GeoStrategies Inc.

AQUIFER TEST REPORT

UNOCAL Service Station No. 5760
376 Lewelling Boulevard
San Lorenzo, California

780909-18

March 7, 1994

GeoStrategies Inc.

March 7, 1994

UNOCAL Corporation
P. O. Box 5155
San Ramon, California 94583

Attn: Ms. Tina Berry

Re: **AQUIFER TEST REPORT**
UNOCAL Service Station No. 5760
376 Lewelling Boulevard
San Lorenzo, California

Ms. Berry:

This Aquifer Test Report was prepared by GeoStrategies Inc. (GSI), and presents results of the aquifer test performed February 2 through 4, 1994, at the above referenced site (Plate 1). Site activities were performed as outlined in the GSI *Work Plan* (GSI Report No. 7809-16, dated October 23, 1993).

SITE BACKGROUND

The underground storage tanks were replaced at this site during November and December 1987. Well U-1 was installed by Woodward-Clyde Consultants in February 1988 in response to contamination observed during the underground tank replacement (Woodward-Clyde Report No. 8820011A-0015, March 25, 1988). Benzene concentrations of 3,600 parts per billion (ppb) were detected in groundwater samples from Well U-1, as a result, GSI installed three groundwater monitoring wells (U-2 through U-4) in August, 1990 (GSI Report No. 7809-3, November 16, 1990). In March 1992, GSI installed four additional groundwater monitoring wells (U-5 through U-8) to further delineate the groundwater hydrocarbon plume (GSI Report No. 7809-10, June 15, 1992). Well U-9 was installed by GSI May 25, 1993 (GSI Report No. 7809-15, August 9, 1993. Quarterly groundwater monitoring and sampling has been performed at the site since March, 1990.

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HYDROGEOLOGIC CONDITIONS AND SITE GEOLOGY

The site is located approximately 500 feet north of San Lorenzo Creek, in an area of relatively flat topography. Soils beneath the subject site are Holocene-age alluvial deposits consisting of unconsolidated, moderately sorted, permeable fine sand, silt, and clayey silt with a few thin beds of coarse sand (Helley, et. al., 1979).

Available boring logs indicate that the subsurface lithology consists of interfingering units of clay, silt and sands to a depth of 25 feet. The shallow groundwater zone consists of a sand layer between 5 and 10 feet in thickness that appears to be laterally continuous beneath the site. Below this sand zone is a clay/silt rich zone approximately 5 to 10 feet in thickness. This clay zone may act locally as an aquitard.

Groundwater is currently measured at approximately 16 feet below the surface. The water-bearing zone appears to be unconfined.

AQUIFER TEST FIELD ACTIVITIES

A three-hour step-drawdown and a 24-hour constant-rate discharge test were performed utilizing Well U-1 as the extraction well on February 2 through 4, 1994. The tests were performed to assess the feasibility of utilizing groundwater extraction to achieve hydrodynamic control of groundwater for extraction of petroleum hydrocarbons from the uppermost shallow groundwater zone beneath the site.

Water level measurements were obtained from Wells U-1 through U-9 prior to conducting the test to establish baseline data (Plate 3). Pressure transducers connected to a Hermit SE2000 data logger were installed in Wells, U-1, U-3, U-4 and U-8 to monitor water level changes during the tests. Water level changes in Wells U-2, U-5, U-6, U-7 and U-9 were monitored with an electronic interface probe at various times throughout the duration of the tests.

AQUIFER TEST RESULTS

Data collected during the three-hour step-drawdown and 24-hour constant-rate test were evaluated and used to calculate specific aquifer parameters; Transmissivity (T) and Storativity (S). Additional aquifer and well characteristics evaluated include observed radius of influence and well efficiency.

Step-Drawdown Test

Well U-1 was pumped at various discharge rates to establish an optimum long-term discharge rate for the constant-rate test. The step-drawdown test consisted of six steps. The discharge rates for steps one through five were:

Step 1 - 40 minutes at 0.25 gallons per minute (gpm)
Step 2 - 40 minutes at 0.50 gpm
Step 3 - 50 minutes at 1 gpm
Step 4 - 46 minutes at 2 gpm
Step 5 - 3 minutes at 4 gpm

The pumping well dewatered during the fifth step (4 gpm). Step six was the well recovery step (10 minutes). Evaluation of the step-drawdown test data indicated a constant discharge rate of 2 gpm (Appendix A).

Constant-Rate Test

Well U-1 was pumped for a total of 1440 minutes at a constant discharge rate of 2 gpm. Maximum observed drawdown in pumping well U-1 was 3.44 feet. Maximum observed drawdown in the pumping well and observation wells are summarized in Table 1. Water-level data were collected and recorded as the pumping well recovered to greater than 90% of the total recorded drawdown in Well U-1. Maximum observed drawdown data were used to construct a map of water-levels at the end of pumping (Plate 4).

Well Efficiency

The well efficiency was calculated using constant-rate drawdown data as described in Driscoll (1989, pp. 244-245). Calculations of the well efficiency and a graph of the drawdown versus distance from the pumping well for Wells U-2, U-3, U-7 and U-8 is included in Appendix B. Well efficiency was calculated at approximately 12% for a flow rate of 2 gpm.

Aquifer Characteristics

Time versus drawdown data were plotted for observation Wells U-2, U-3, U-7 and U-8. Transmissivity (T) and Storativity (S) values were calculated from these field data plots using the Jacob straight-line Method (Cooper and Jacob, 1946). Calculated transmissivity values from the data plots using the Jacob Method ranged from 2,736 to 7,437 gallons per day per foot (gpd/ft). Storativity values ranged from 0.014 to 0.036. Storativity values are indicative of unconfined aquifer conditions and appears to be consistent with field observations. Jacob Method transmissivity and storativity data are summarized in Table 2. Data plots are presented in Appendix C.

To further evaluate transmissivity and storativity values, GSI used Graphical Well Analysis Package (GWAP) software to analyze constant rate test data using the Theis Method (Neuman, 1975). Data plots generated utilizing GWAP are presented in Appendix D. Transmissivity values calculated using the Theis Method for Wells U-2, U-3, U-7 and U-8 ranged from 2,631 to 7,081 gpd/ft. Storativity values for these wells ranged from 0.012 to 0.035. Transmissivity and storativity values appear to be consistent with the calculated Jacob values. GWAP transmissivity and storativity values are summarized in Table 2.

Approximately 3,500 gallons of groundwater were pumped during the aquifer tests. Groundwater was transported by UNOCAL's contract transporter to UNOCAL's refinery in Rodeo, California for disposal.

