shell Oil Company
Date: 03/23/90
Client Work ID: GR3632,3790 Hopyard,Pleasantn

Work Order: T0-03-063

TEST NAME: **TPH Gas & BTEX**

SAMPLE ID: **S-8**
SAMPLE DATE: **03/05/90**
LAB SAMPLE ID: **T003063-05**
SAMPLE MATRIX: **aqueous**
RECEIPT CONDITION: **Cool pH < 2**
ANALYSIS DATE: **03/14/90**

RESULTS in Milligrams per Liter:

PARAMETER	DETECTION LIMIT	DETECTED
Low Boiling Hydrocarbons, calculated as Gasoline	0.050	**None**
Benzene	0.0005	**None**
Toluene	0.0005	**0.0005**
Ethylbenzene	0.0005	**None**
Xylenes (total)	0.001	**None**

TEST NAME: **TPH Gas & BTEX**

SAMPLE ID: **SR-1**
SAMPLE DATE: **03/05/90**
LAB SAMPLE ID: **T003063-06**
SAMPLE MATRIX: **aqueous**
RECEIPT CONDITION: **Cool pH < 2**
ANALYSIS DATE: **03/08/90**

RESULTS in Milligrams per Liter:

PARAMETER	DETECTION LIMIT	DETECTED
Low Boiling Hydrocarbons, calculated as Gasoline	0.050	**0.064**
Benzene	0.0005	**0.020**
Toluene	0.0005	**None**
Ethylbenzene	0.0005	**0.0015**
Xylenes (total)	0.001	**0.004**

IT ANALYTICAL SERVICES
SAN JOSE, CA

Company: Shell Oil Company
Date: 03/23/90
Client Work ID: **GR3632,3790 Hopyard,Pleasantn**

Work Order: T0-03-063

TEST NAME: **TPH Gas & BTEX**

SAMPLE ID: **SR-2**
SAMPLE DATE: **03/05/90**
LAB SAMPLE ID: **T003063-07**
SAMPLE MATRIX: **aqueous**
RECEIPT CONDITION: **Cool pH < 2**
ANALYSIS DATE: **03/07/90**

RESULTS in Milligrams per Liter:

PARAMETER	DETECTION LIMIT	DETECTED
Low Boiling Hydrocarbons, calculated as Gasoline	0.050	**0.14**
Benzene	0.0005	**0.0030**
Toluene	0.0005	**None**
Ethylbenzene	0.0005	**0.012**
Xylenes (total)	0.001	**0.007**

TEST NAME: **TPH Gas & BTEX**

SAMPLE ID: **SR-3**
SAMPLE DATE: **03/05/90**
LAB SAMPLE ID: **T003063-08**
SAMPLE MATRIX: **aqueous**
RECEIPT CONDITION: **Cool pH < 2**
ANALYSIS DATE: **03/07/90**

RESULTS in Milligrams per Liter:

PARAMETER	DETECTION LIMIT	DETECTED
Low Boiling Hydrocarbons, calculated as Gasoline	0.050	**0.070**
Benzene	0.0005	**0.015**
Toluene	0.0005	**0.0008**
Ethylbenzene	0.0005	**0.0058**
Xylenes (total)	0.001	**0.010**

IT ANALYTICAL SERVICES
SAN JOSE, CA

Company: Shell Oil Company
Date: 03/23/90
Client Work ID: GR3632,3790 Hopyard,Pleasantn

Work Order: T0-03-063

TEST NAME: **TPH Gas & BTEX**

SAMPLE ID: **SD-2**
SAMPLE DATE: **03/05/90**
LAB SAMPLE ID: **T003063-09**
SAMPLE MATRIX: **aqueous**
RECEIPT CONDITION: **Cool pH < 2**
ANALYSIS DATE: **03/08/90**

RESULTS in Milligrams per Liter:

PARAMETER	DETECTION LIMIT	DETECTED
Low Boiling Hydrocarbons, calculated as Gasoline	0.050	**0.38**
Benzene	0.0005	**0.022**
Toluene	0.0005	**0.0012**
Ethylbenzene	0.0005	**None**
Xylenes (total)	0.001	**0.044**

TEST NAME: **TPH Gas & BTEX**

SAMPLE ID: **SF-8**
SAMPLE DATE: **03/05/90**
LAB SAMPLE ID: **T003063-10**
SAMPLE MATRIX: **aqueous**
RECEIPT CONDITION: **Cool pH < 2**
ANALYSIS DATE: **03/08/90**

RESULTS in Milligrams per Liter:

PARAMETER	DETECTION LIMIT	DETECTED
Low Boiling Hydrocarbons, calculated as Gasoline	0.050	**None**
Benzene	0.0005	**None**
Toluene	0.0005	**None**
Ethylbenzene	0.0005	**None**
Xylenes (total)	0.001	**None**

IT ANALYTICAL SERVICES
SAN JOSE, CA

Company: Shell Oil Company
Date: 03/23/90
Client Work ID: GR3632,3790 Hopyard,Pleasantn

Work Order: T0-03-063

TEST NAME: **TPH Gas & BTEX**

SAMPLE ID: **Trip Blank**
SAMPLE DATE: **not spec**
LAB SAMPLE ID: **T003063-11**
SAMPLE MATRIX: **aqueous**
RECEIPT CONDITION: **Cool pH < 2**
ANALYSIS DATE: **03/08/90**

RESULTS in Milligrams per Liter:

