gettler — ryan inc.

91 JUL 19 AM 10:40

July 16, 1991

County of Alameda
Department of Environmental Health
Hazardous Materials Division
80 Swan Way, Room 200
Oakland, California 94621

Attention: Mr. ~~Larry Seto~~ Susan — certified mail

Reference: ARCO Service Station #4931
731 W. MacArthur Boulevard
Oakland, California 94611

Mr. Seto:

As requested by ARCO Products Company, we are forwarding a copy of the Aquifer Test report dated July 10, 1991.

Please do not hesitate to call should you have any questions or comments.

Sincerely,

Keith E. Bullock

KEB/jpz

Enclosure

cc: Mr. Charles Carmel, ARCO Products Company
Mr. Tom Callaghan, Regional Water Quality Control Board (certified mail)
Mr. H. C. Winsor, ARCO Products Company

GeoStrategies Inc.

AQUIFER TEST REPORT

ARCO Service Station No. 4931
731 W. MacArthur
Oakland, California

790903-10

July 10, 1991

GeoStrategies Inc.
2140 WEST WINTON AVENUE
HAYWARD, CALIFORNIA 94545

July 10, 1991

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

Re: AQUIFER TEST REPORT
ARCO Service Station No. 4931
731 W. MacArthur
Oakland, California

Gentlemen:

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

If you have any questions, please call.

GeoStrategies Inc. by,

Cliff M. Garratt
Hydrogeologist

Jeffrey L. Peterson
Hydrogeology Manager
R.E.A. 1021

CMG/JLP/mlg

REGISTERED GEOLOGIST
DAVID H. PETERSON
No. 1186
CERTIFIED
ENGINEERING
GEOLOGIST
STATE OF CALIFORNIA

790903-10

QC Review:
David H. Peterson
C.E.G. 1186

INTRODUCTION

This report presents the activities and results of aquifer testing performed by GeoStrategies Inc. (GSI) at the ARCO Service Station No. 4931 located at 731 W. MacArthur Boulevard in Oakland, California (Plate 1). Currently, the site is an active service station located on the southeast corner of the intersection of W. MacArthur Boulevard and West Street. There are nine on-site monitoring wells and two off-site monitoring wells (Plate 2). Commercial and residential properties are adjacent to and across from the site.

HYDROGEOLOGIC SETTING

The site is situated on the western portion of the Temescal Formation. This formation is comprised of alluvial fan deposits with interfingering lenses of clayey gravel, sand silt clay, and sand-clay-silt mixtures (Radbruch, 1957). Previous investigations at this site by Groundwater Technology Inc. (GTI) and Pacific Environmental Group Inc. (PACIFIC) identified a shallow water-bearing zone consisting of well-graded sand to clay with gravel. The shallow water-bearing zone was encountered between 12 and 18 feet below grade. Observed saturated thickness ranges from approximately 2 to 20 feet. Available boring log information indicate that the uppermost water-bearing zone is unconfined to semi-confined in nature and may be laterally continuous beneath the site. This water-bearing zone is underlain by a less permeable clay unit, which may locally act as a basal aquitard. However, the lateral continuity and thickness of the possible aquitard is not known.

FIELD ACTIVITIES AND DATA ANALYTICAL TECHNIQUES

A hybrid step-drawdown/constant-rate test was performed on Well A-9 on April 4 and 5, 1991. The test was performed to evaluate the potential for using Well A-9 to achieve hydrodynamic control of groundwater for extraction and treatment.

Water-level measurements were collected in the pumping well and selected observation wells using an electronic oil-water interface probe prior to the aquifer test to establish baseline data (Plate 3). Static ground-water was measured between 7.15 and 9.33 feet below grade, which corresponds to 43.22 to 47.85 feet above Mean Sea Level (MSL). The local hydraulic gradient was calculated to be 0.02 with ground-water flow generally south to southwest. During the test, drawdown and water-level recovery data were continuously recorded in pumping Well A-9 and three selected observation wells (A-5, A-8 and A-10) with pressure transducers connected to a Hermit SE2000 data logger. Water-levels in Wells A-3, A-4, A-6, A-7, A-11 and A-12 were measured with an interface probe at selected time intervals throughout the duration of pumping and recovery phases of the test. Well A-2 was not influenced by pumping Well A-9 during the aquifer test.

AQUIFER TEST RESULTS

Hybrid Step-Drawdown/Constant-Rate Test: Well A-9

The hybrid step-drawdown/constant-rate test for Well A-9 consisted of four pumping steps and a recovery step: Step 1 ran for 29 minutes at a pumping rate of 1.0 gpm, Step 2 ran for 30 minutes at a pumping rate of 3.0 gpm, Step 3 ran for 95 minutes at a pumping rate of 6.0 gpm, and Step 4 ran for 1116 minutes at a pumping rate of 12 gpm and step 5 (well recovery) ran for 376 minutes. Maximum observed drawdown in Well A-9 was 4.55 feet after the combined 154 minute step-test and the 1116 minute constant-rate test. Maximum observed drawdowns in observation wells are summarized in Table 1. Observed drawdowns, referenced to Mean Sea Level (MSL) after pumping Well A-9 after 1270 minutes total are presented on Plate 4. Well-recovery data were collected and recorded as the pumping well water-level recovered to greater than 80% of initial static water level before the test was terminated. The well influence map is presented on Plate 5.

Time versus drawdown data were plotted for observation Wells A-3 through A-8 and A-11 and A-12. Transmissivity (T) and Storativity (S) values were calculated from field data plots using the Jacob Straight-line Method (1946). These data results are summarized in Table 1. The field data plots for these wells are presented in Appendix A. Calculated Transmissivity from field plots using Jacob's Method ranged from 1092 to 2668 gpd/ft. Storativity values varied from 1.18 x 10^{-2} to 4.24 x 10^{-6}. These storativity values are indicative of a heterogenous environment.

To evaluate the potential effects of delayed drainage in an unconfined aquifer, GSI used Graphical Well Analysis Package (GWAP) software to analyze test data using the Neuman Method (1975). These data plots are presented in Appendix A and are considered to be most representative of actual site conditions. Transmissivity values using the Neuman method ranged from 996 to 2502 gpd/ft. Specific yield values ranged from 1.74 x 10^{-2} to 9.65 x 10^{-3}. Specific yield values by Neuman analysis are suggestive of unconfined to semi-confined conditions. A transmissivity value of 2170 gpd/ft for Well A-9 was calculated by the Harrill/Recovery Method used to evaluate step-drawdown test results. These data are summarized in Table 1 and presented in Appendices A and B.

The Hantush-Jacob type curve method was applied to Well A-10 as a check to verify suspected unconfined to semi-confined aquifer conditions. The results of this analysis method appears to substantiate the validity of using the Neuman Method in analyzing aquifer characteristics beneath the site.

The Jacob and Neuman Method values for storativity and specific yield appear to agree for the most part with the primary assumption that the local aquifer tends to be unconfined to semi-confined. Variations in storativity values are suspected to be the result of the heterogeneous nature of the aquifer.

Ground-water Model

A finite-difference model, (Wellfield Simulation, Hall Groundwater Consultants, Inc. 1987) developed by Prickett and Lonnquist (1971) was used to predict long-term influence of pumping Well A-9. The "Basic Aquifer Model With Water Table Conditions" was selected as the most appropriate model for the assumed subsurface conditions.

Aquifer parameters used in the model simulation included averaged values for; Transmissivity (2069 gpd/ft) and Storativity (5.65 x 10^{-3}), and saturated aquifer thickness (18 feet). Three boundary zones were approximated using transmissivity values of 996, 900 and 750 gpd/ft; a storativity value of 1.74 x 10^{-2} and a saturated thickness of 10 feet to simulate observed subsurface conditions. Additionally, historical ground-water flow direction and hydraulic gradients were approximated and induced into the model definition. The finite difference model follows Dupuits Assumptions (i.e. the assumption that the aquifer is aerial infinite, homogeneous of uniform aquifer thickness, and wells fully penetrate the saturated zone, etc). A simulated well influence map was prepared from drawdown data resulting from the model run (Plate 6). Water-level contours are presented relative to MSL and represent approximately 30 days of pumping Well A-9 at 12 gpm. A first quarter (1991) TPH-Gasoline/Benzene concentration map (Plate 7) illustrates the known extent of the hydrocarbon contamination.

SUMMARY AND CONCLUSIONS

Results and conclusions of the hybrid step-drawdown/constant-rate discharge test are summarized below:

- Drawdowns were observed and recorded from eight of the on-site wells and the two off-site wells. Maximum observed drawdowns ranged from 4.55 feet (Well A-9) to 1.06 feet (Well A-6). Hydraulic influence from pumping Well A-9 was not detected in Well A-2.

- On-site Wells A-3 through A-8 and Well A-10 appear to be within the area of influence of pumping Well A-9 at an average discharge rate of 12 gpm for a period of 1116 minutes.

- Off-site Wells A-11 and A-12 appear to be within the area of hydraulic influence of pumping Well A-9 at an discharge rate of 12 gpm for a period of 1116 minutes.

- The cone of depression created by pumping Well A-9 at 12 gpm did not stagnate during the aquifer test. This suggests that the area of influence may extend beyond the areal extent observed during this test.

- The finite-difference model suggests that hydrodynamic control may be possible beneath the site, with the exception of the area near to Well A-2. However, long-term pumping may influence Well A-2. If not, an additional recovery well may be necessary to address the area.

- The observed influence and modeled long-term influence of pumping at the site are based on a relatively short duration aquifer test. Hydrogeologic boundary conditions may be present that would not be evident during an aquifer test of this duration. Therefore, long-term pumping influence and potential area of capture for an operating recovery well will need to be re-evaluated on an on-going basis.

LIST OF ATTACHMENTS

References Cited

Groundwater Graphics, 1986, Graphics Well Analysis Package, Version 2.0, Oceanside, California.

Hall Ground-water Consultants Inc., 1987, Wellfield Simulation, Earthware Laguna Niguel, California.

Harrill, J.R., 1970, "Determining transmissivity from water-level recovery of a step-drawdown test", U.S. Geological Survey Professional Paper 766-C, pp. C212-213.

Jacob, C.E., 1946, "Drawdown test to determine screen loss and effective radius of an artesian well", Proc. Amer. Soc. Civil Engrs., 1946.

Neuman, S.P., 1975, "Analysis of pumping test data from an anisotropic unconfined aquifer considering delayed gravity response". Water Resources Res., 11 pp. 329-342.

Pacific Environmental Group Report, ARCO Service Station No. 4931, Oakland, California, Report dated January 20, 1988, Project No. 130-12.03.

Prickett, T.A. and Lonquist, C.G., 1971, "Selected Digital Computer Techniques for Groundwater Resource Evaluation", Illinois State Water Survey, Bulletin 55.

Radbruch, Dorothy H., 1957, Areal and Engineering Geology of the Oakland West Quadrangle, California, Miscellaneous Geologic Investigations Map I-239, U.S. Geological Survey Washington D.C.

Theis, C.V., 1935, "The relation between the lowering of the piezometric surface and the rate and duration of discharge of a well using groundwater storage," Am. Geophys. Union Trans. vol. 16: 519-524.

TABLE 1

WELL A-9 PUMP TEST RESULTS

WELL NO.	PUMP RATE (gpm)	PUMPING DURATION (Min.)	MAXIMUM DRAWDOWN (Ft.)	JACOB METHOD T	JACOB METHOD S	NEUMAN METHOD T	NEUMAN METHOD Sy
A-3	12	1116	2.07	1092	1.25×10^{-2}	996	1.74×10^{-2}
A-4	12	1116	3.44	2170	3.19×10^{-4}	2081	1.02×10^{-3}
A-5	12	1116	3.62	2044	5.08×10^{-4}	2389	2.82×10^{-3}
A-6	12	1116	1.06	2215	4.24×10^{-6}	1731	9.01×10^{-3}
A-7	12	1116	1.17	2364	6.48×10^{-3}	2081	9.65×10^{-3}
A-8	12	1116	3.51	1625	7.27×10^{-3}	2179	5.32×10^{-3}
A-9	12	1116	4.55	(6)	(6)	(4)2170	(7)
A-10	12	1116	3.53	(5)	(5)	2282	2.42×10^{-3}
A-11	12	1116	3.13	2247	6.68×10^{-4}	2282	1.36×10^{-3}
A-12	12	1116	2.11	2668	1.18×10^{-2}	2502	1.86×10^{-3}

1. T = Transmissivity (gpd/ft)
2. S = Storativity (dimensionless)
3. Sy = Specific yield (volume of delayed drainage from storage per unit drawdown per unit horizontal area)
4. Transmissivity value determined by Harrill/Recovery Method.
5. Insufficient late test data to use Jacob Method.
6. Jacob Method valid for observation wells only.
7. Sy not applicable to Harrill/Recovery Method.