Well Influence

Data collected from the observations wells during the constant-rate aquifer test were used to construct a water-level map after 1400 minutes of pumping from Well U-1 at 2 gpm (Plate 4). Drawdown recorded in the observation wells ranged from approximately 0.08 to 0.19 feet. Barometric pressure changes recorded during the constant rate test ranged from 29.91 to 30.16 inches of water. The change in barometric pressure during the test should not affect the observed depth-to-water measurements. The observed radius of influence appears elliptical in shape, extending to the northeast (Well U-2) and southwest (Well U-7) of the pumping well. The cone of depression created by pumping Well U-1 did not equilibrate during the constant-rate test, indicating that pumping for a longer time duration may produce greater influence.

DISCUSSION

Results of the aquifer test indicate that a groundwater extraction remediation system may be feasible for treatment of the petroleum hydrocarbon plume beneath the site. The observed radius of influence and pumping rate appear to be sufficient to affect hydrodynamic control of the known hydrocarbon plume.

If you have questions, please call.

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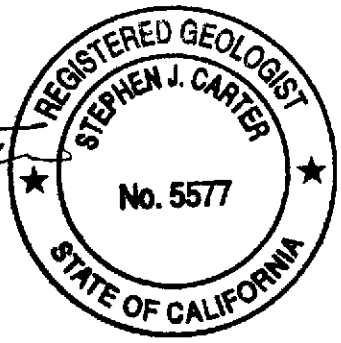

Stephen J. Carter
Project Geologist
RG 5577

FOR
Cliff M. Garratt
Hydrogeologist

SJC/CMG

Table 1. Maximum Observed Drawdown
Table 2. Aquifer Parameters

Plate 1. Vicinity Map
Plate 2. Site Plan
Plate 3. Water-Level Map (Prior to Pumping)
Plate 4. Water-Level Map (After Pumping)

Appendix A. Time vs. Drawdown Plot for Step-Drawdown Test
Appendix B. Well Efficiency Plot
Appendix C. Jacob Method Plots for Constant-Rate Test
Appendix D. GWAP Plots for Constant-Rate Test

QC Review:

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REFERENCES

Cooper, H. H., Jr., and Jacob, C. E., 1946, *A Generalized Graphical Method for Evaluating Formation Constant and Summarizing Well Field History*, Transactions, American Geophysical Union, 36, pp. 90-100.

Dansby, D.A. and Price, C.A., 1990, *Graphical Well Analysis Package*, Groundwater Graphics, Version 2.33.

Driscoll, F.G., 1986, *Groundwater and Wells*, 2nd Edition, Johnson Filtration Systems Inc., Saint Paul, Minnesota,1108 p.

Helley E.J., Lajoie K.R., Spangle W.E., and Blair M.L., 1979, *Flatland Deposits of the San Francisco Bay Region, California - their geology and engineering properties and their importance to comprehensive planning*, Geological Survey Professional Paper 943, U.S. Government Printing Office, Washington.

Neuman, S.P., 1975, *Analysis of Pumping Test Data From an Anisotropic Unconfined Aquifer considering Delayed Response*, Water Resources Res., 11 pp. (329-342).

Table 1
Maximum Observed Drawdown
UNOCAL Service Station No. 5760
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Well Number	Maximum Drawdown (ft.)
U-1	3.44
U-2	0.11
U-3	0.18
U-4	0.04
U-5	0.10
U-6	0.07
U-7	0.07
U-8	0.14
U-9	0.05

Note:
1. Well U-1 pumped at Q = 2 gpm for t = 1440 minutes.
2. Wells U-1, U-3, U-4 and U-8 measured with pressure transducers at t = 1440 minutes.
3. Wells U-2, U-5, U-6, U-7 and U-9 measured with electronic interface probe between t = 1442 and 1450 minutes.

Table 2
Aquifer Parameters
UNOCAL Service Station No. 5760
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San Lorenzo, California

Monitoring Well	Transmissivity (Jacobs) (gpd/ft)	Storativity (Jacobs)	Transmissivity (Neuman) (gpd/ft)	Storativity (Neuman)	Hydraulic Conductivity (gpd/ft^2)
U-2	5077	0.036	5013	0.012	334.2
U-3	2736	0.036	2631	0.034	175.4
U-7	7437	0.014	7081	0.014	472.1
U-8	6140	0.02	5249	0.035	350.0

Note: 1. Well U-1 pumped at Q = 2 gpm for t = 1440 minutes.
2. gpd/ft = gallons per day per foot.
3. gpd/ft^2 = gallons per day per square foot.

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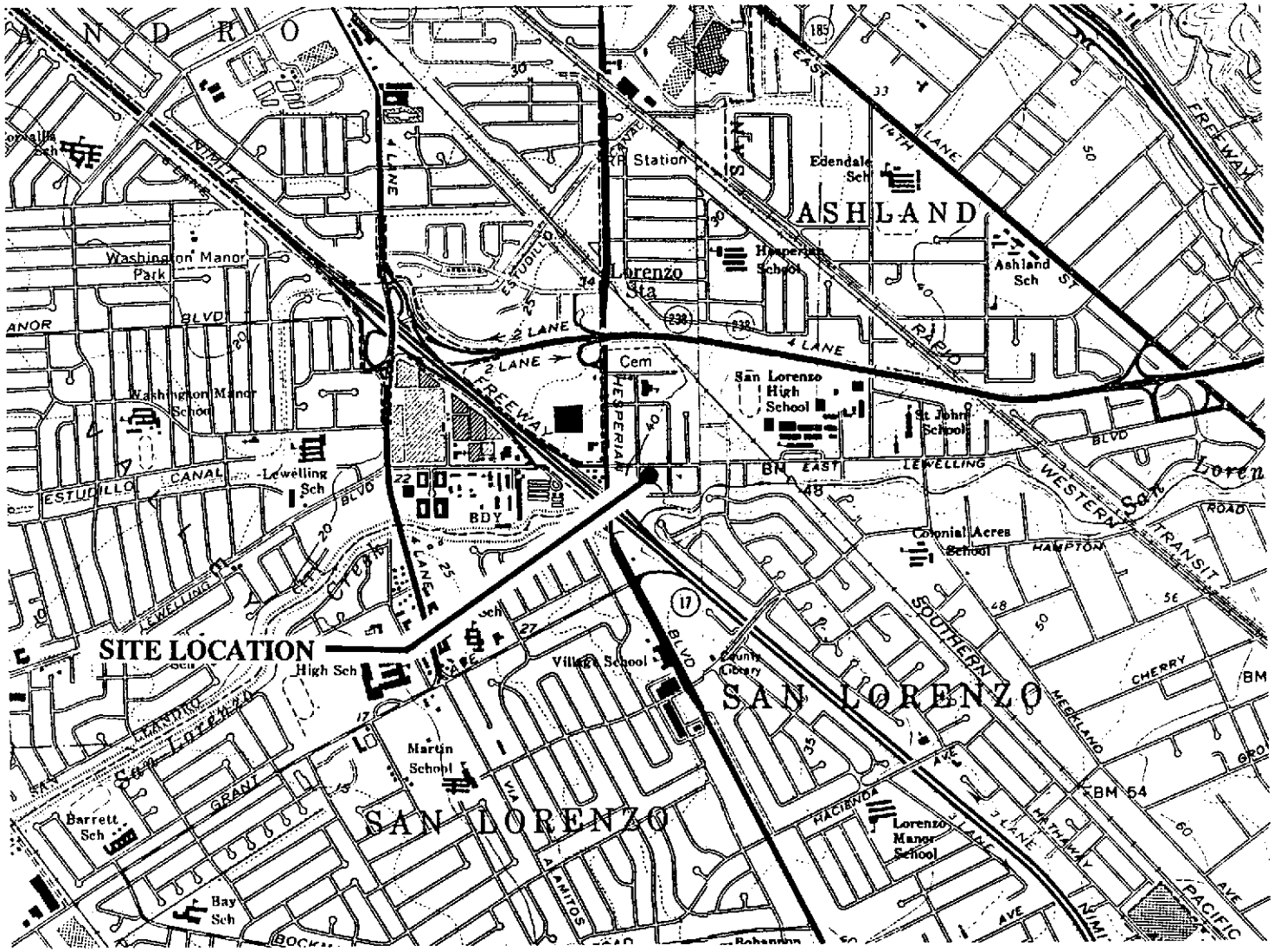