PARAMETER	DETECTION LIMIT	DETECTED
Low Boiling Hydrocarbons, calculated as Gasoline	0.050	**None**
Benzene	0.0005	**None**
Toluene	0.0005	**None**
Ethylbenzene	0.0005	**None**
Xylenes (total)	0.001	**None**

Company: Shell Oil Company
Date: 03/23/90
Client Work ID: GR3632,3790 Hopyard,Pleasantn **Work Order: T0-03-063**

TEST CODE **TPHV_W** TEST NAME **TPH Gas & BTEX**

The method of analysis for low boiling hydrocarbons is taken from EPA Methods 8015, 8020 and 5030. The sample is examined using the purge and trap technique. Final detection is by gas chromatography using a flame ionization detector as well as a photoionization detector. The result for total low boiling hydrocarbons is calculated as gasoline and includes benzene, toluene, ethylbenzene and xylenes.

INTERNATIONAL TECHNOLOGY CORPORATION

ANALYTICAL SERVICES

CERTIFICATE OF ANALYSIS

Gettler-Ryan
2150 West Winton
Hayward, CA 94545
ATTN: Tom Paulson

Date: March 21, 1990

Work Order Number: TO-03-057

P.O. Number: MOH 890501A

This is the Certificate of Analysis for the following samples:

Client Project ID:	GR #3632, Shell, 3790 Hopyard, Pleasanton, CA
Date Received by Lab:	03/06/90
Number of Samples:	6
Sample Type:	Water

The method of analysis for low boiling hydrocarbons is taken from EPA Methods 8015, 8020 and 5030. The sample is examined using the purge and trap technique. Final detection is by gas chromatography using a flame ionization detector as well as a photoionization detector. The result for total low boiling hydrocarbons is calculated as gasoline and includes benzene, toluene, ethyl benzene and xylenes.

Reviewed and Approved

Suzanne Veaudry
Project Manager

SV/tw
1 Page Following - Table of Results

Date: March 21, 1990

Client Project ID: GR #3632, Shell, 3790 Hopyard, Pleasanton, CA

Work Order Number: TO-03-057

IT ANALYTICAL SERVICES
SAN JOSE, CA

Lab Sample ID	Client Sample ID	Sample Date	Date Analysis Completed	Sample Condition on Receipt
TO-03-057-01	S-6	03/06/90	03/13/90	Cool,pH<2
TO-03-057-02	S-7	03/06/90	03/09/90	Cool,pH<2
TO-03-057-03	S-9	03/06/90	03/13/90	Cool,pH<2
TO-03-057-04	S-10	03/06/90	03/13/90	Cool,pH<2
TO-03-057-05	SF-6	03/06/90	03/13/90	Cool,pH<2
TO-03-057-06	Trip Blank	----	03/13/90	Cool,pH<2

Total Petroleum Hydrocarbons - Modified E.P.A. Methods 8015, 8020

ND = None Detected

Results - Milligrams per Liter

Lab Sample ID	Client Sample ID	Low Boiling Hydrocarbons (calculated as Gasoline)	Benzene	Toluene	Ethyl Benzene	Xylenes (total)
TO-03-057-01	S-6	0.42	0.0031	ND	0.014	ND
TO-03-057-02	S-7	ND	ND	ND	ND	ND
TO-03-057-03	S-9	ND	ND	ND	ND	ND
TO-03-057-04	S-10	ND	ND	ND	ND	ND
TO-03-057-05	SF-6	ND	ND	ND	ND	ND
TO-03-057-06	Trip Blank	ND	ND	ND	ND	ND
Detection Limit		0.050	0.0005	0.0005	0.0005	0.001

Gettler - Ryan Inc. (T0·03·063 ENVIRONMENTAL DIVISION (0597 **Chain of Custody**

COMPANY Shell Oil Co. JOB NO.

JOB LOCATION 3790 Hopyard / Las Positas.

CITY Pleasonton, CA PHONE NO. 783-7500

AUTHORIZED John Werfal / Tom Paulson DATE 3/5/90 P.O. NO. 3632

SAMPLE ID	NO. OF CONTAINERS	SAMPLE MATRIX	DATE/TIME SAMPLED	ANALYSIS REQUIRED	SAMPLE CONDITION LAB ID
S-2	3	liquid	3/5/90 / 16:09	THC(gas) BTXE	OK/Cool
S-3	↓	↓	/ 15:33	↓	↓
S-4			/ 15:55		
* S-5			/ 12:20		
* S-8			/ 14:50		
SR-1			/ 16:22		
SR-2			/ 15:48		
SR-3			/ 12:55		
SD-2			/ —		
* SF-8	↓		↓ / —		
* Trip Blank	1	↓	3/2/90	↓	↓

RELINQUISHED BY: John P. Zwerzyk 3/6/90 7:15 am

RECEIVED BY: [signature] 3/6/90 07:16am

RELINQUISHED BY: [signature] 3/6/90 16:35

RECEIVED BY:

RELINQUISHED BY:

RECEIVED BY LAB: Josephine DeCarli 3/6/90 16:35

DESIGNATED LABORATORY: IT (SCV) DHS #: 137

REMARKS: Normal TAT on S-5, S8 SF-8

* are preserved with HCl, all others are not!!