ILLUSTRATIONS

N

Base Map: USGS Topographic Map

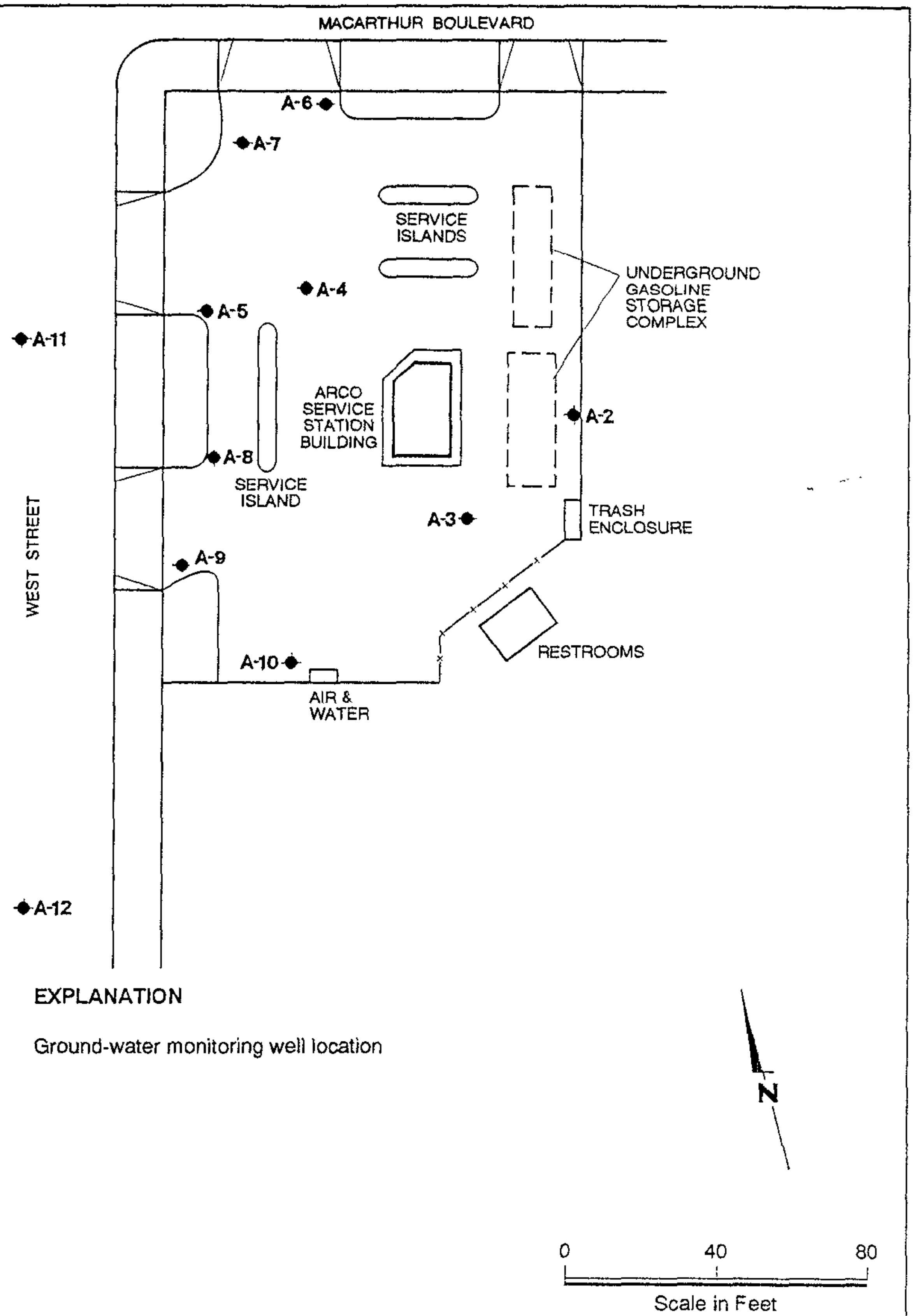
Approximate Scale : 1" = 2000'

GSI GeoStrategies Inc.

Vicinity Map
ARCO Service Station #4931
731 W. MacArthur Boulevard
Oakland, California

PLATE
1

JOB NUMBER	REVIEWED BY RG/CEG	DATE	REVISED DATE	REVISED DATE
7909		1/90		



EXPLANATION

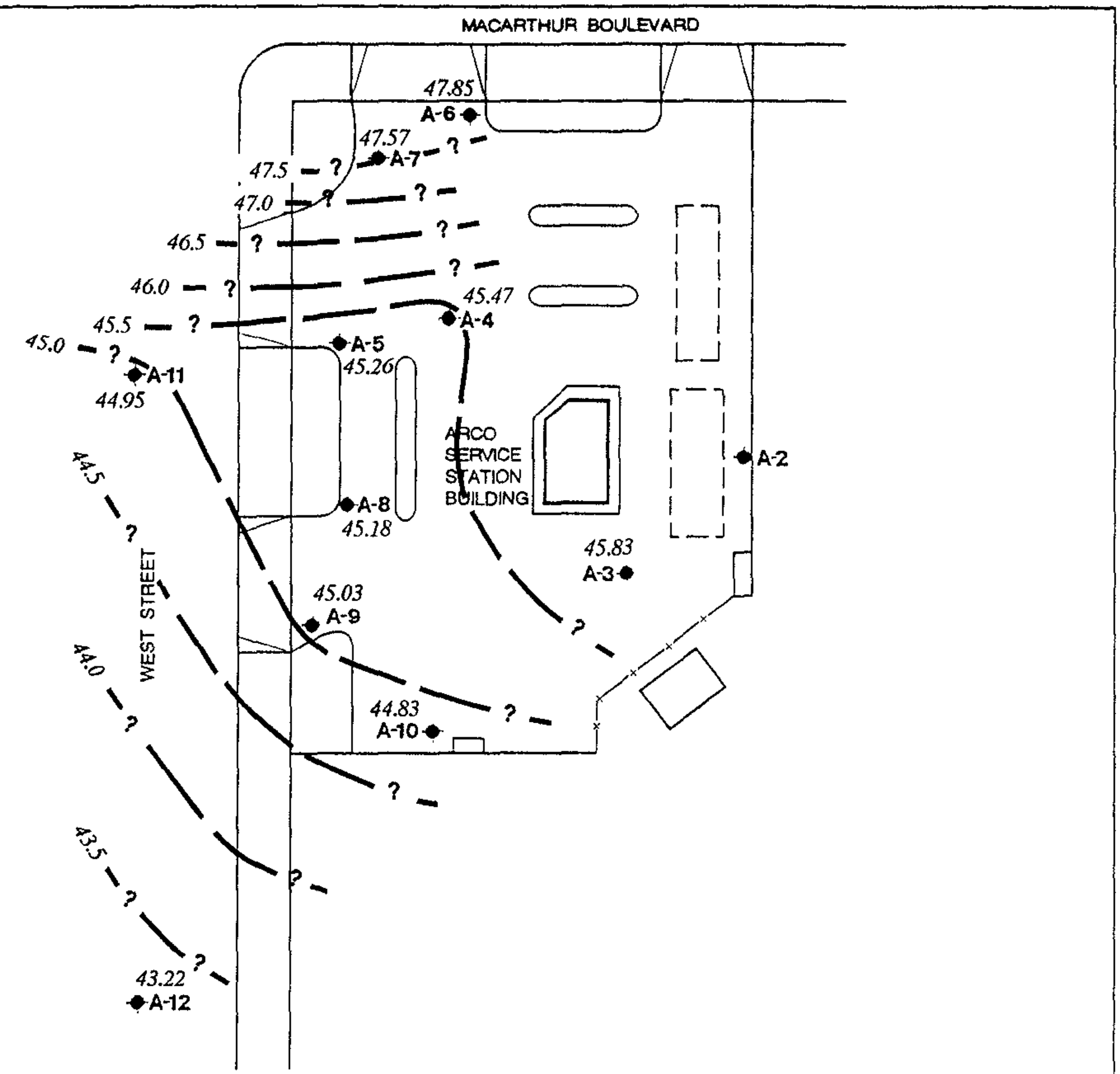
◆ A-2 Ground-water monitoring well location

GeoStrategies Inc.

Site Plan
ARCO Service Station #4931
731 W. MacArthur Boulevard
Oakland, California

PLATE 2

JOB NUMBER	REVIEWED BY	DATE	REVISED DATE	REVISED DATE
790903-10	DHP	5/91		



EXPLANATION

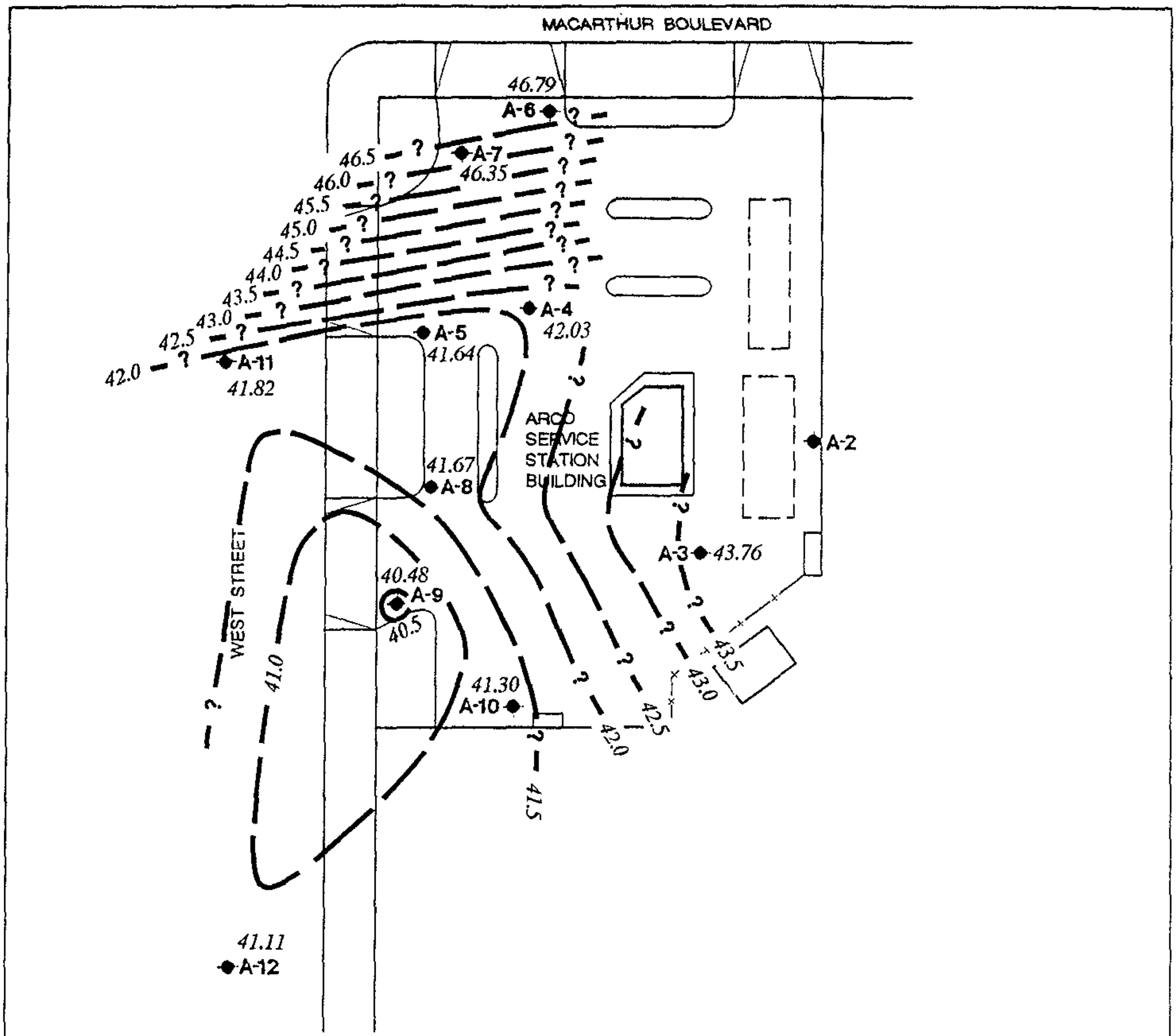
◆ A-2	Ground-water monitoring well location
43.5	Ground-water elevation contour Approximate Gradient = 0.02
43.22	Ground-water elevation in feet referenced to Mean Sea Level (MSL) measured on April 4, 1991

GSI GeoStrategies Inc.