N

0 2000

Scale in Feet

Base Map: USGS Topographic Map

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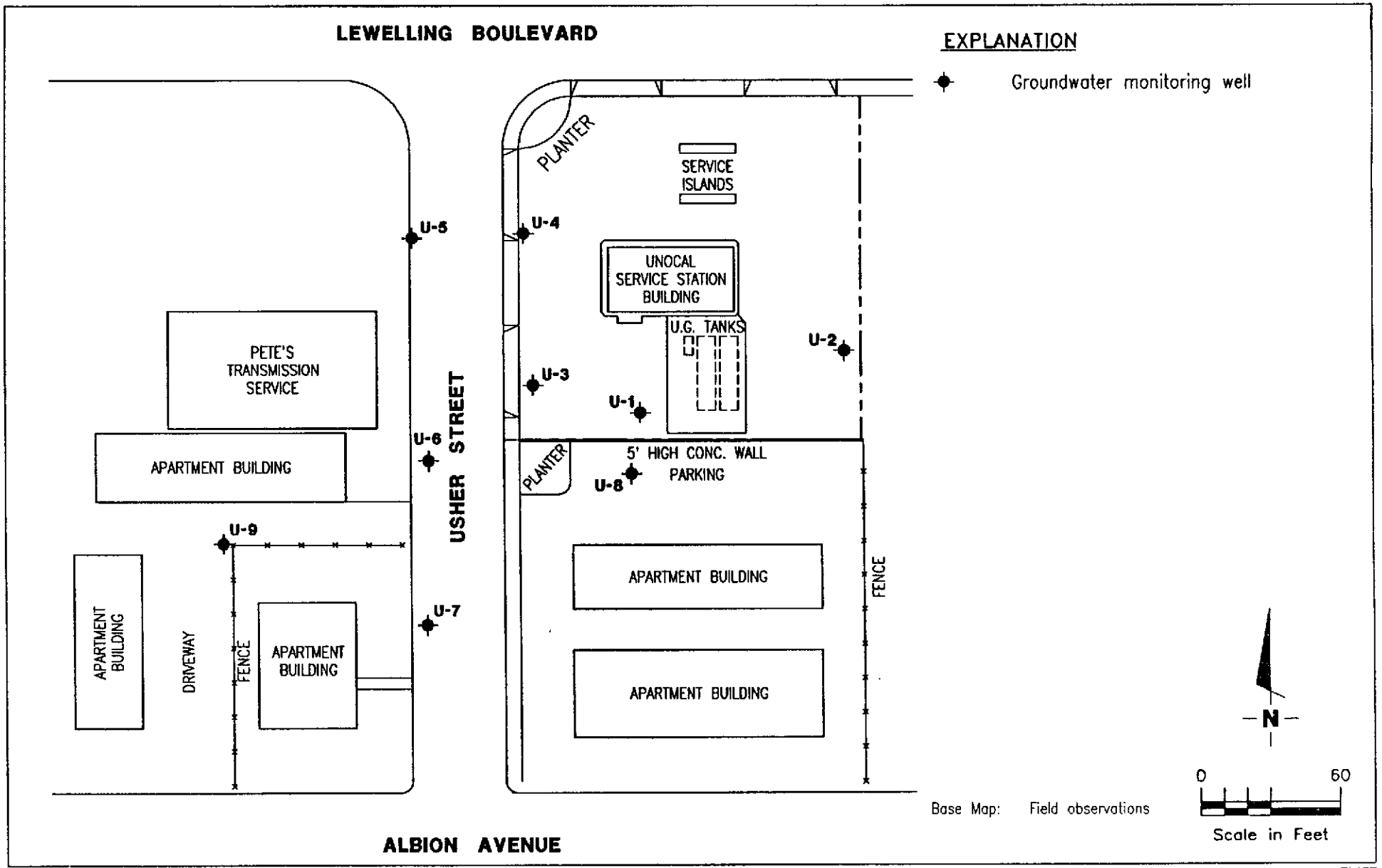
VICINITY MAP
UNOCAL Service Station #5760
376 Lewelling Boulevard
San Lorenzo, California

PLATE 1

JOB NUMBER	REVIEWED BY	DATE	REVISED DATE
7809		2/91	



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SITE PLAN
UNOCAL Service Station #5760
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PLATE **2**