DATE COMPLETED 3/5/90 FOREMAN

Gettler - Ryan Inc. (TO-03-057 (ENVIRONMENTAL DIVISION 1199 **Chain of Custody**

COMPANY: Shell Oil Company JOB NO.:

JOB LOCATION: 3790 Hopyard Rd / Las Positas

CITY: Pleasanton, CA PHONE NO. (415) 783-7500

AUTHORIZED: John Werfal DATE: 3/6/90 P.O. NO. 3632

SAMPLE ID	NO. OF CONTAINERS	SAMPLE MATRIX	DATE/TIME SAMPLED	ANALYSIS REQUIRED	SAMPLE CONDITION LAB ID
S-6	3	Liquid	3/6/90 / 10:48	TPH (gas) BTXE	OK / Cool
S-7	↓	↓	↓ / 9:48	↓	↓
S-9	↓	↓	↓ / 8:30	↓	↓
S-10	↓	↓	↓ / 12:02	↓	↓
SF-6	↓	↓	↓ / 10:48	↓	↓
trip blank	1	↓	↓ / –	↓	↓

RELINQUISHED BY: Guadalupe Sanchez 3/6/90 13:40

RECEIVED BY:

RELINQUISHED BY:

RECEIVED BY:

RELINQUISHED BY:

RECEIVED BY LAB: [signature] 3-6-90 1340

DESIGNATED LABORATORY: IT/SCV DHS #: 137

REMARKS: WIC # 204-6138-0501

AFE # 986624

Normal TAT

EXP. CODE 5440

ENG. Diane Lundquist

DATE COMPLETED: 3/6/90 FOREMAN: Guadalupe Sanchez

APPENDIX H

BENZENE TRANSPORT MODEL DOCUMENTATION

SIMULATION OF BENZENE TRANSPORT

(July 1987)

M. W. Kemblowski, A. J. Stabenau

Shell Development Company
Westhollow Research Center

Assumptions

Although the groundwater flow field is not truly uniform, and the streamlines show mild curvature, it was assumed that the flow system can be approximated assuming a uniform velocity distribution (Figure 1). This assumption may result in small discrepancies between the actual and predicted concentration distributions. The pore-water velocity q was estimated as follows:

$$q = k \cdot i/n$$

where:

k = hydraulic conductivity. Variable head tests performed at the site provided the following values:

Well No.	k [gpd/ft^2]	k [ft/d]
S-1	32.1	4.3
S-4	83.3	11.2
S-6	41.6	5.6

For modeling purposes it was assumed that k = 10 ft/day. It is a conservative assumption, since the chosen value is close to the upper range of hydraulic conductivity, and therefore produces higher pore-water velocities, which in turn results in a higher source mass flux calculated by the model.

i = hydraulic gradient, estimated to be i = 0.007 (Figure 1).

n = porosity, estimated to be n = 0.4, which is typical for the type of soils that underlie the service station.

Using these parameters, the pore-water velocity is estimated as q = .175 ft/day.

Source strength and location. The following benzene concentrations were measured in the samples taken from the monitoring wells:

Well No.	S-1	S-2	S-3	S-4	S-5	S-6	S-7	S-8	S-9	S-10
					Benzene Concentration, ppb					
Jan. 1986	24	2	ND	1800	NM	NM	NM	NM	NM	NM
June 1986	210	67	ND	3000	ND	59	0.7	ND	ND	NM
Nov. 1986	18	14	2.5	4800	ND	790	ND	ND	ND	22
Jan. 1987	35	50	ND	3600	ND	1200	1.7	ND	ND	18
Apr. 1987	16	23	ND	4000	ND	270	ND	ND	ND	0.6

* NM - not measured (the wells did not exist)
** ND - not detected (below 0.5 ppb)

At the beginning of the investigation, it was thought that the previous storage complex (Figure 1) was the source of groundwater contamination. The spatial distribution of the benzene concentration confirms this hypothesis. The most contaminated well (well S-4) is located downgradient from the storage complex, whereas the wells located on both sides of the complex (wells S-1 and S-2) show much lower benzene concentrations. The time series of the monitored benzene concentrations in wells S-2, S-4, S-6, and S-10 are shown in Figures 2 through 5. Analysis of these data indicates that in two wells (S-2 and S-10) the benzene concentration levels are declining. This is particularly evident for well S-10 (Figure 5), which is located some 165 ft downgradient from the source. This concentration decline may be due to increased biodegradation activity resulting from adaptation of the microbial population to the contaminant plume. The well closest to the source (well S-4, Figure 3), however, does not show any significant decrease in the benzene concentration levels. The benzene concentration in this well fluctuates about 4 ppm level, most likely due to the precipitation events and groundwater level fluctuations. Therefore, it was conservatively decided to use the average concentrations for the last three measurement dates as representative of the benzene distribution. For the wells used in calibration, these average values are: S-4 - 4133 ppb, S-6 - 753 ppb, and S-10 - 14 ppb.

The horizontal size of the source, Y, in the direction perpendicular to the flow direction was estimated, based on the analysis of the flow and chemical data, to be Y = 30 ft. It was assumed that the source was submerged about 5 ft below the water table. It is a conservative assumption, but in order to change it we would have to obtain some information about the three-dimensional concentration distribution near the source.

Dispersive properties of the aquifer were assumed to be constant. Based on the data available in the literature, the following values were estimated: $\alpha_x = 5$ ft, $\alpha_y = 0.5$ ft, and $\alpha_z = 0.01$ ft, where α_x, α_y, α_z are longitudinal, transverse (horizontal), and vertical dispersivities, respectively.