Water Level Map - Prior to Pumping Well A-9
ARCO Service Station #4931
731 W. MacArthur Boulevard
Oakland, California

PLATE **3**

JOB NUMBER	REVIEWED BY	DATE	REVISED DATE	REVISED DATE
790903-10	DHP	5/91		



EXPLANATION

A-2 — Ground-water monitoring well location

46.5 — Ground-water elevation contour after 1270 min. of pumping

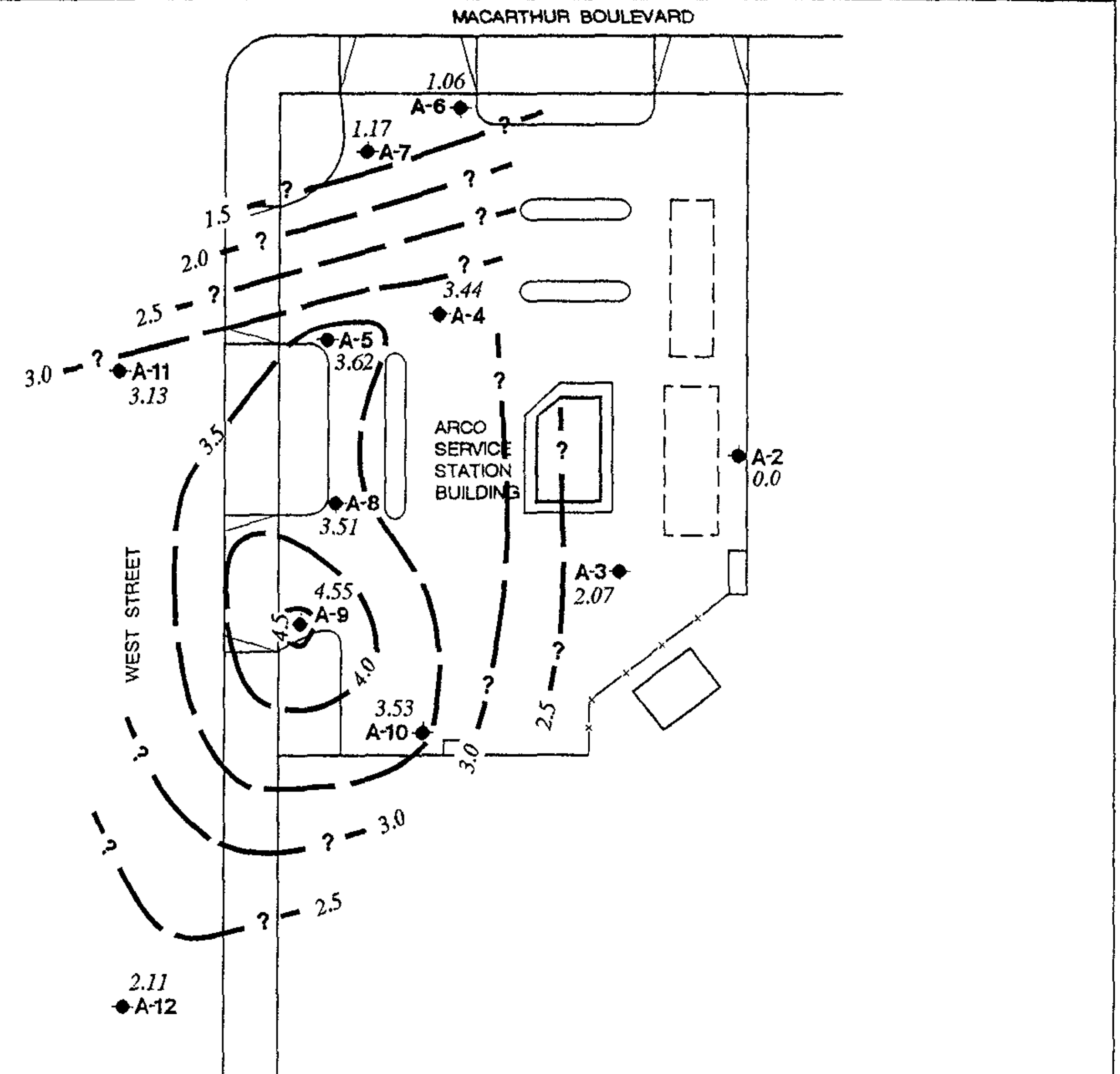
41.11 — Ground-water elevation in feet referenced to Mean Sea Level (MSL) measured on April 5, 1991

GSI GeoStrategies Inc.

Water Level Map - After Pumping Well A-9
ARCO Service Station #4931
731 W. MacArthur Boulevard
Oakland, California

PLATE
4

JOB NUMBER	REVIEWED BY	DATE	REVISED DATE	REVISED DATE
790903-10	DHP	5/91		



EXPLANATION

A-2 — Ground-water monitoring well location

3.0 — Drawdown contour

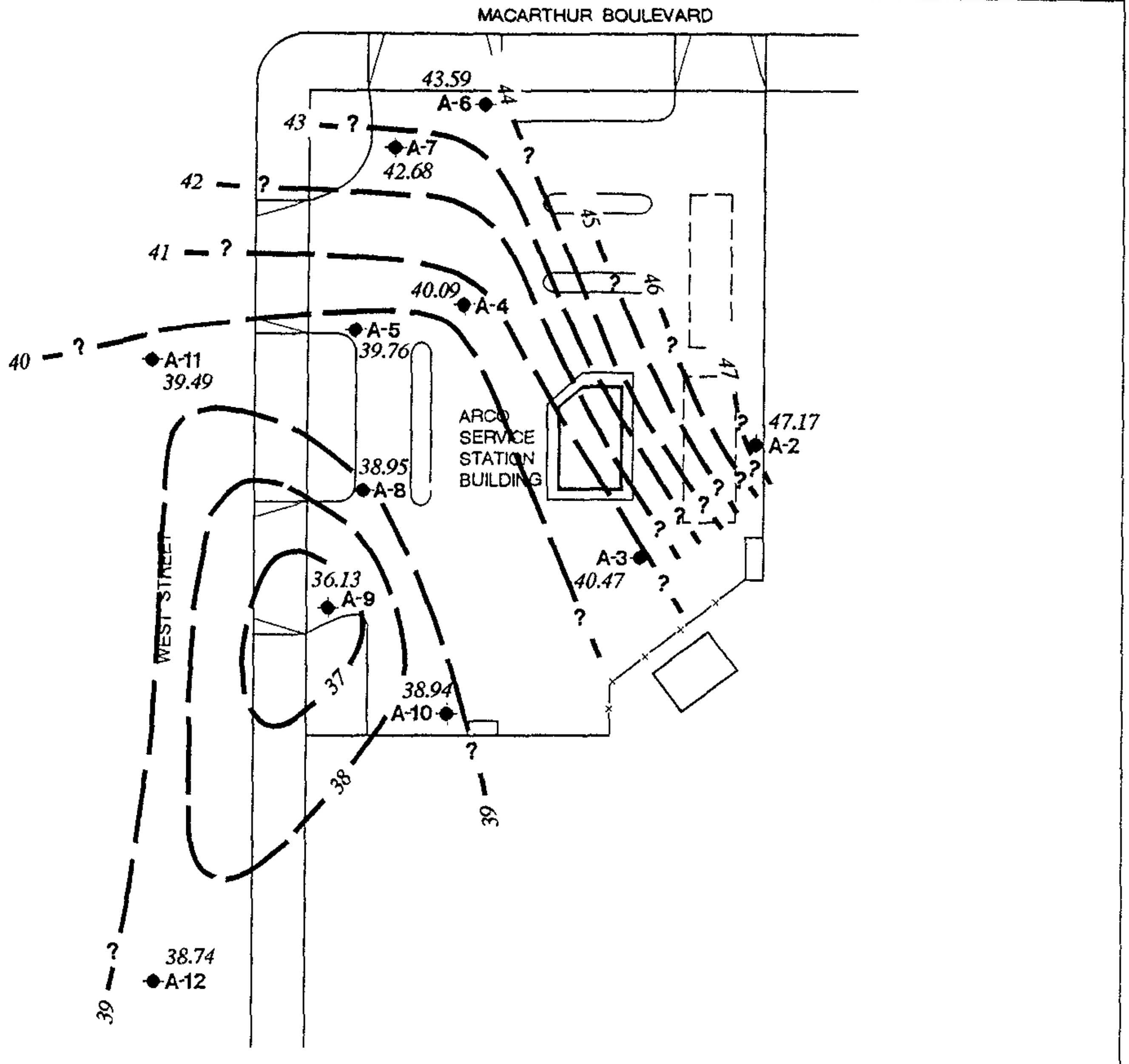
2.11 — Drawdown in feet relative to static water level after pumping Well A-9 for 1270 min. on April 5, 1991; 154 min. step-test, 1116 min. constant-rate test.

GSI GeoStrategies Inc.

Well Influence Map
ARCO Service Station #4931
731 W. MacArthur Boulevard
Oakland, California

PLATE
5

JOB NUMBER	REVIEWED BY	DATE	REVISED DATE	REVISED DATE
790903-10	DHP/	5/91		



EXPLANATION

A-2 — Ground-water monitoring well location

40 — Computer simulated ground-water elevation contour in feet by pumping Well A-9 at 12 gpm for approximately 30 days.

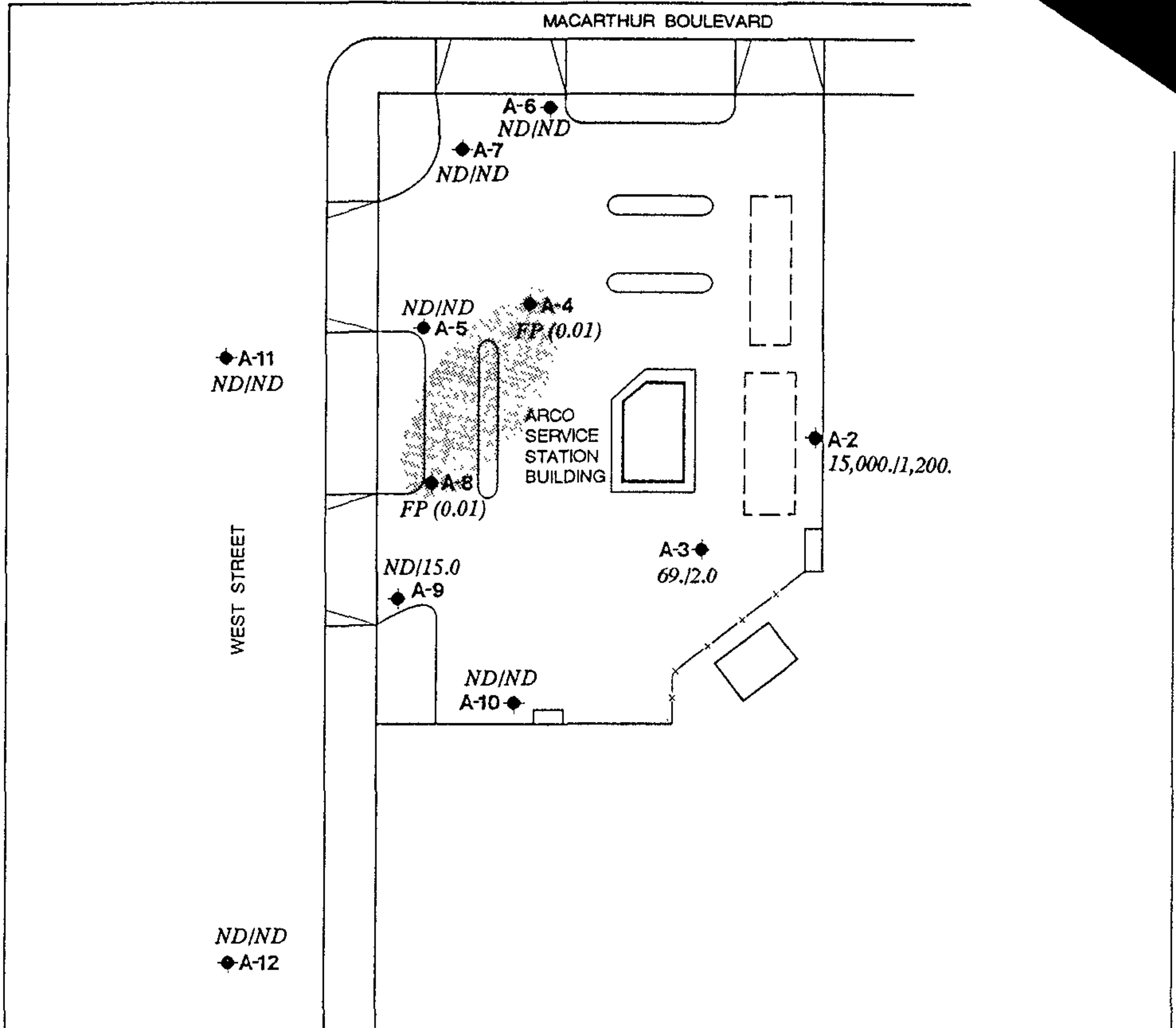
38.74 — Computer simulated ground-water elevation approximated to Mean Sea Level (MSL)

GSI GeoStrategies Inc.

Simulated Well Influence Map
ARCO Service Station #4931
731 W. MacArthur Boulevard
Oakland, California

PLATE 6

JOB NUMBER	REVIEWED BY	DATE	REVISED DATE	REVISED DATE
790903-10	DHP/	5/91		



EXPLANATION

A-2	Ground-water monitoring well location
69./2.0	TPH-G (Total Petroleum Hydrocarbons calculated as Gasoline)/Benzene concentrations in ppb sampled on January 16, 1991
ND	Not Detected (see laboratory reports for detection limits)
FP (0.01)	Approx. Area of Floating Product (measured thickness in feet)

0 40 80

Scale in Feet

GSI GeoStrategies Inc.