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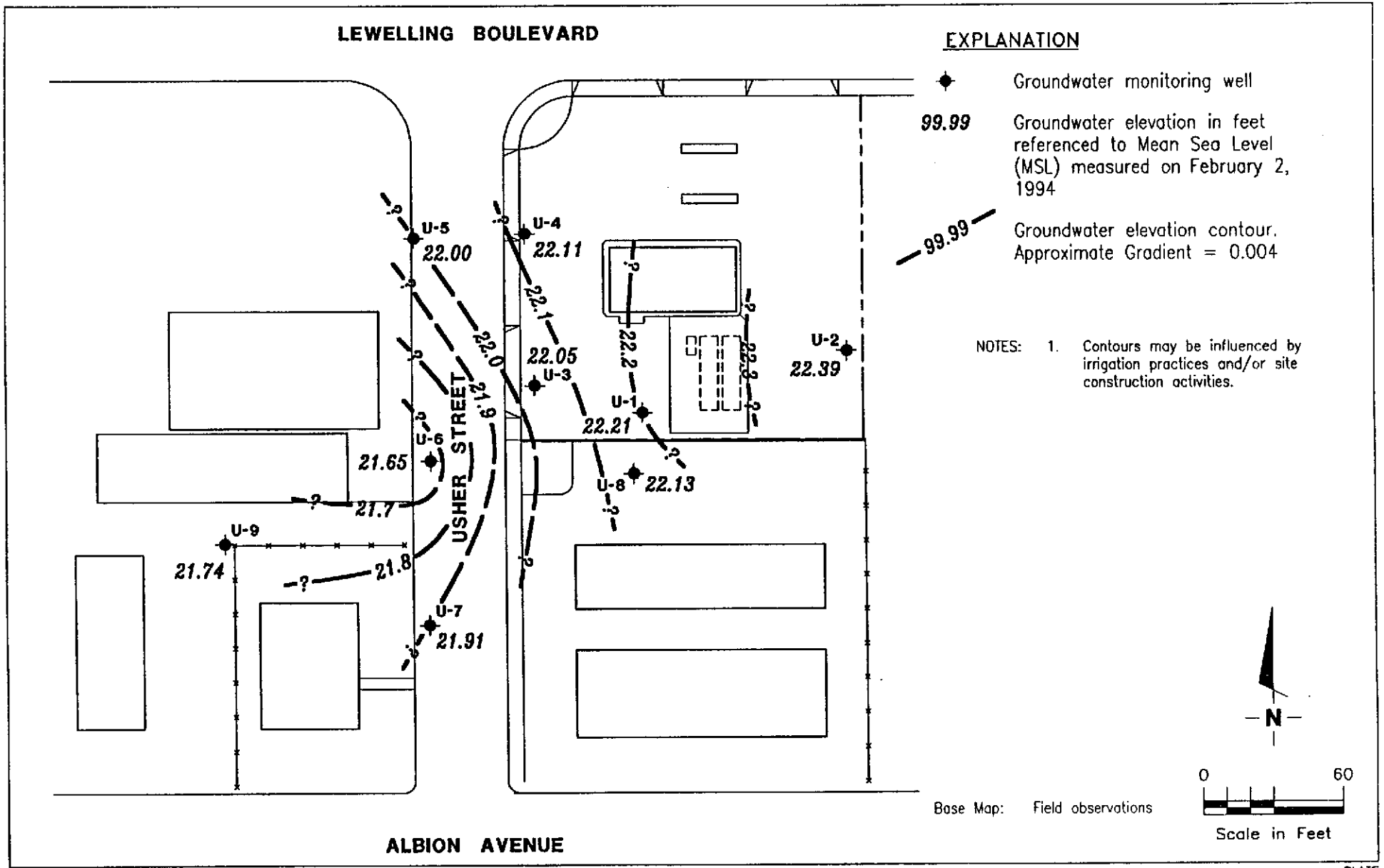

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WATER LEVEL MAP (PRIOR TO PUMPING)
UNOCAL Service Station #5760
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PLATE 3

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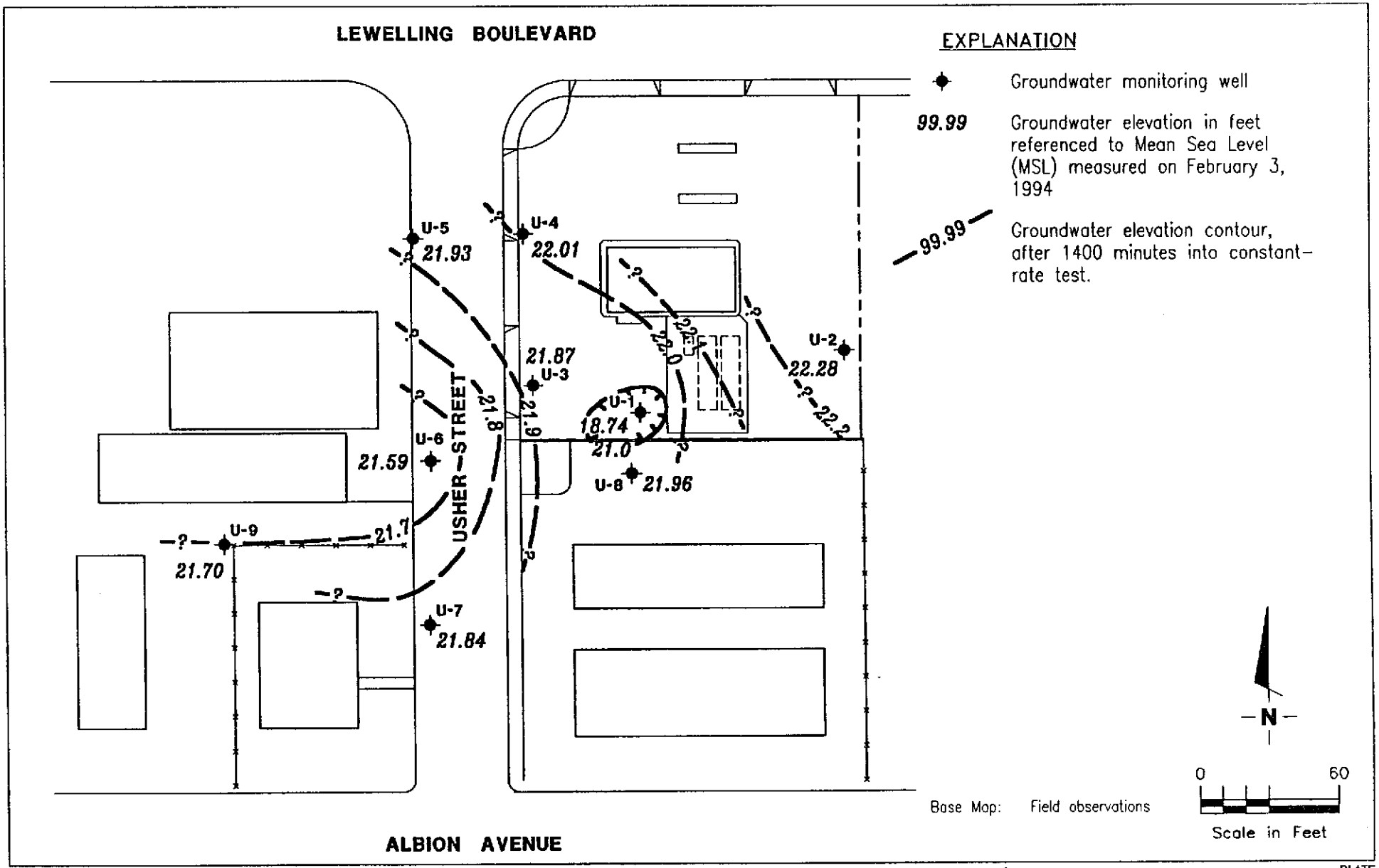

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WATER LEVEL MAP (AFTER PUMPING)
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PLATE
4