Biodegradation rate. Recent laboratory and field experiments indicate that benzene is biodegraded at the average rate of 5 - 10% per week. Assuming that the process can be described as first-order decay, the decay constant is calculated to be between 0.007/day to 0.015/day. This gives us the order of magnitude for the decay constant. The actual value is estimated based on the field data.

Continuous Release Model

The transient, three-dimensional concentration distribution of continuously released contaminant from a source of constant concentration, C_o, and constant dimensions Y and Z (where Y = horizontal dimension in the direction perpendicular to flow, Z - vertical size of the source in the saturated zone, may be described by

$$C(x,y,z,t) = \frac{C_o}{8} \exp\left(\frac{x}{2\alpha_x} [1-(1+4m\alpha_x/q)^{1/2}]\right)$$

$$\mathrm{erf}\left([x-qt\ (1+4m\alpha_x/q)^{1/2}]/[2\ (\alpha_x qt)^{1/2}]\right)$$

$$\{\mathrm{erf}[(y+Y/2)/2(\alpha_y x)^{1/2}] - \mathrm{erf}[(y-Y/2)/2(\alpha_y x)^{1/2}]\}$$

$$\{\mathrm{erf}[(z+Z)/2(A\alpha_z x)^{1/2}] - \mathrm{erf}[(z-Z)/2(\alpha_z x)^{1/2}]\}$$

For the steady-state conditions, the concentration distribution at the water table along the centerline (y = 0, z = 0) may be calculated as follows:

$$c(x) = C_o \exp\left\{\frac{x}{2\alpha_x} [1 - (1+4m\alpha_x/q)^{1/2}]\right\}$$

$$\mathrm{erf}\left[\frac{Y}{4(\alpha_y x)^{1/2}}\right] \mathrm{erf}\left[\frac{Z}{2(\alpha_z x)^{1/2}}\right]$$

This equation was utilized to fit the field data and to estimate the degradation rate characteristic to the site. Figure 6 shows the distribution of computed and observed benzene concentration. The observed data are the averages from the last three measurements in wells S-4 (x = 0), S-6 (x = 90 ft), and S-10 (x = 165 ft). The simulation was performed for m = 0.0032/day. It may be seen that the model fits the concentration in well S-6 quite well. The difference between the observed and simulated concentrations at well S-10 may be caused by higher degradation rate between wells S-6 and S-10, due to lower benzene concentration. Such behavior has been observed in laboratory experiments. Figure 7 shows the benzene concentration distribution at the low concentration (<100 ppb) region. Analysis of this distribution indicates that, according to the calibrated model, benzene concentration should not exceed 7 ppb at the distance larger than some 350 ft downgradient from well S-4.

Summary

A benzene mass transport model for the Shell Service Station was developed. The input parameters were estimated based on the field investigation (seepage velocity, source size and concentration), calibration procedure (biodegradation rate), and other studies (dispersivities). The calibrated benzene degradation rate is m = 0.0032/day. The results indicate that the biodegradation process should reduce the benzene concentration below 7 ppb at some 350 ft from the source.