TPH-G/Benzene Concentration Map
ARCO Service Station #4931
731 W. MacArthur Boulevard
Oakland, California

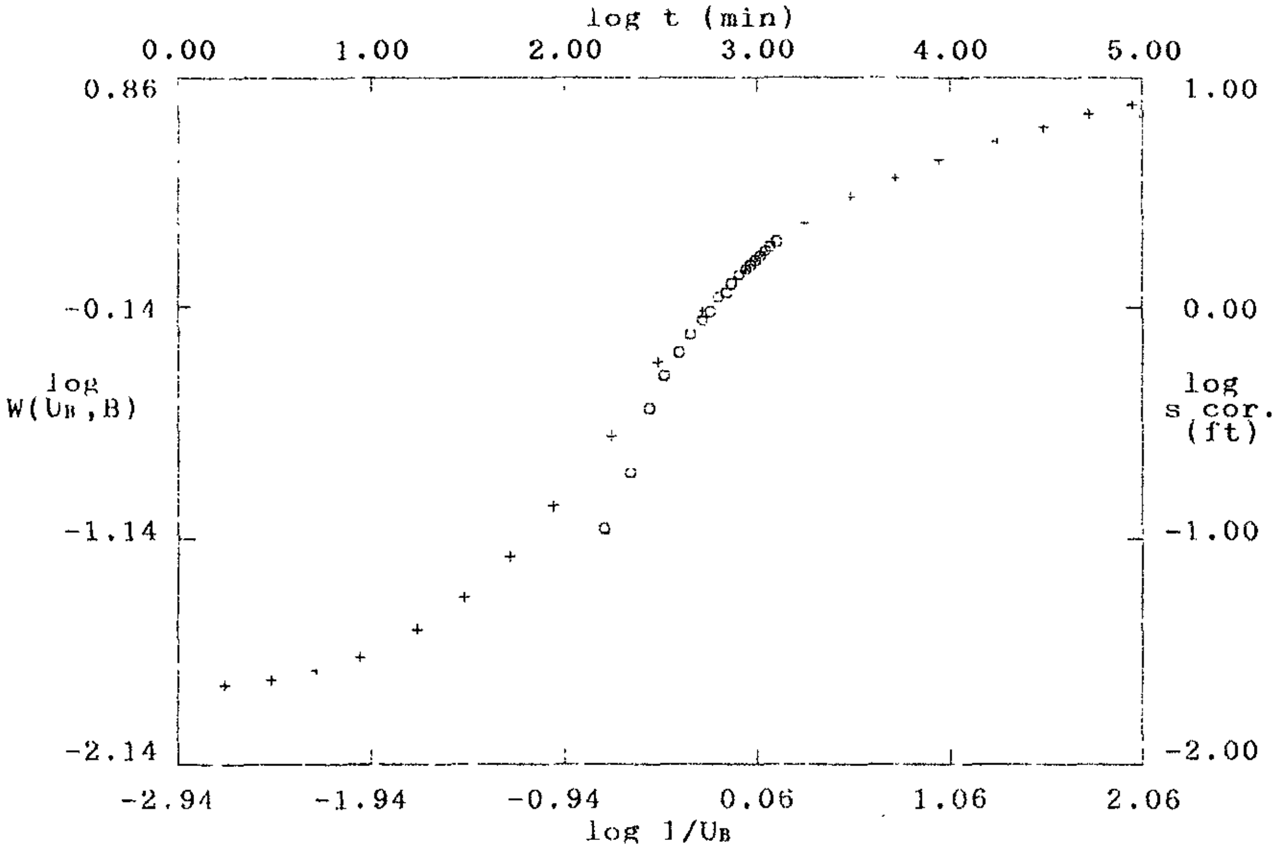
PLATE **7**

JOB NUMBER	REVIEWED BY RG/CEG	DATE	REVISED DATE	REVISED DATE
790903-10	DHP/922	2/91	5/91	

APPENDIX A

JACOB FIELD DATA PLOTS, GWAP DATA PLOTS AND CALCULATIONS FOR WELL A-9 HYBRID STEP/CONSTANT RATE DISCHARGE TESTS

Well A-3



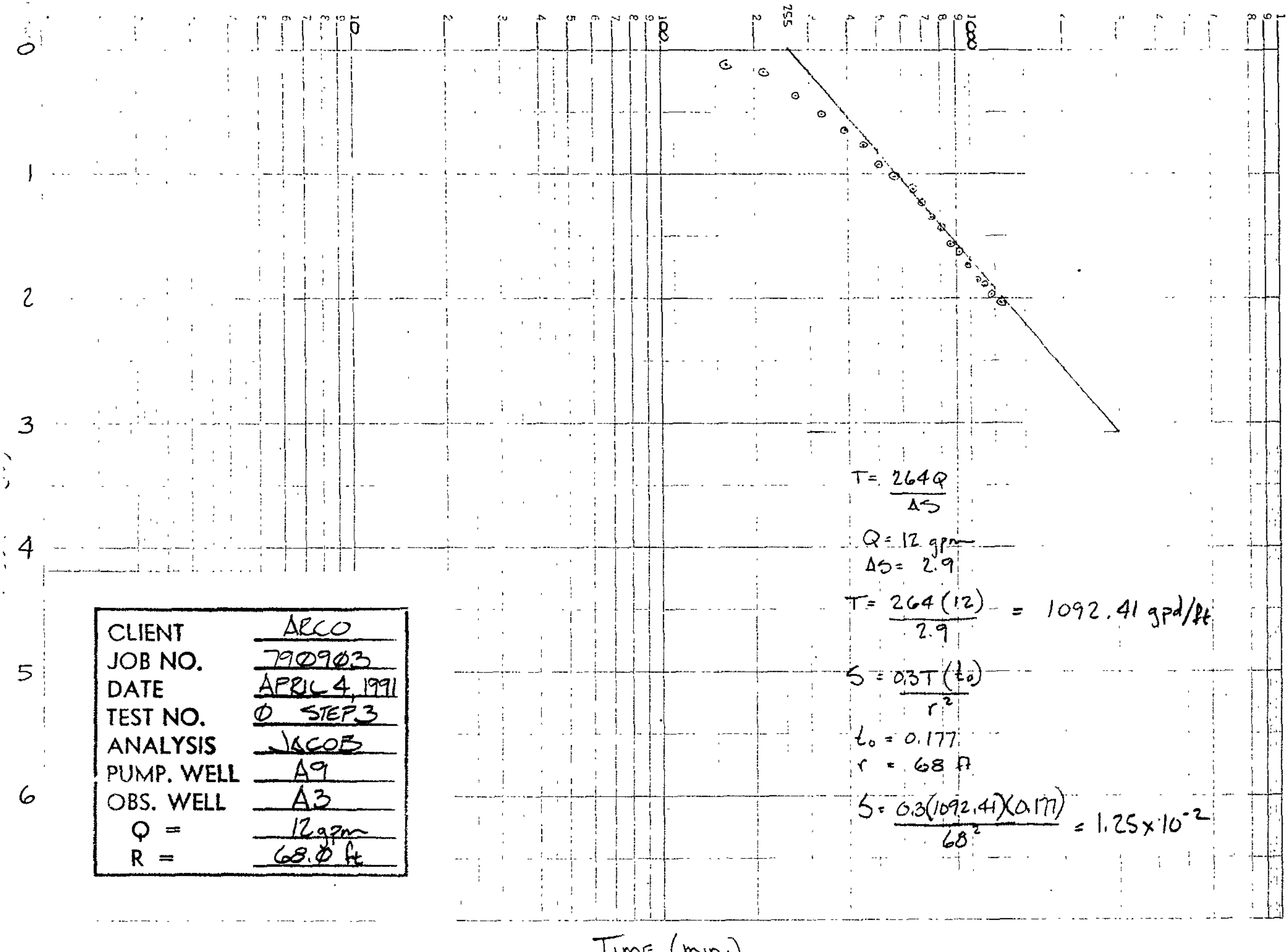
o - Data

\+ - Type Curve
Unconfined Delayed: beta = 7.00

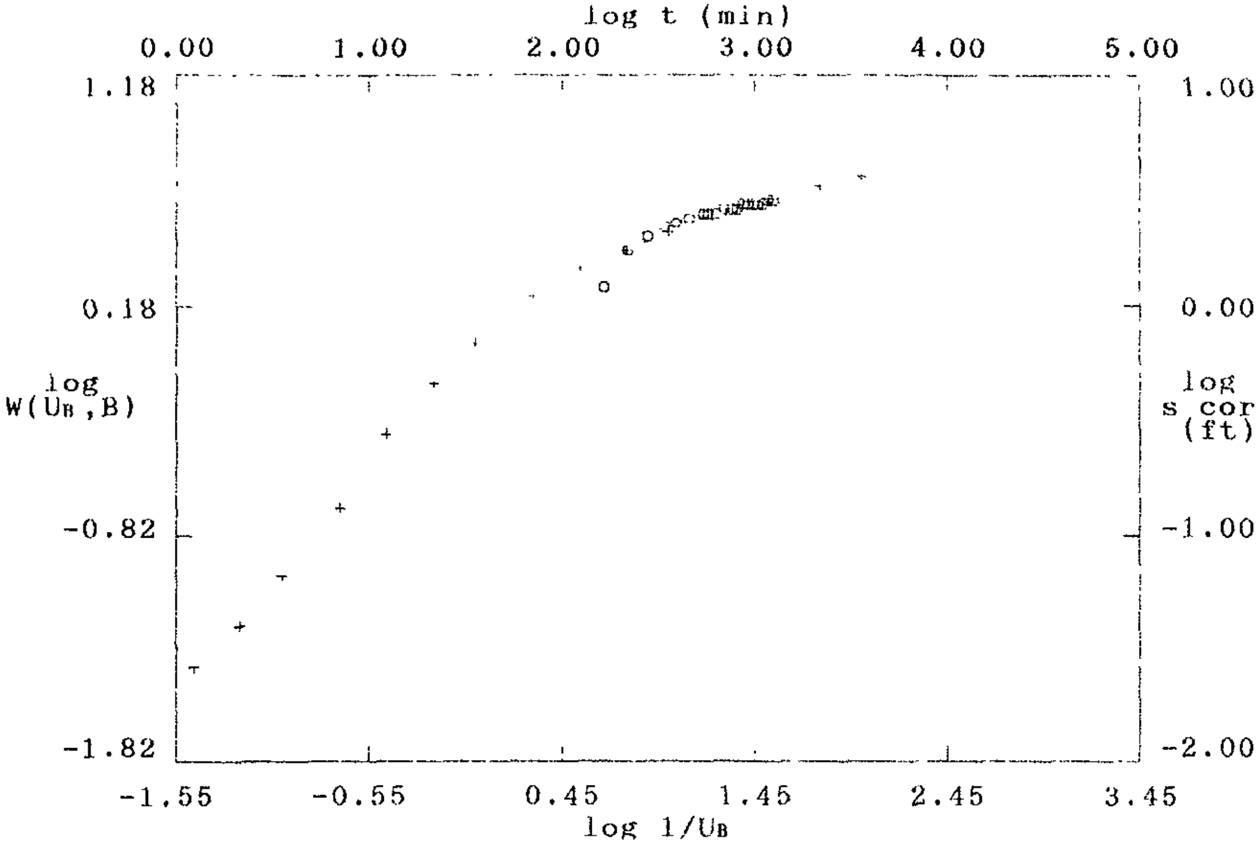
SOLUTION

Transmissivity = 9.960E+0002 gpd/ft
Aquifer Thick. = 1.100E+0001 ft
Hydraulic Cond.= 9.054E+0001 gpd/sq ft
Specific Yield = 1.742E-0002

WELL A3 12 gpm
TEST 0 STEP 3



Well A-4



o - Data

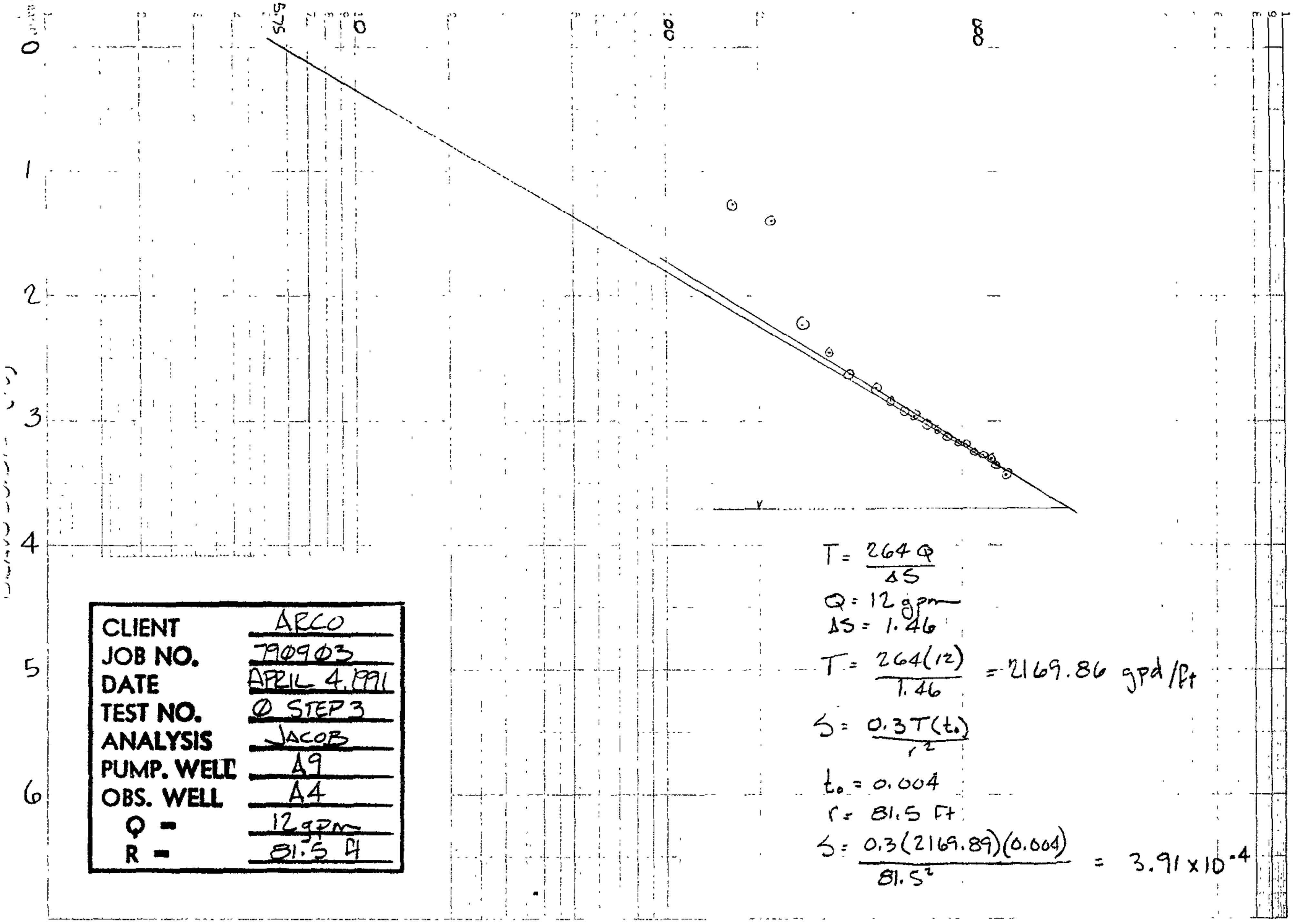
\+ - Type Curve
Unconfined Delayed: beta = 7.00