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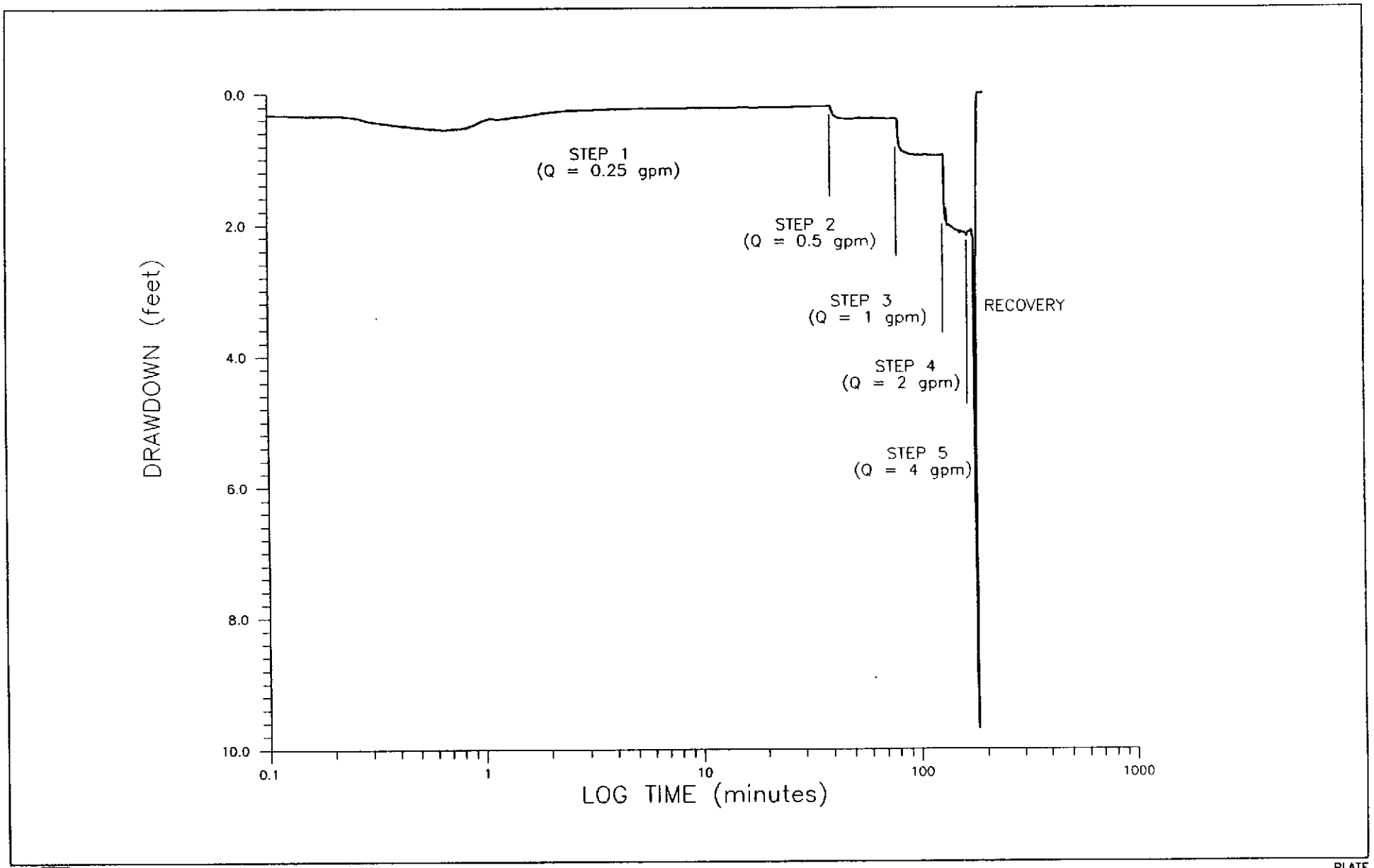
APPENDIX A

TIME VS. DRAWDOWN PLOT

FOR

STEP-DRAWDOWN TEST



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WELL U-1 – Step Test Plot
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PLATE
A

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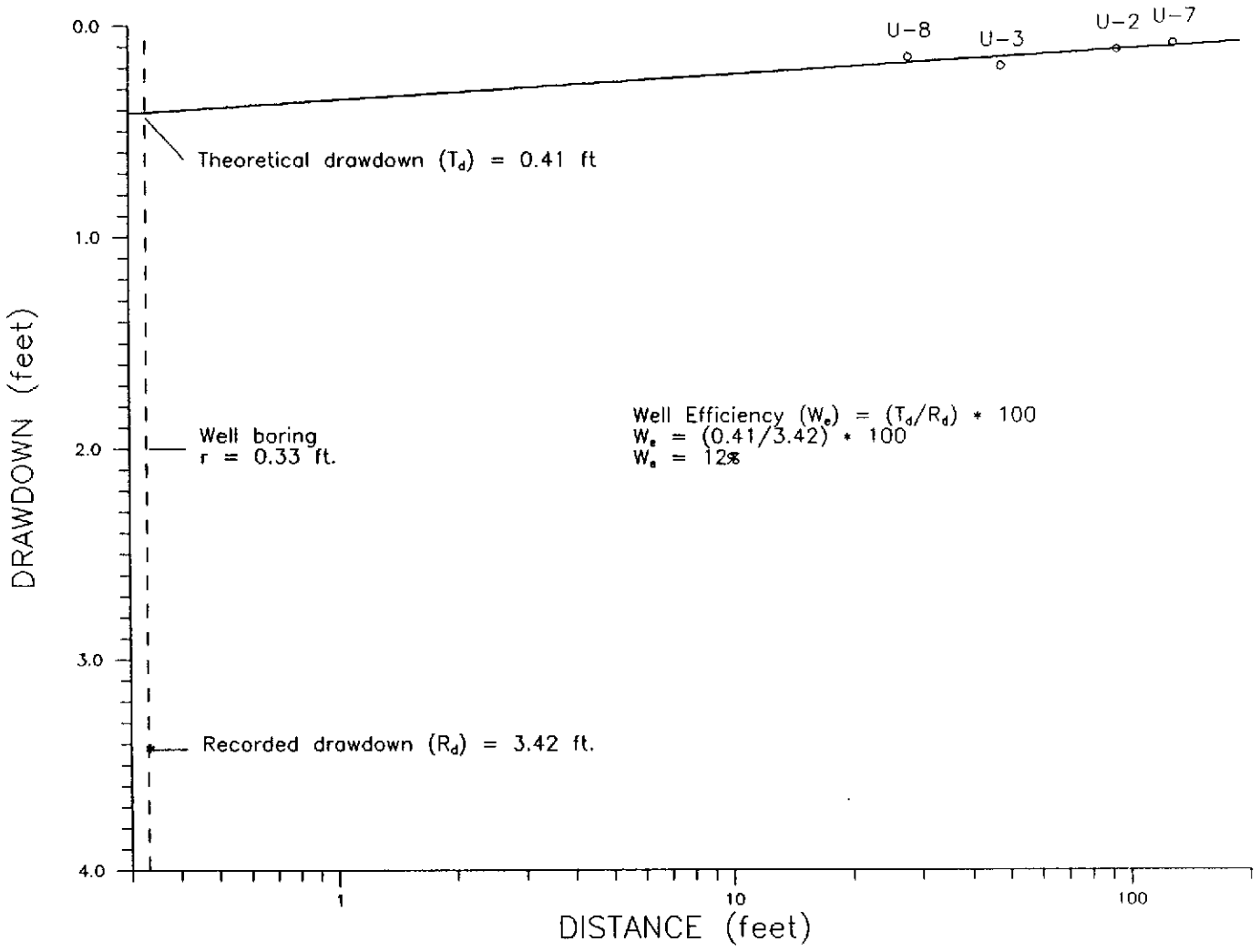
APPENDIX B