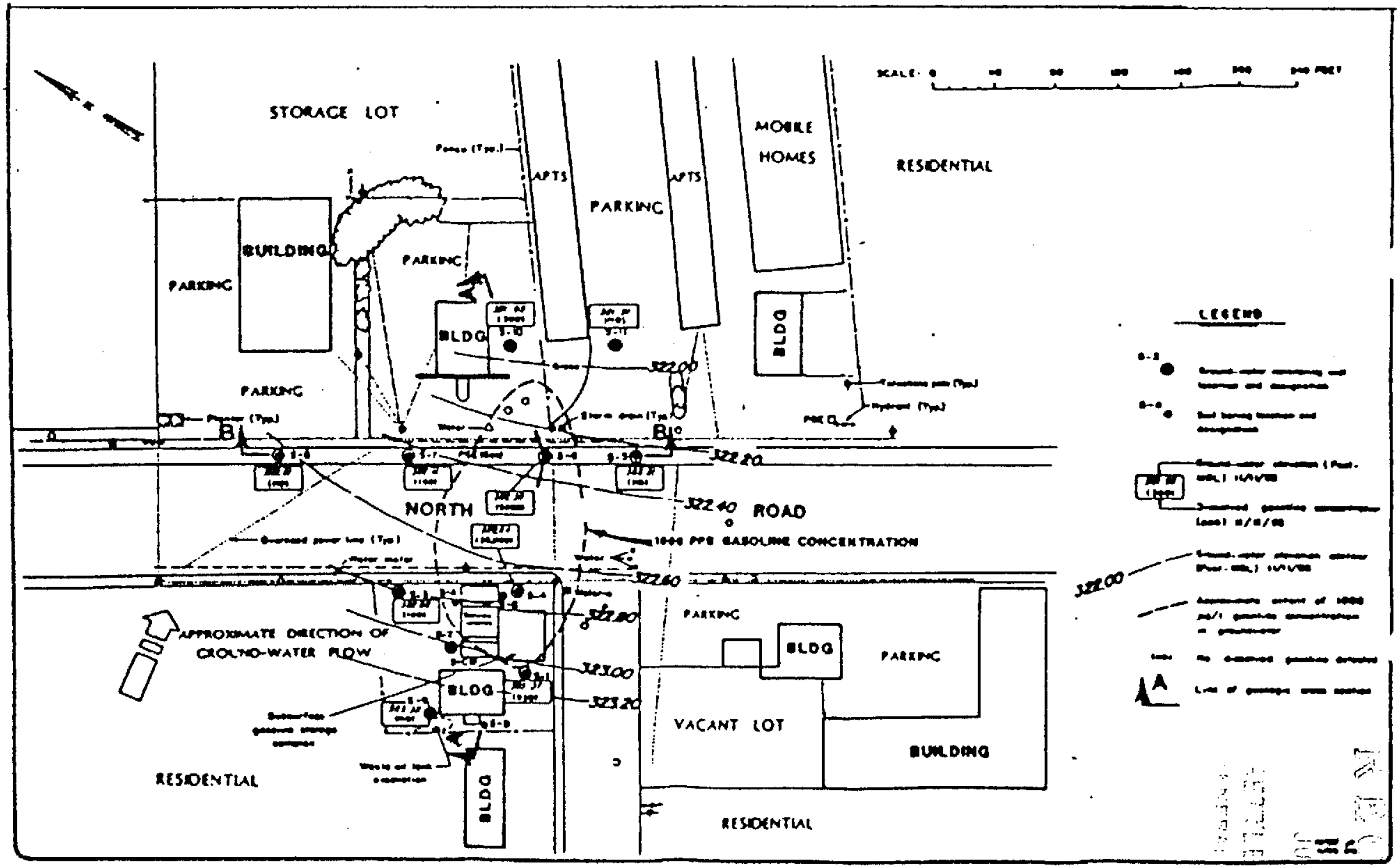


FIGURE 1. SITE PLAN

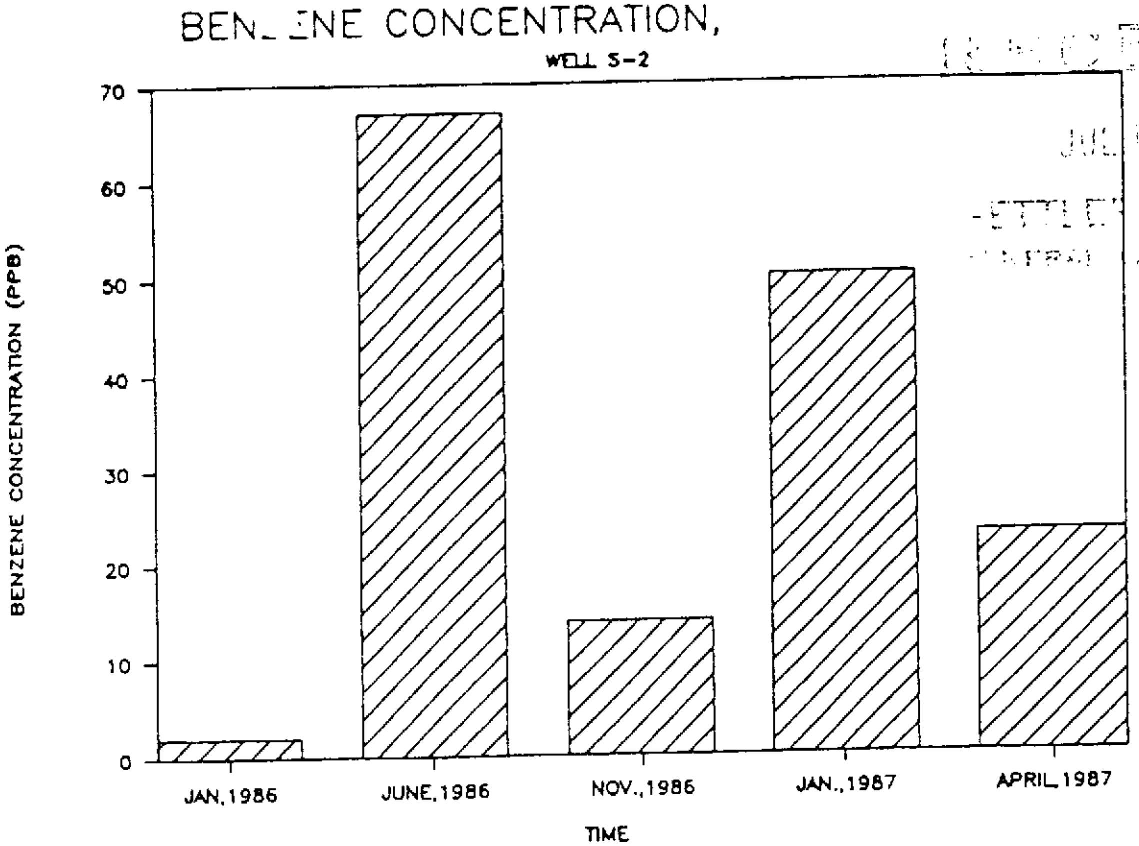


FIGURE 2. OBSERVED BENZENE CONCENTRATION
WELL S-2