SOLUTION

Transmissivity = 2.081E+0003 gpd/ft
Aquifer Thick. = 1.100E+0001 ft
Hydraulic Cond.= 1.892E+0002 gpd/sq ft
Specific Yield = 1.020E-0003

WELL A4 12 gpm

TEST O STEP 3



CLIENT	ARCO
JOB NO.	790903
DATE	APRIL 4, 1991
TEST NO.	Ø STEP 3
ANALYSIS	JACOB
PUMP. WELL	A9
OBS. WELL	A4
Q =	12 gpm
R =	81.5 ft

$T = \frac{264 Q}{\Delta S}$

$Q = 12$ gpm

$\Delta S = 1.46$

$T = \frac{264(12)}{1.46} = 2169.86$ gpd/ft

$S = \frac{0.3 T (t_0)}{r^2}$

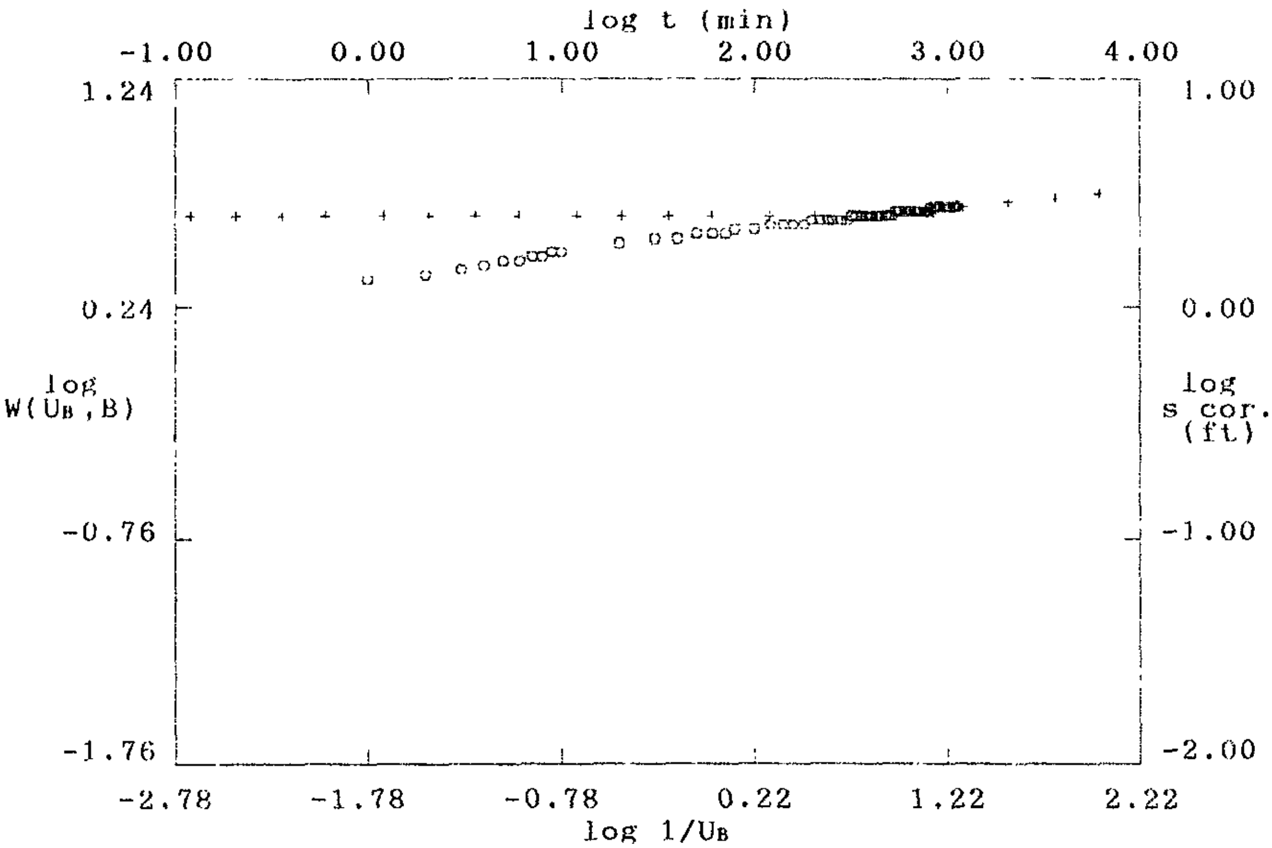
$t_0 = 0.004$

$r = 81.5$ Ft

$S = \frac{0.3(2169.89)(0.004)}{81.5^2} = 3.91 \times 10^{-4}$

Time (min)

Well A-5



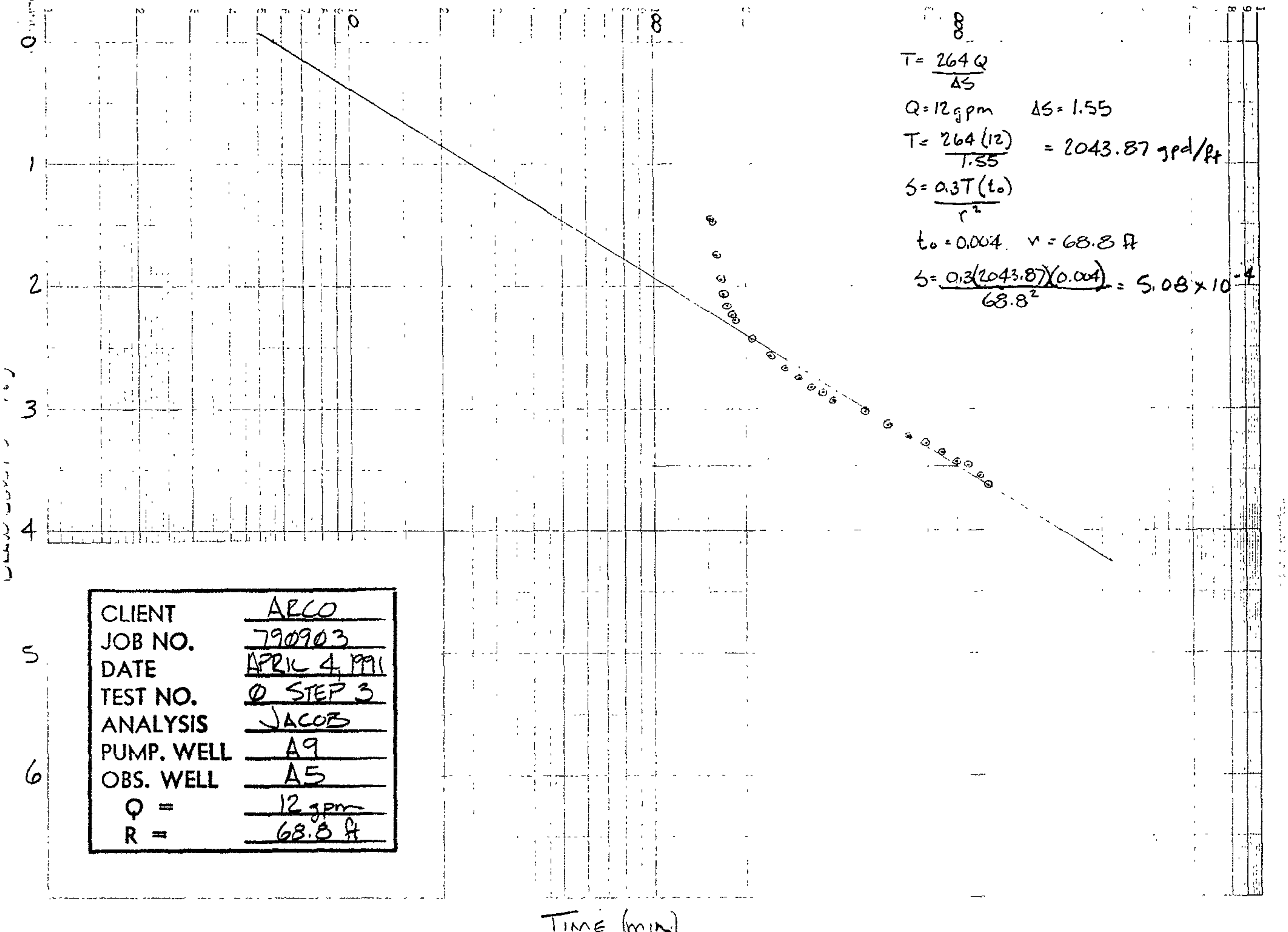
o - Data

\+ - Type Curve
Unconfined Delayed: beta = 0.004

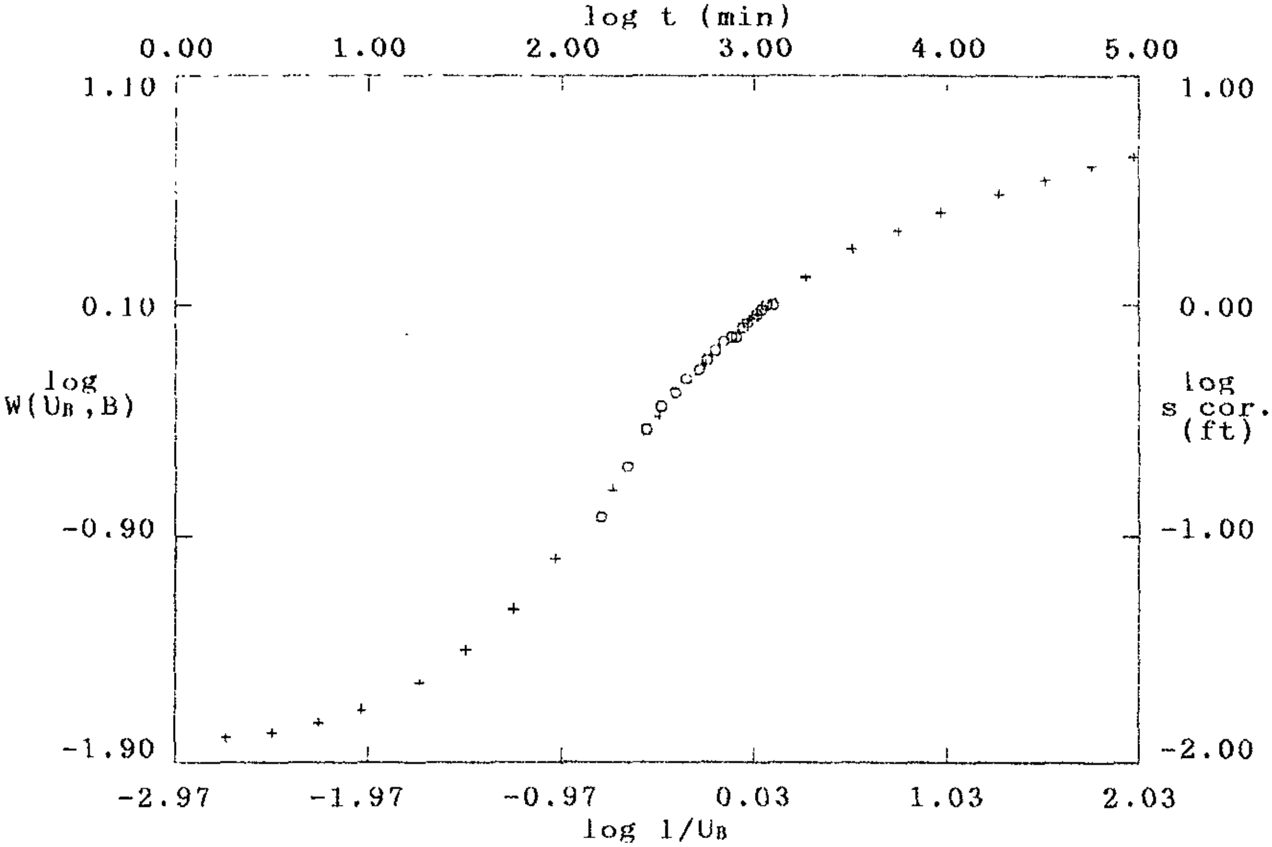
SOLUTION

Transmissivity = 2.389E+0003 gpd/ft
Aquifer Thick. = 8.000E+0000 ft
Hydraulic Cond.= 2.987E+0002 gpd/sq ft
Specific Yield = 2.824E-0003