WELL EFFICIENCY PLOT



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WELL U-1 – Well Efficiency Plot
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PLATE
B

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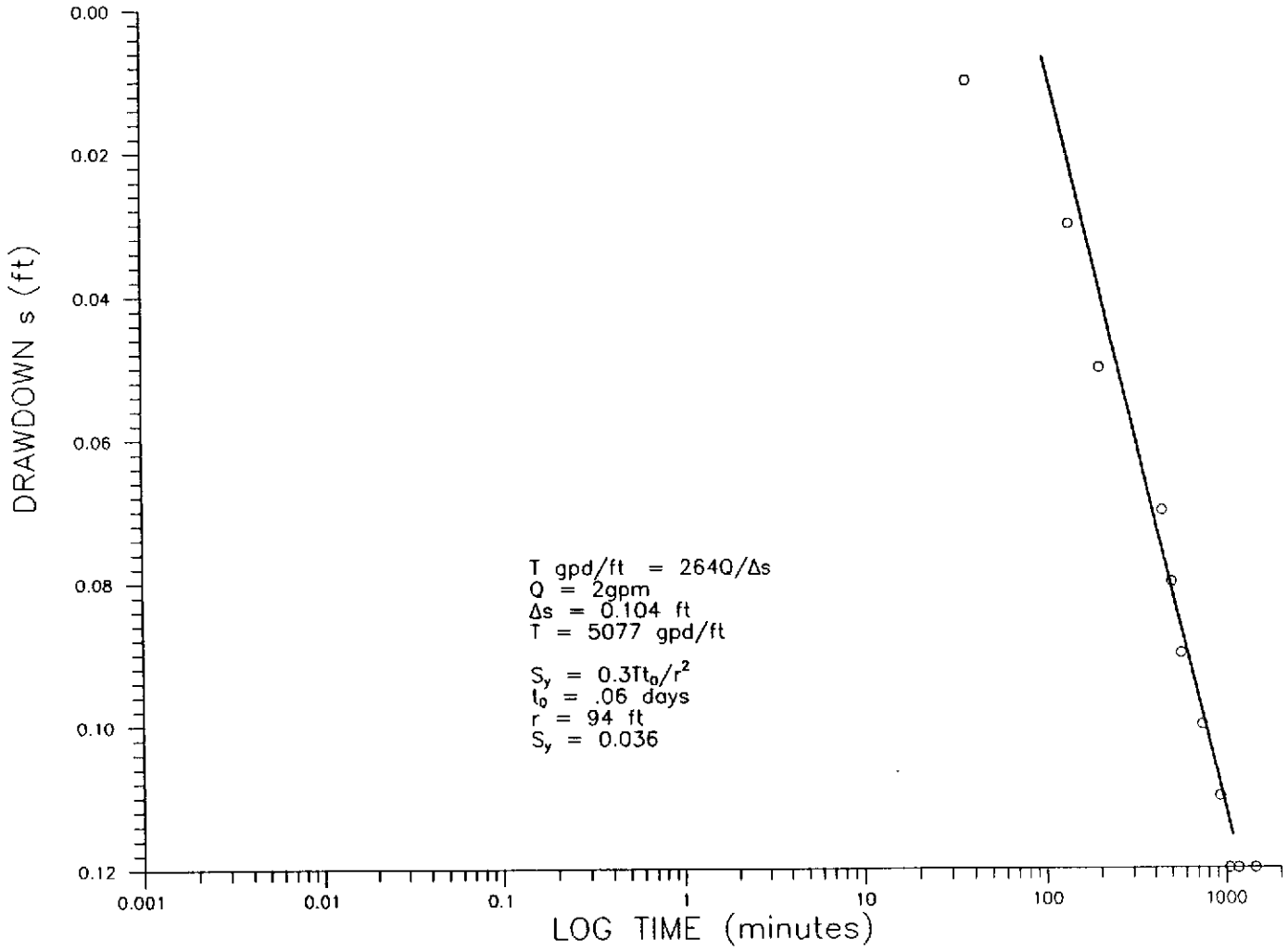
APPENDIX C

JACOB METHOD PLOTS

FOR

CONSTANT-RATE TEST



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WELL U-2 – Jacob Plot
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PLATE
C

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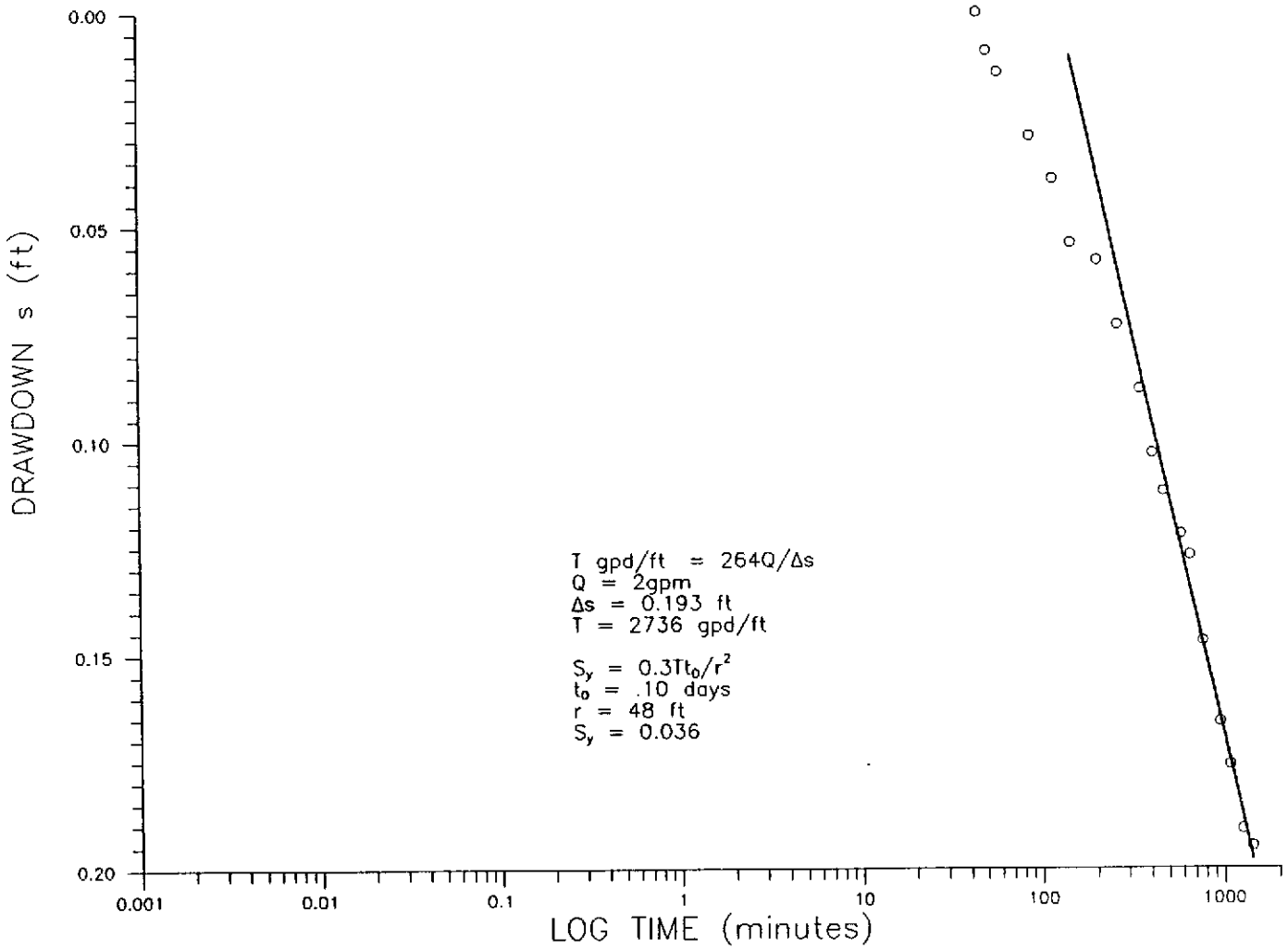