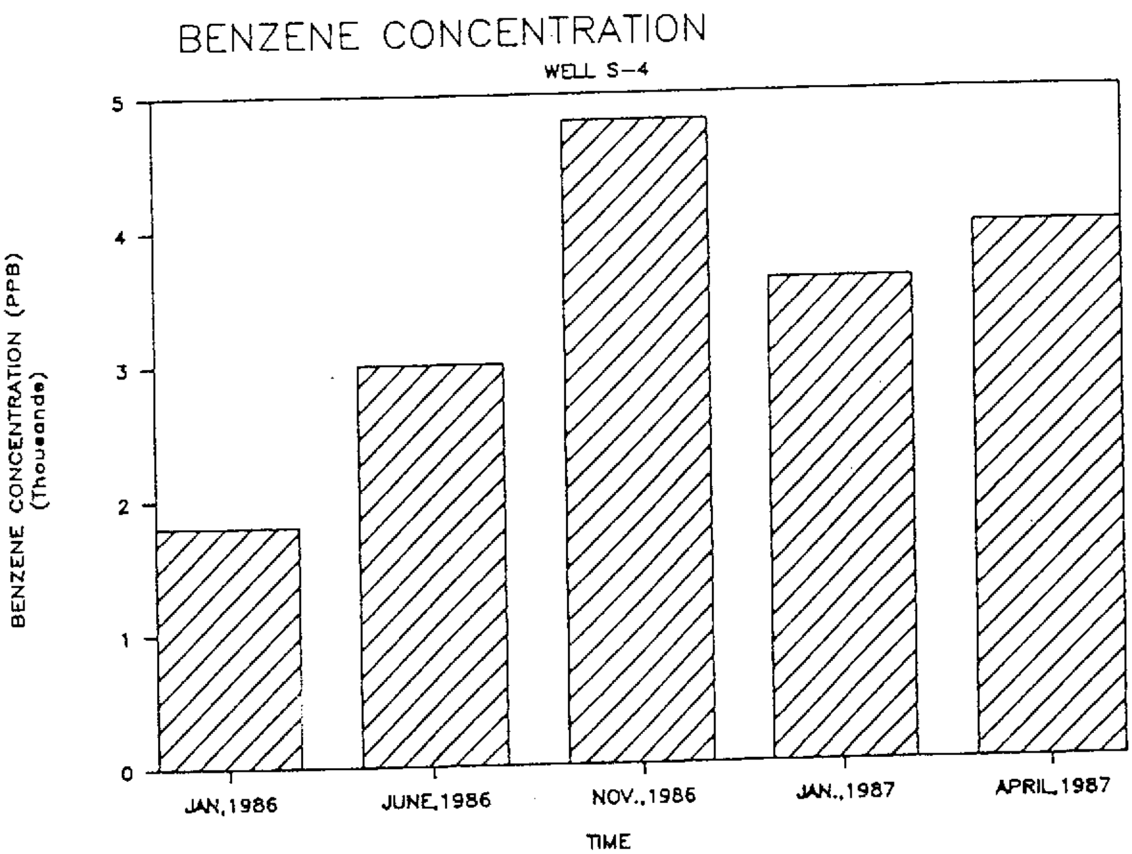


FIGURE 3. OBSERVED BENZENE CONCENTRATION
WELL S-4

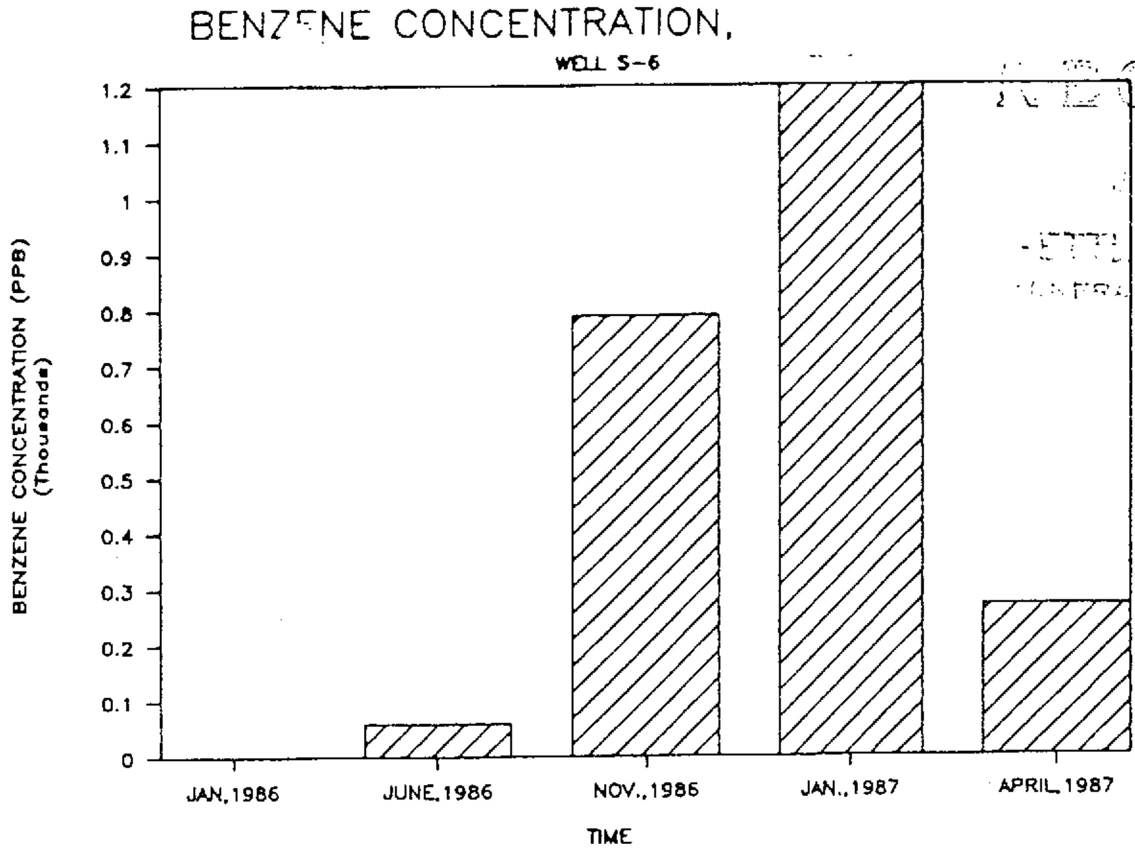


FIGURE 4. OBSERVED BENZENE CONCENTRATION
WELL S-6