WELL A5 12 gpm
TEST 0 STEP 3



Well A-6



o - Data

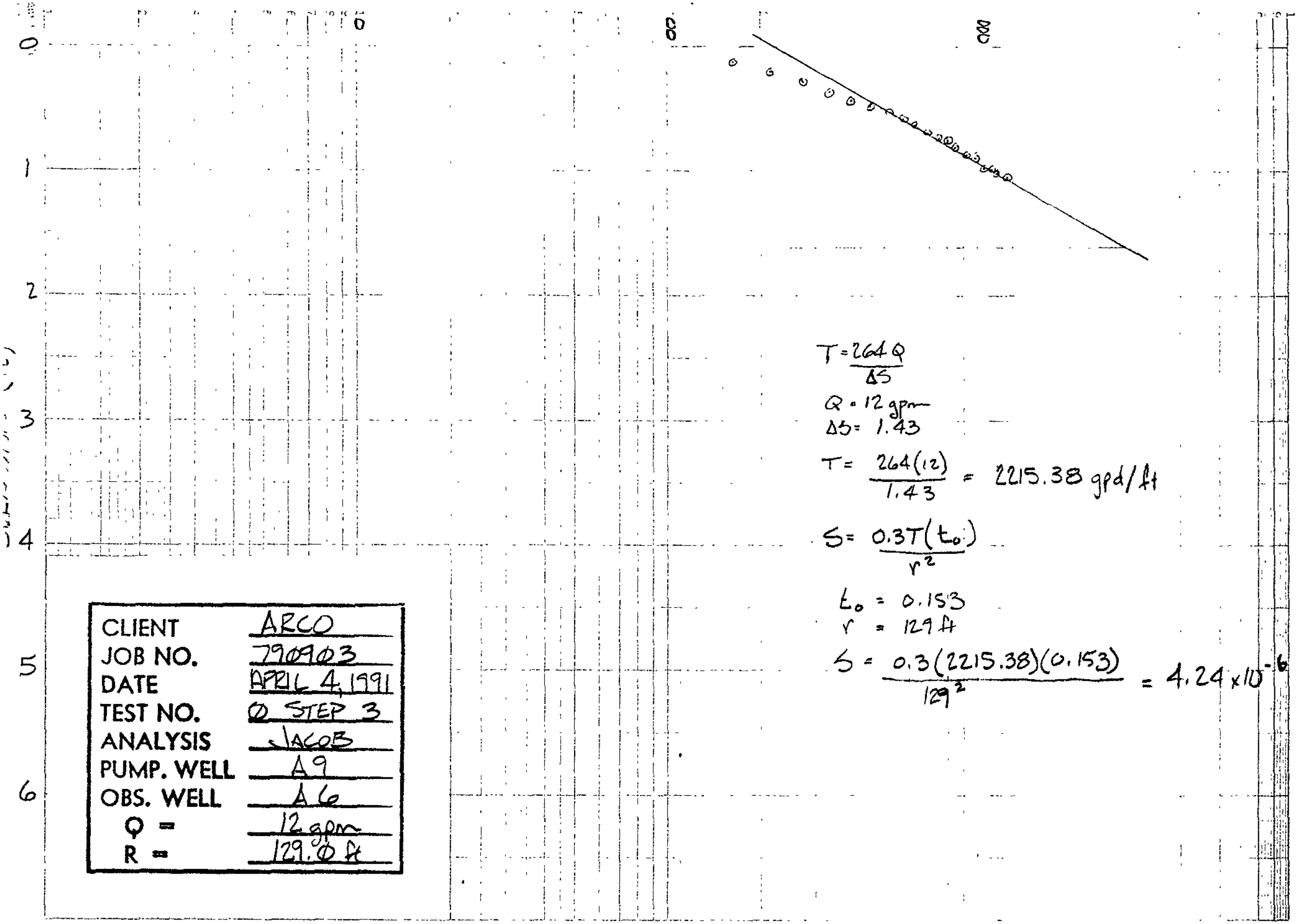
\+ - Type Curve
Unconfined Delayed: beta = 7.00

SOLUTION

Transmissivity = 1.731E+0003 gpd/ft
Aquifer Thick. = 1.300E+0001 ft
Hydraulic Cond.= 1.331E+0002 gpd/sq ft
Specific Yield = 9.013E-0003

WELL A6 12 gpm

TEST 0 STEP 3



$T = \frac{264\,Q}{\Delta s}$

$Q = 12$ gpm

$\Delta s = 1.43$

$T = \frac{264(12)}{1.43} = 2215.38$ gpd/ft

$S = \frac{0.3T(t_o)}{r^2}$

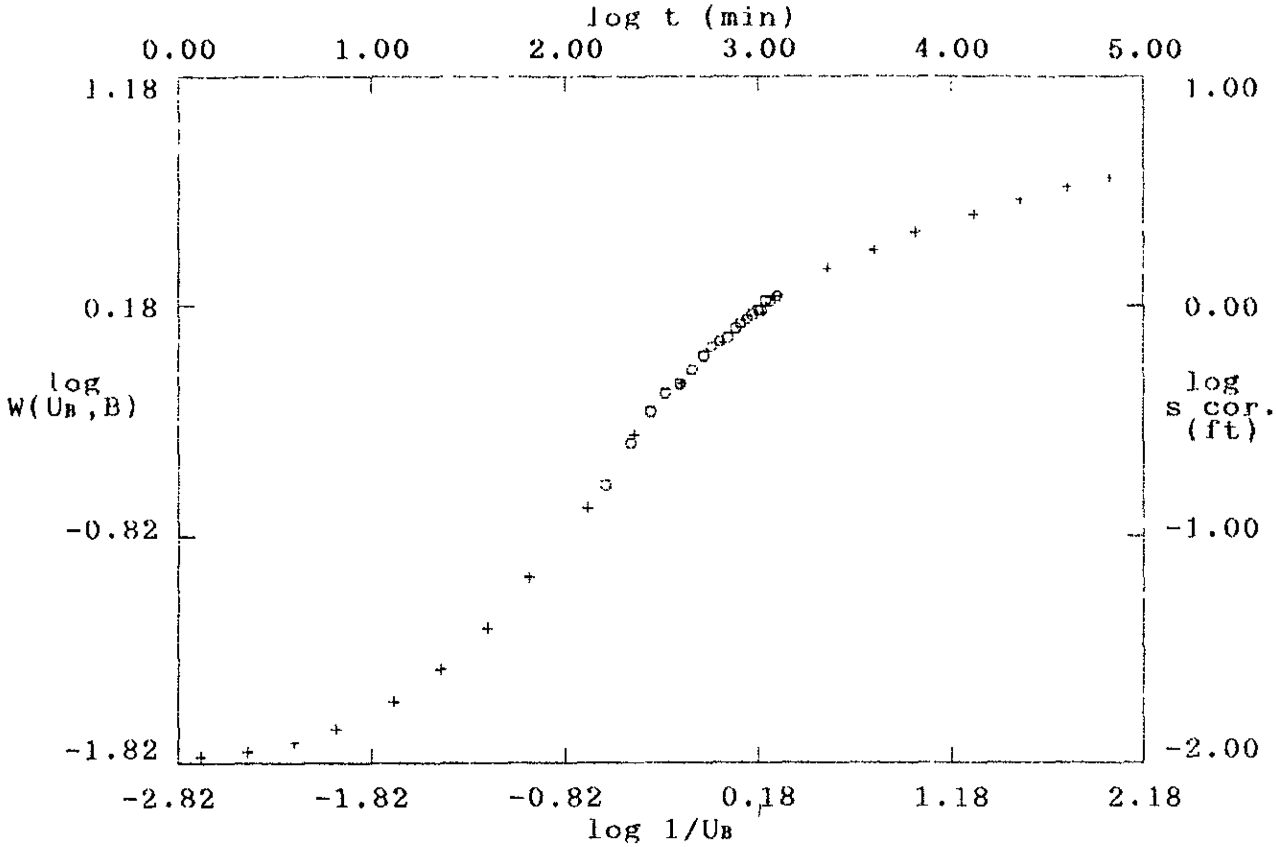
$t_o = 0.153$

$r = 129$ ft

$S = \frac{0.3(2215.38)(0.153)}{129^2} = 4.24 \times 10^{-6}$

CLIENT	ARCO
JOB NO.	790903
DATE	APRIL 4, 1991
TEST NO.	Ø STEP 3
ANALYSIS	JACOB
PUMP. WELL	A9
OBS. WELL	A6
Q =	12 gpm
R =	129.Ø ft

Well A-7



o - Data

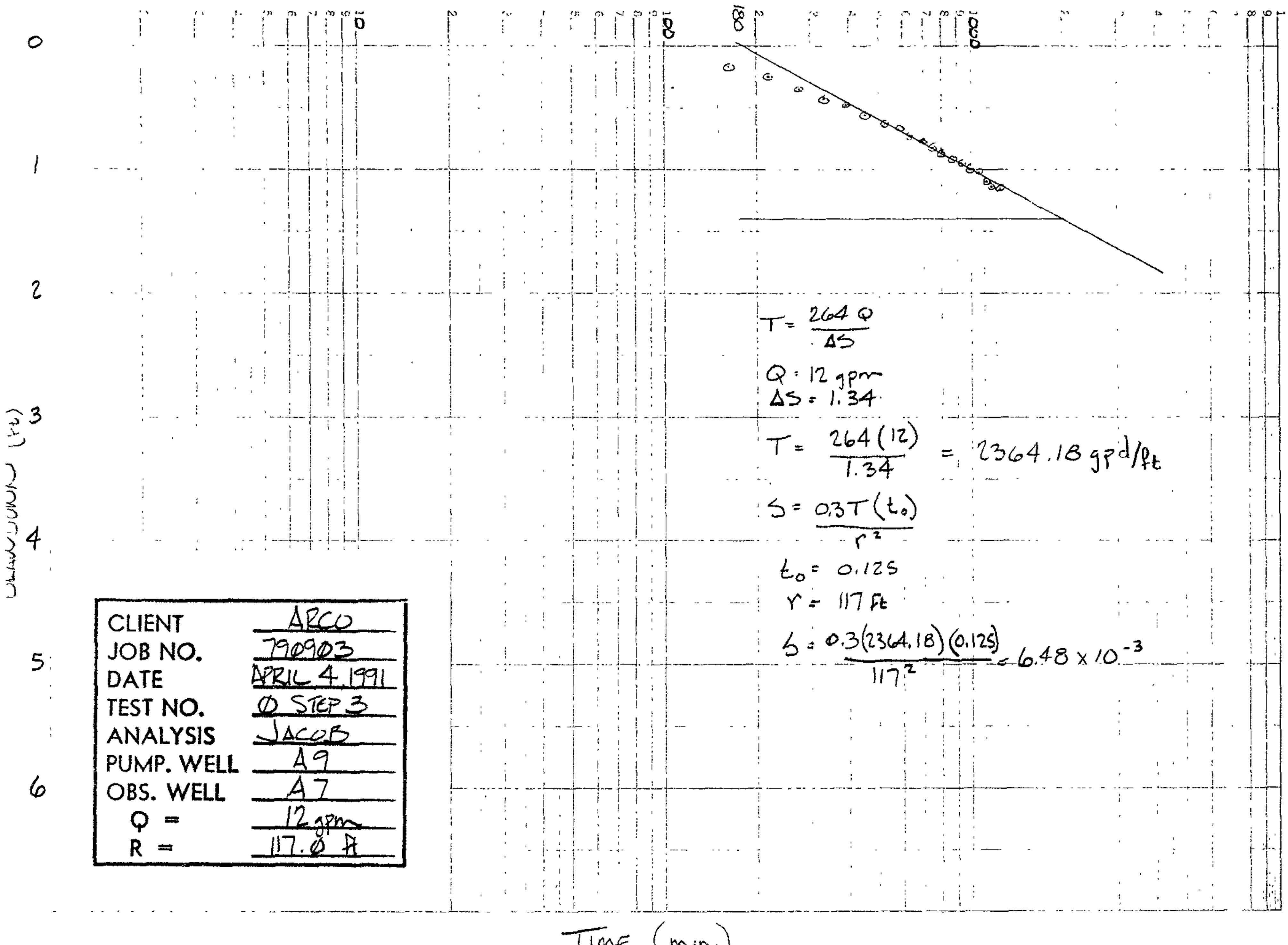
\+ - Type Curve
Unconfined Delayed: beta = 7.00

SOLUTION

Transmissivity = 2.081E+0003 gpd/ft
Aquifer Thick. = 8.000E+0000 ft
Hydraulic Cond.= 2.601E+0002 gpd/sq ft
Specific Yield = 9.653E-0003