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WELL U-3 – Jacob Plot
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PLATE
D

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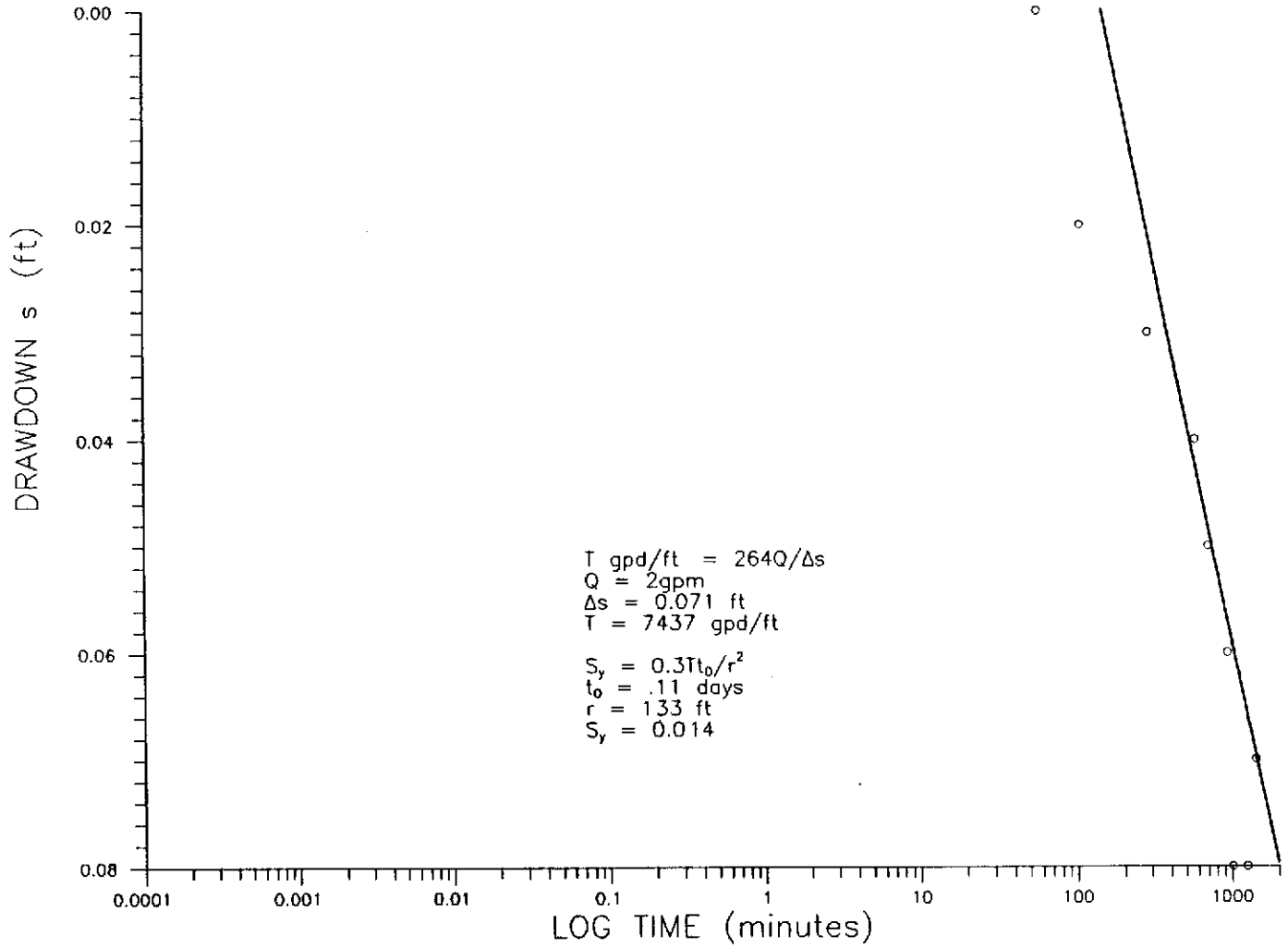

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WELL U-7 – Jacob Plot
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PLATE
E