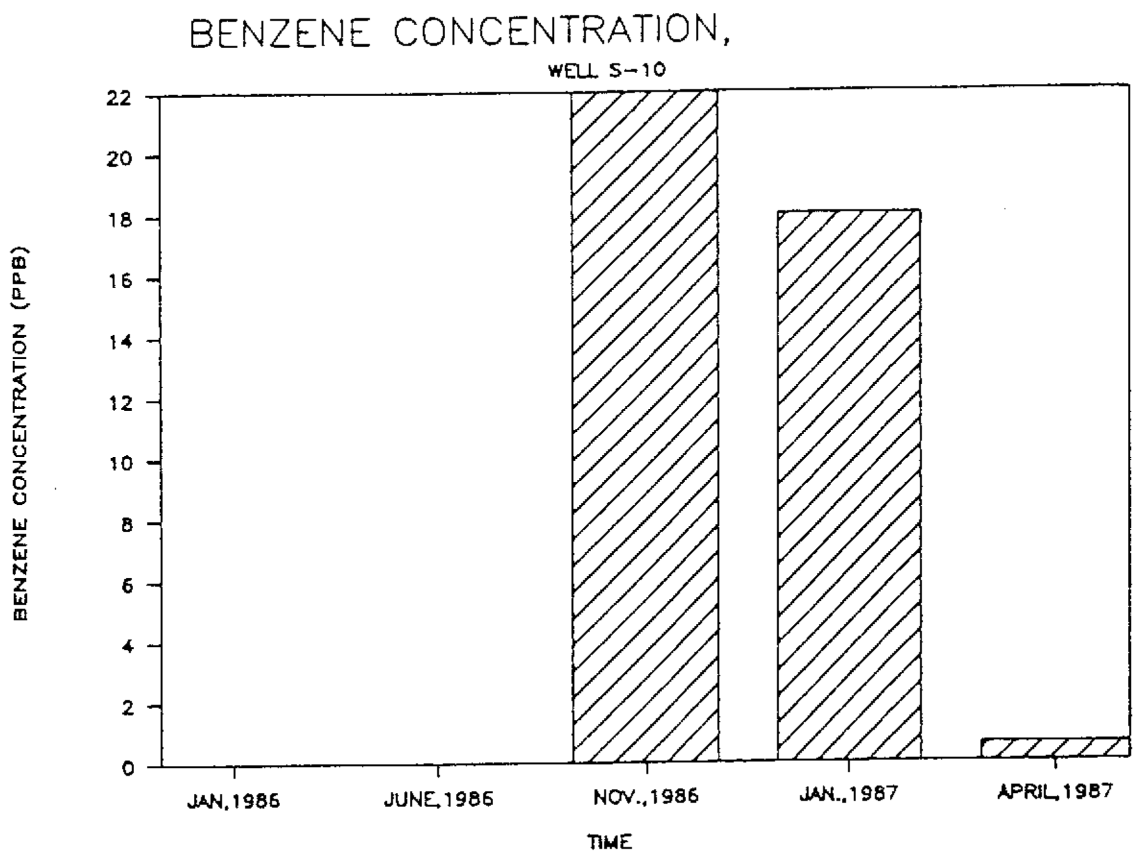


FIGURE 5. OBSERVED BENZENE CONCENTRATION
WELL S-7

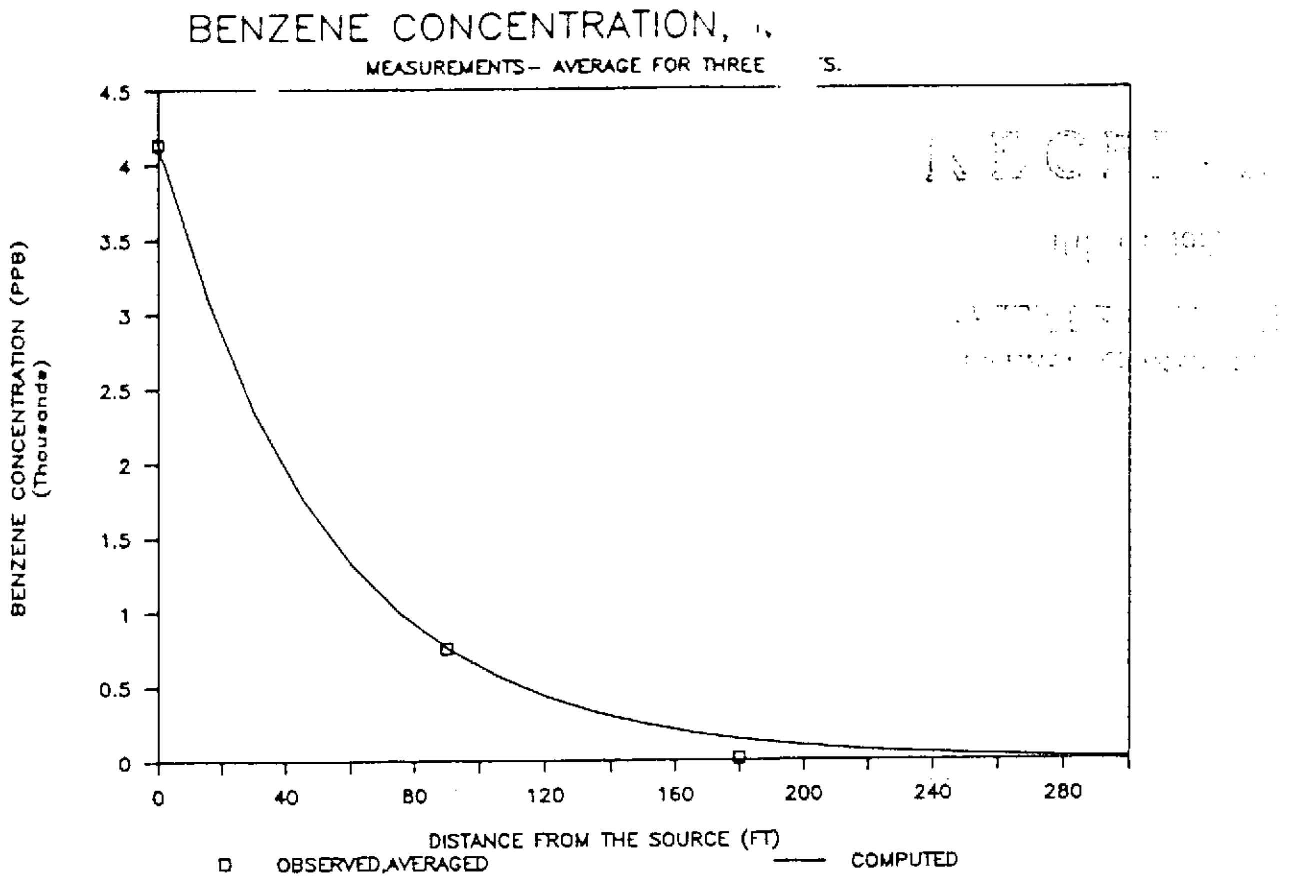


FIGURE 6. OBSERVED AND COMPUTED