WELL A7 12gpm

TEST 0 STEP 3



$T = \frac{264\,Q}{\Delta s}$

$Q = 12$ gpm

$\Delta s = 1.34$

$T = \frac{264(12)}{1.34} = 2364.18$ gpd/ft

$S = \frac{0.3T(t_0)}{r^2}$

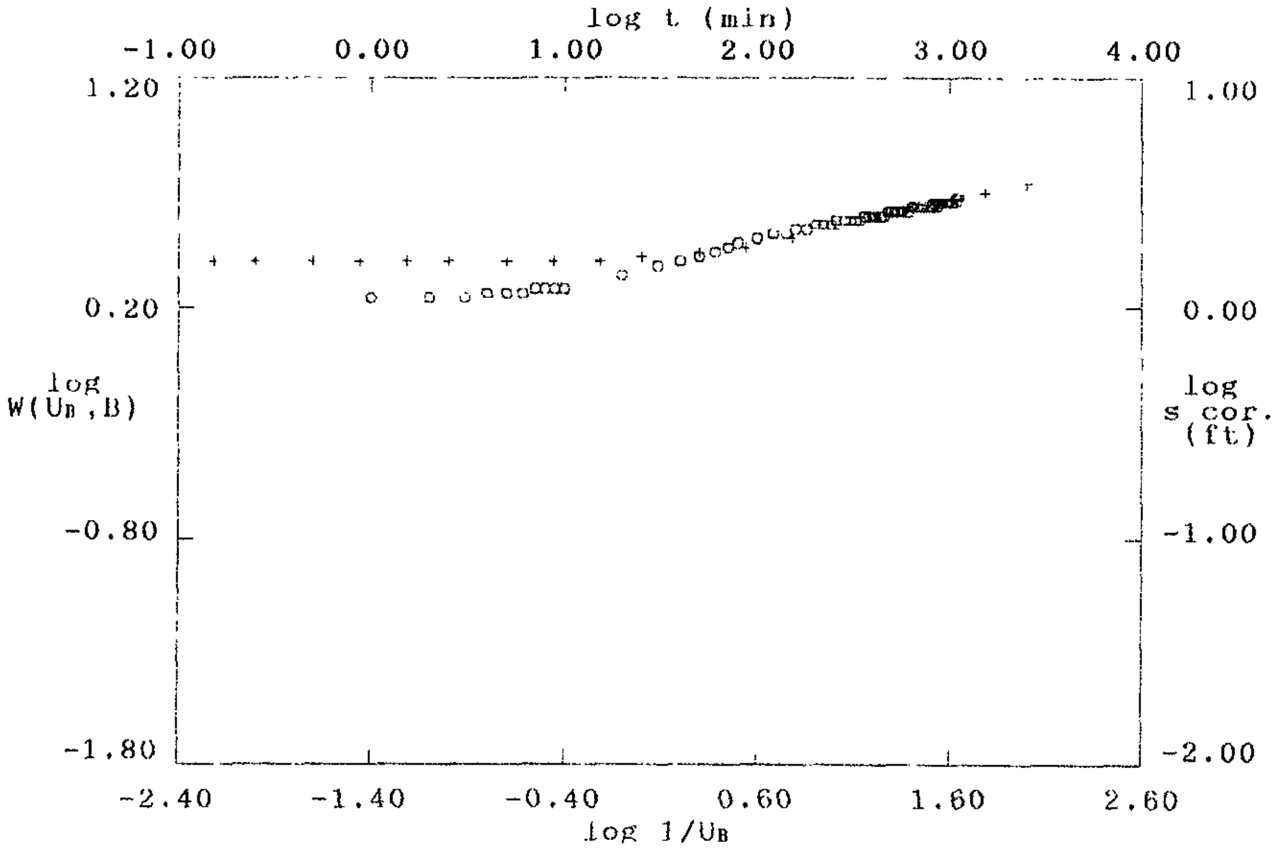
$t_0 = 0.125$

$r = 117$ ft

$S = \frac{0.3(2364.18)(0.125)}{117^2} = 6.48 \times 10^{-3}$

CLIENT	ARCO
JOB NO.	790903
DATE	APRIL 4 1991
TEST NO.	Ø STEP 3
ANALYSIS	JACOB
PUMP. WELL	A9
OBS. WELL	A7
Q =	12 gpm
R =	117.Ø ft

Well A-8



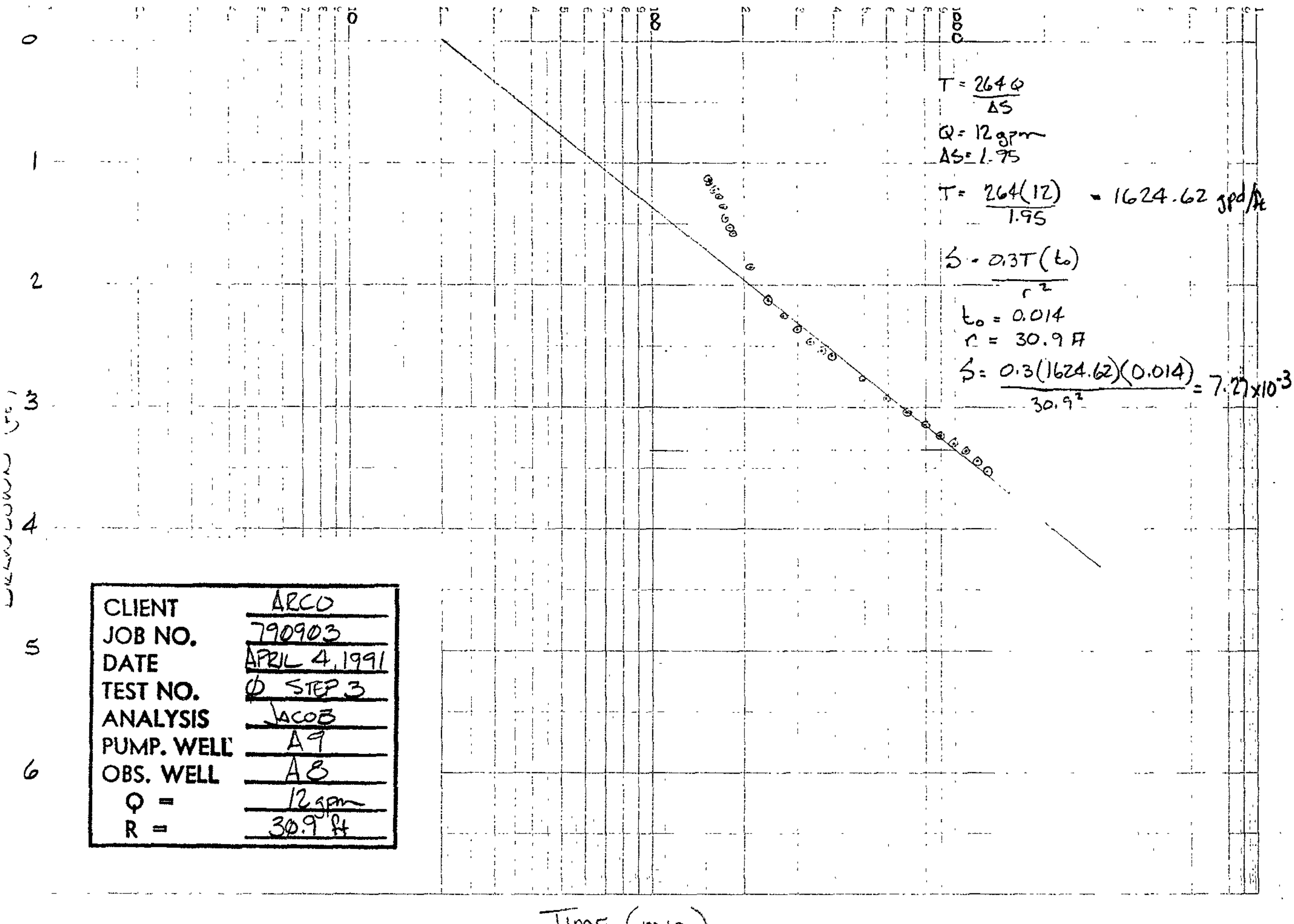
o - Data

\+ - Type Curve
Unconfined Delayed: beta = 0.03

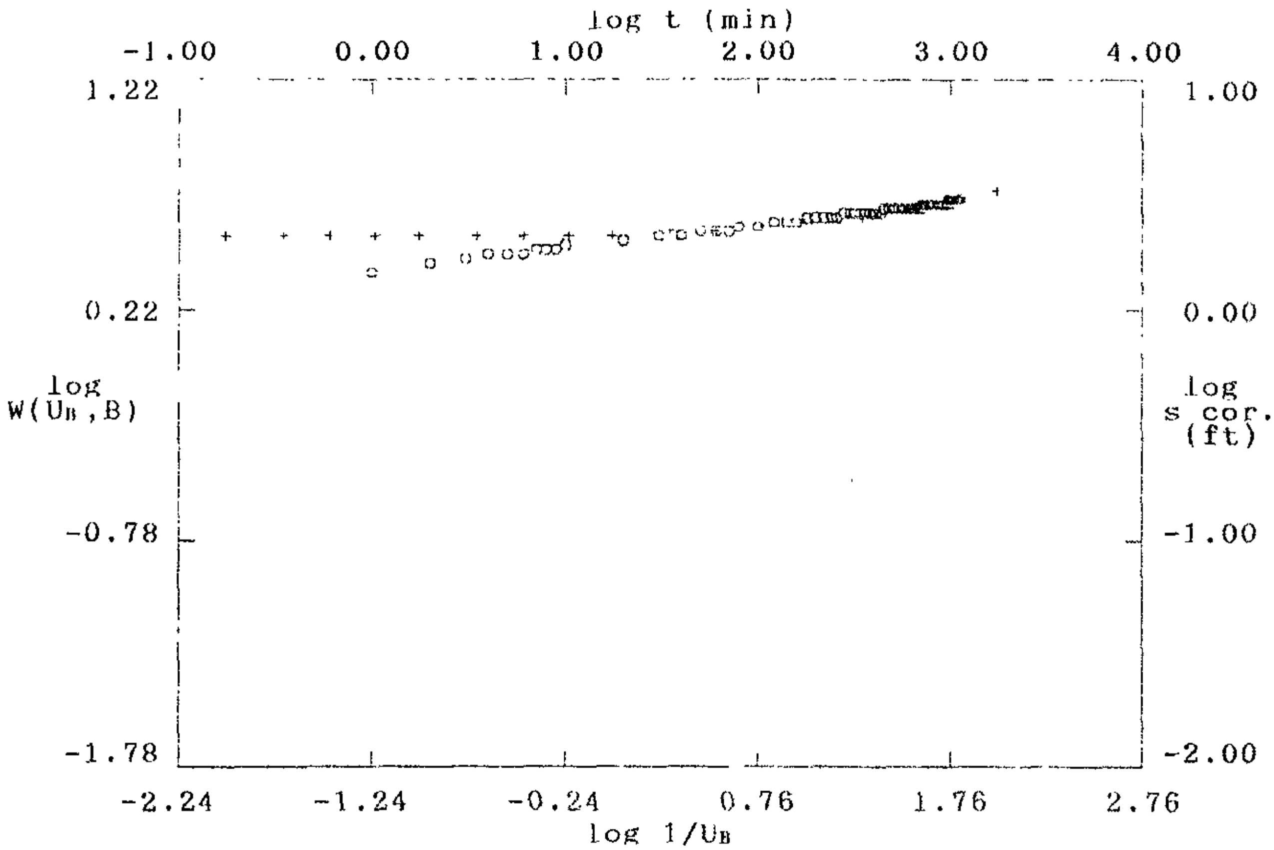
SOLUTION

Transmissivity = 2.179E+0003 gpd/ft
Aquifer Thick. = 1.120E+0001 ft
Hydraulic Cond.= 1.946E+0002 gpd/sq ft
Specific Yield = 5.323E-0003

WELL A8 12 gpm
TEST·0 STEP 3



Well A-10



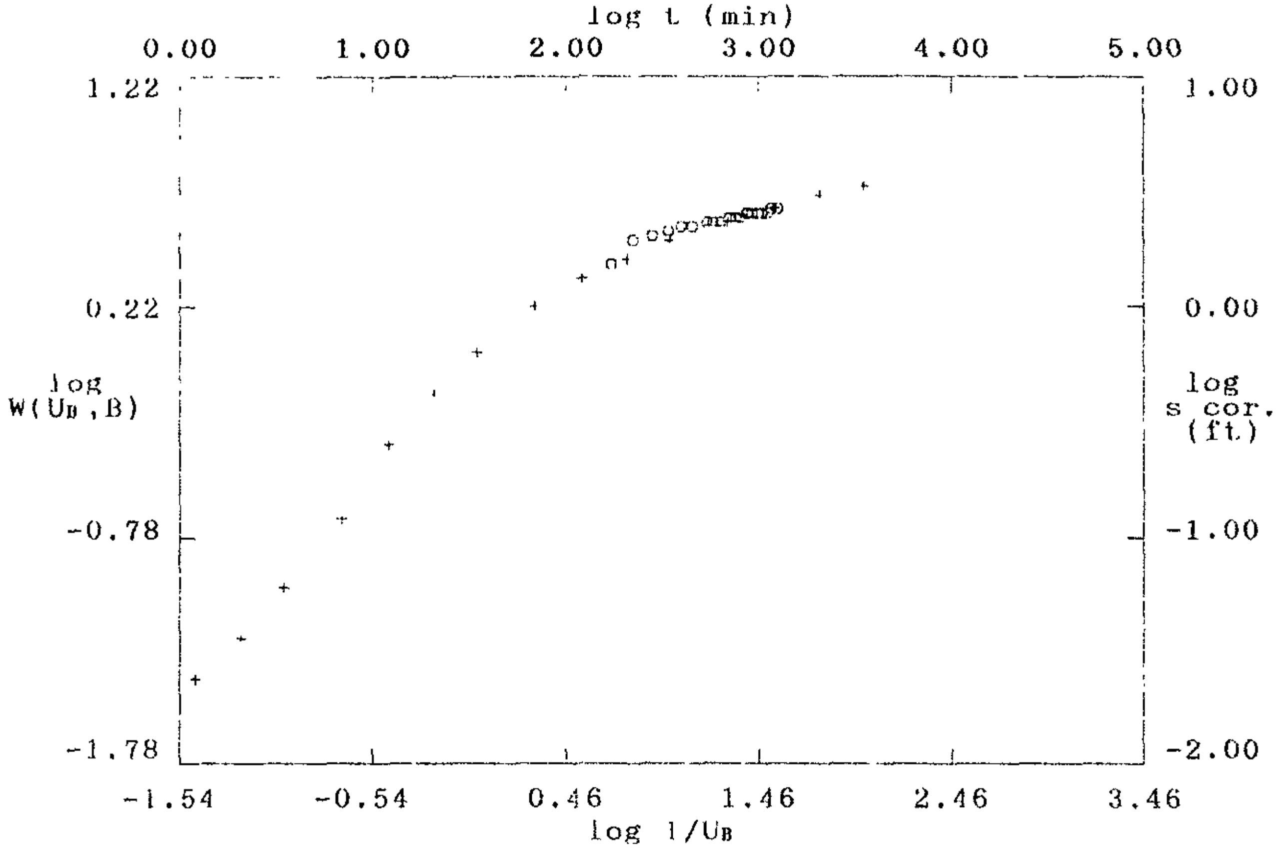
o - Data

\+ - Type Curve
Unconfined Delayed: beta = 0.01

SOLUTION

Transmissivity = 2.282E+0003 gpd/ft
Aquifer Thick. = 1.225E+0001 ft
Hydraulic Cond.= 1.863E+0002 gpd/sq ft
Specific Yield = 2.421E-0003

Well A-11



o - Data

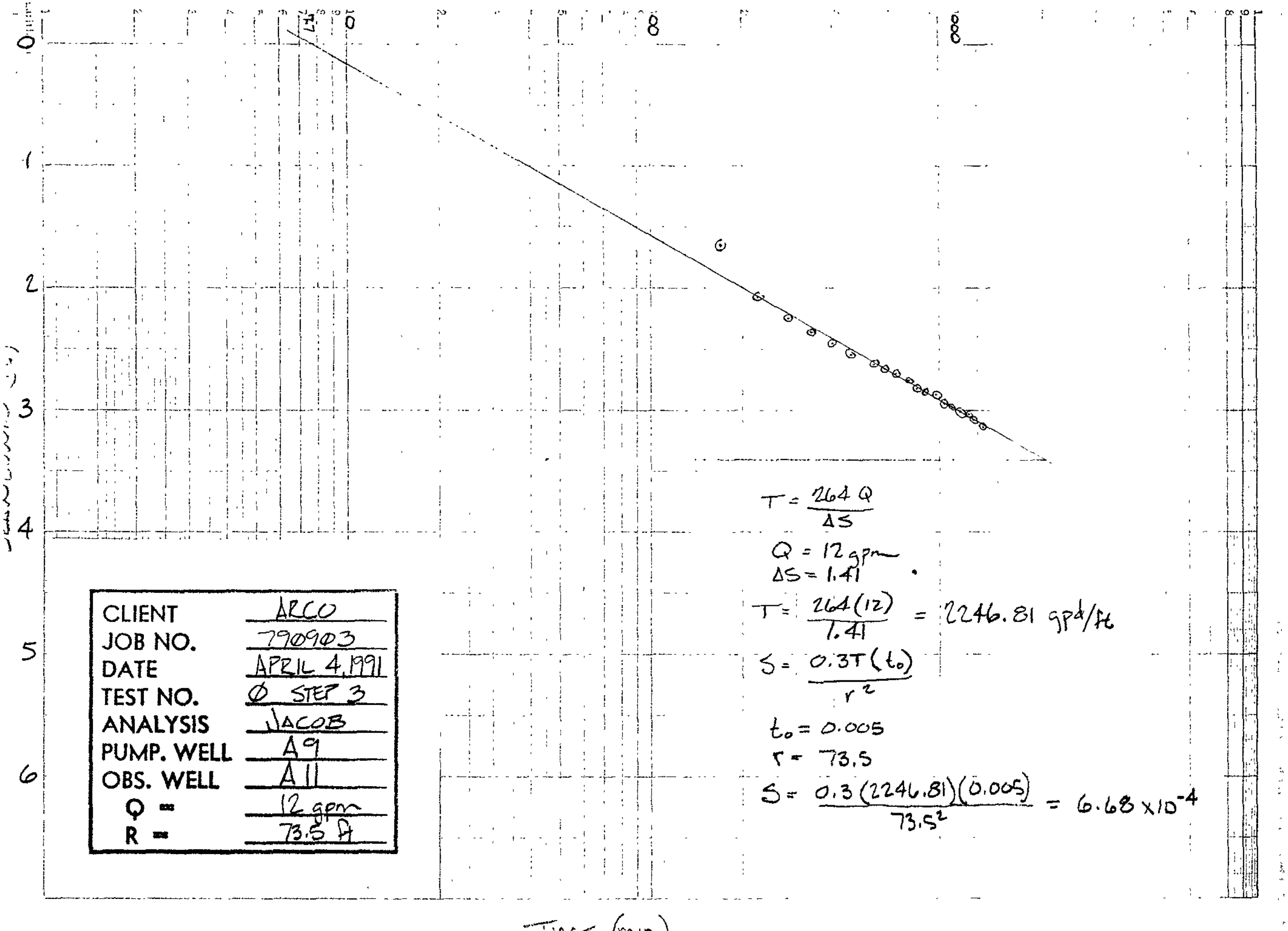
\+ - Type Curve
Unconfined Delayed: beta = 7.00

SOLUTION

Transmissivity = 2.282E+0003 gpd/ft
Aquifer Thick. = 1.000E+0001 ft
Hydraulic Cond.= 2.282E+0002 gpd/sq ft
Specific Yield = 1.360E-0003

WELL A-11   12gpm

TEST 0 STEP 3



CLIENT	ARCO
JOB NO.	790903
DATE	APRIL 4, 1991
TEST NO.	Ø STEP 3
ANALYSIS	JACOB
PUMP. WELL	A9
OBS. WELL	A11
Q =	12 gpm
R =	73.5 ft

$$T = \frac{264\,Q}{\Delta s}$$

$Q = 12$ gpm

$\Delta s = 1.41$

$$T = \frac{264(12)}{1.41} = 2246.81 \text{ gpd/ft}$$

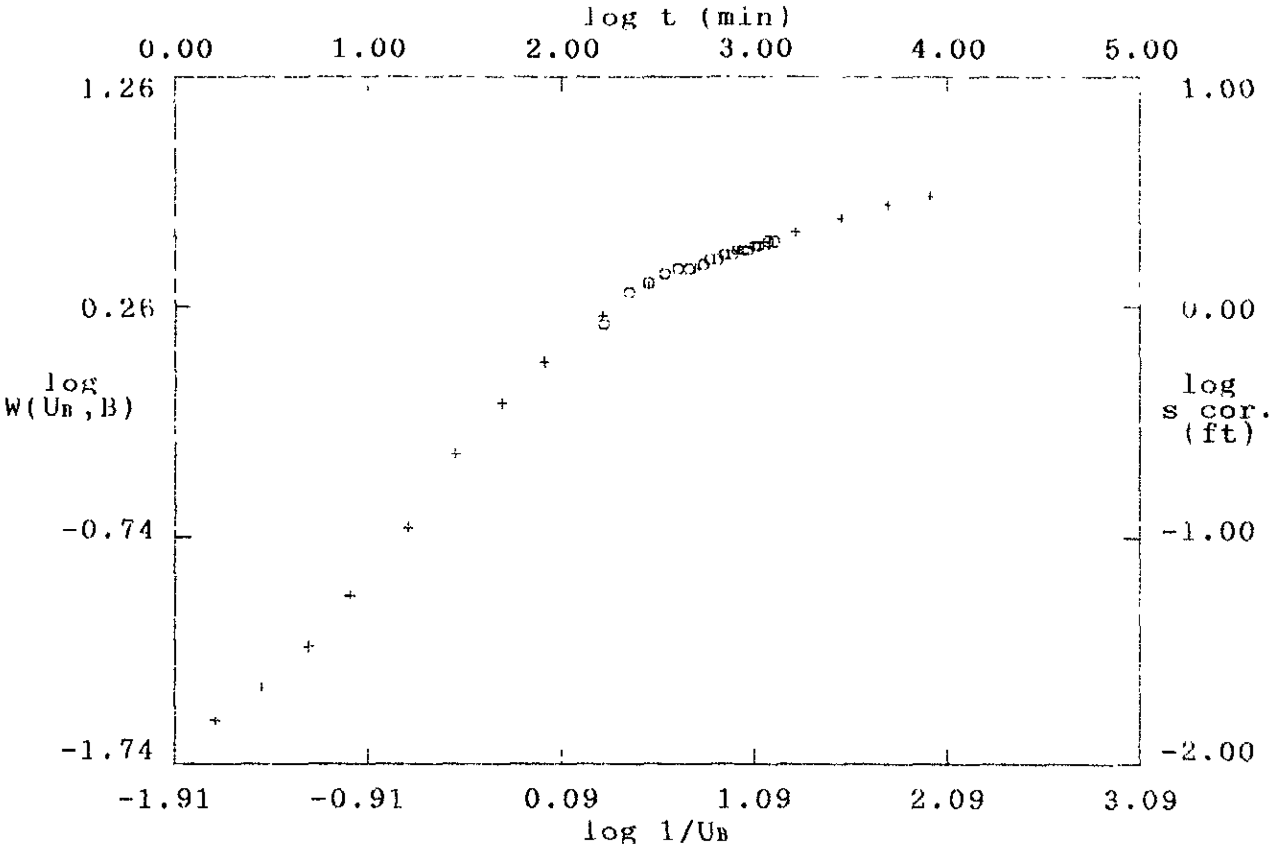
$$S = \frac{0.3T(t_o)}{r^2}$$

$t_o = 0.005$

$r = 73.5$

$$S = \frac{0.3(2246.81)(0.005)}{73.5^2} = 6.68 \times 10^{-4}$$

Well A-12



o - Data

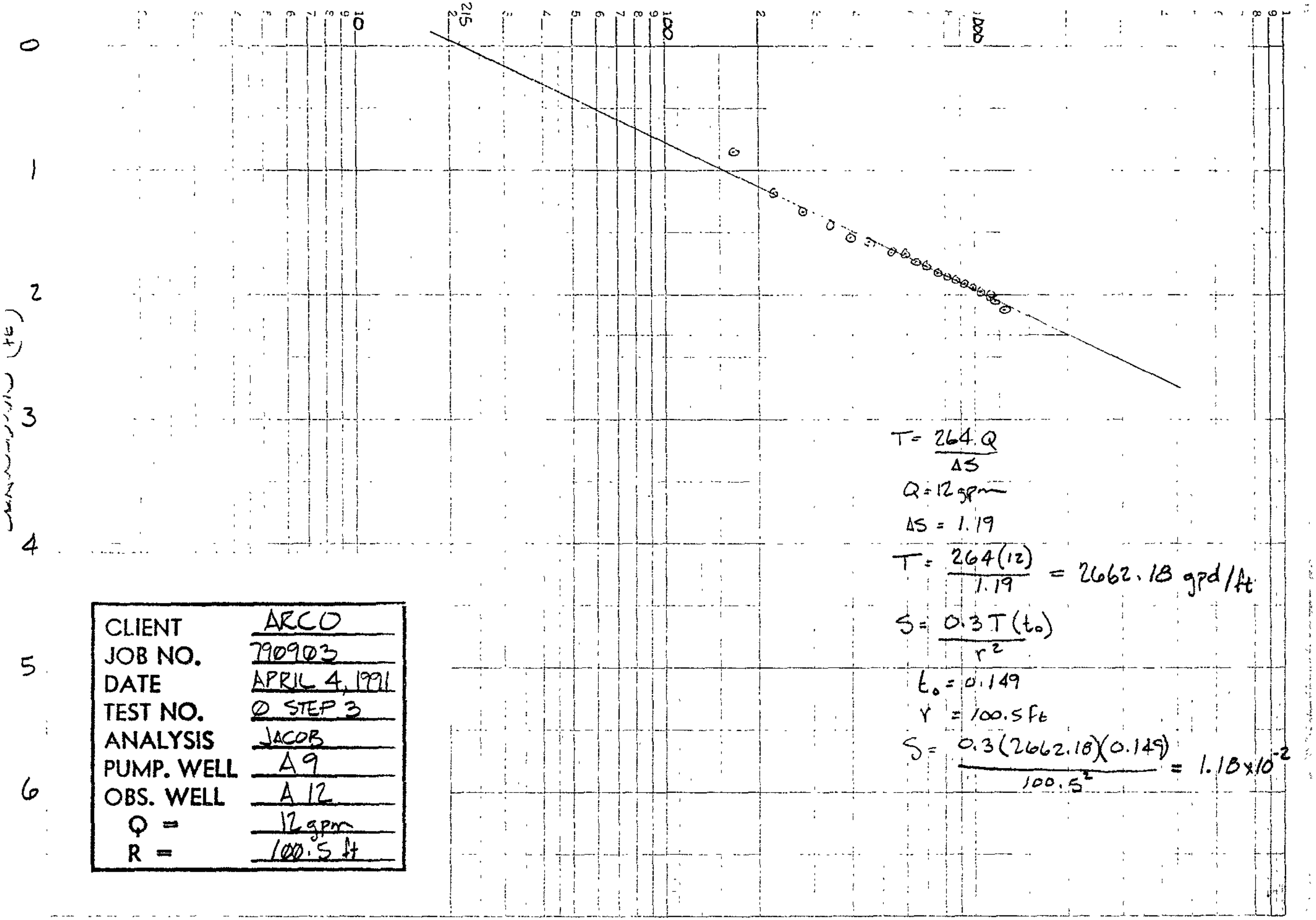
+ - Type Curve
Unconfined Delayed: beta = 7.00

SOLUTION

Transmissivity = 2.502E+0003 gpd/ft
Aquifer Thick. = 1.200E+0001 ft
Hydraulic Cond.= 2.085E+0002 gpd/sq ft
Specific Yield = 1.869E-0003

WELL A12 12 gpm

TEST 0 STEP 3



$$T = \frac{264\,Q}{\Delta S}$$

Q = 12 gpm

$\Delta S = 1.19$

$$T = \frac{264(12)}{1.19} = 2662.18 \text{ gpd/ft}$$

$$S = \frac{0.3\,T\,(t_o)}{r^2}$$

$t_o = 0.149$

r = 100.5 ft

$$S = \frac{0.3(2662.18)(0.149)}{100.5^2} = 1.18 \times 10^{-2}$$

CLIENT	ARCO
JOB NO.	790903
DATE	APRIL 4, 1991
TEST NO.	Ø STEP 3
ANALYSIS	JACOB
PUMP. WELL	A9
OBS. WELL	A 12
Q =	12 gpm
R =	100.5 ft

Time (min)

APPENDIX B

HARRILL/RECOVERY METHOD

HARRILL/RECOVERY METHOD