BENZENE CONCENTRATION DISTRIBUTION DOWNSTREAM FROM THE SOURCE

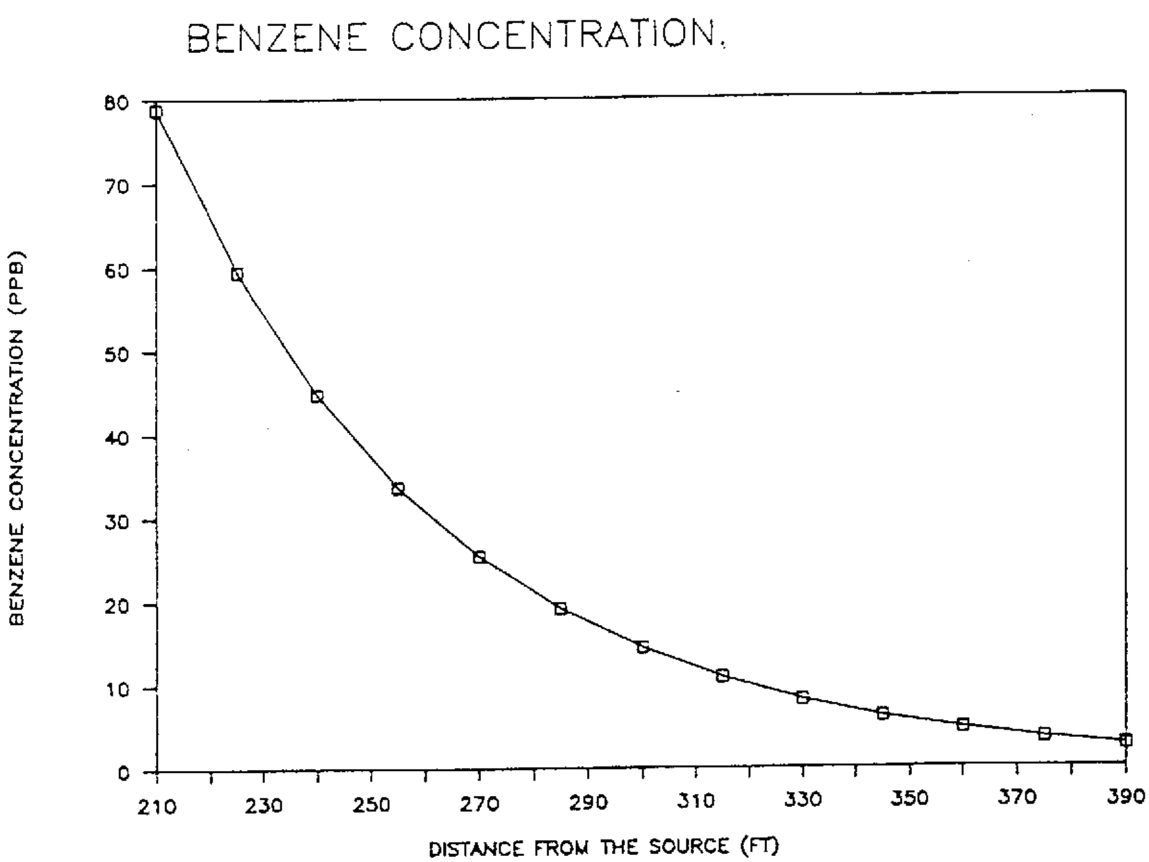


FIGURE 7. COMPUTED BENZENE CONCENTRATION -- LOW CONCENTRATION REGION