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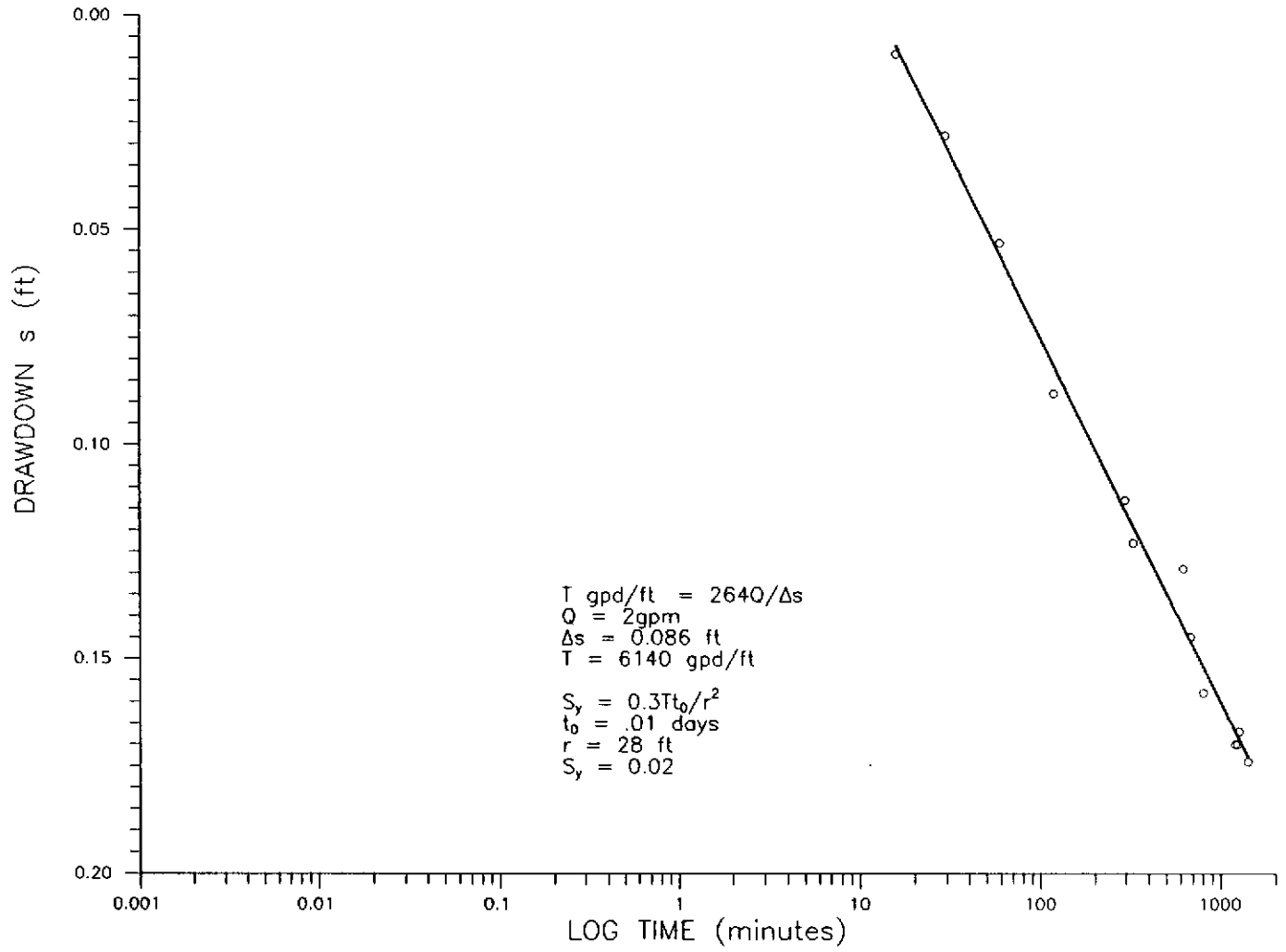

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WELL U-8 – Jacob Plot
UNOCAL Service Station #5760
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PLATE
F

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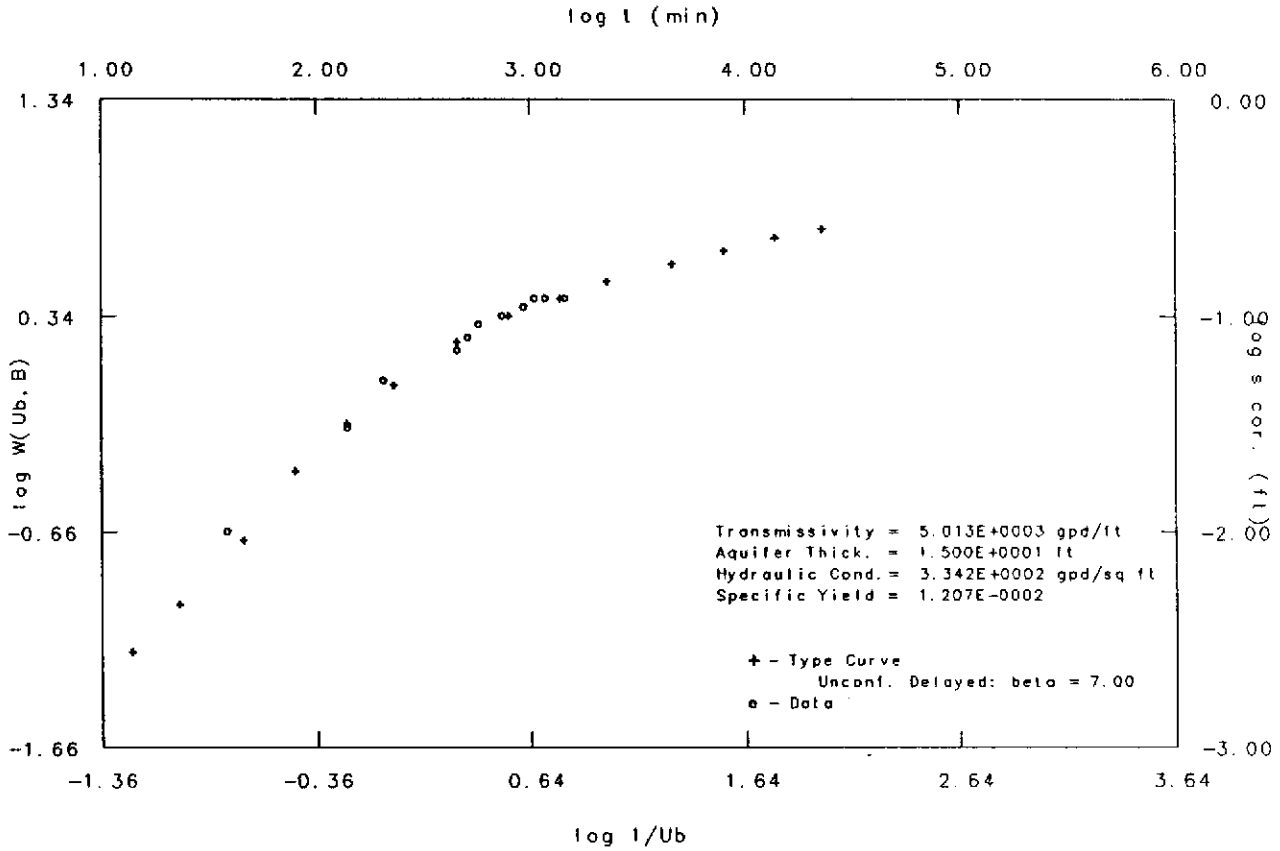
APPENDIX D

GWAP PLOTS

FOR

CONSTANT-RATE TEST



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WELL U-2 – Graphical Well Analysis Plot
UNOCAL Service Station #5760
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PLATE
G

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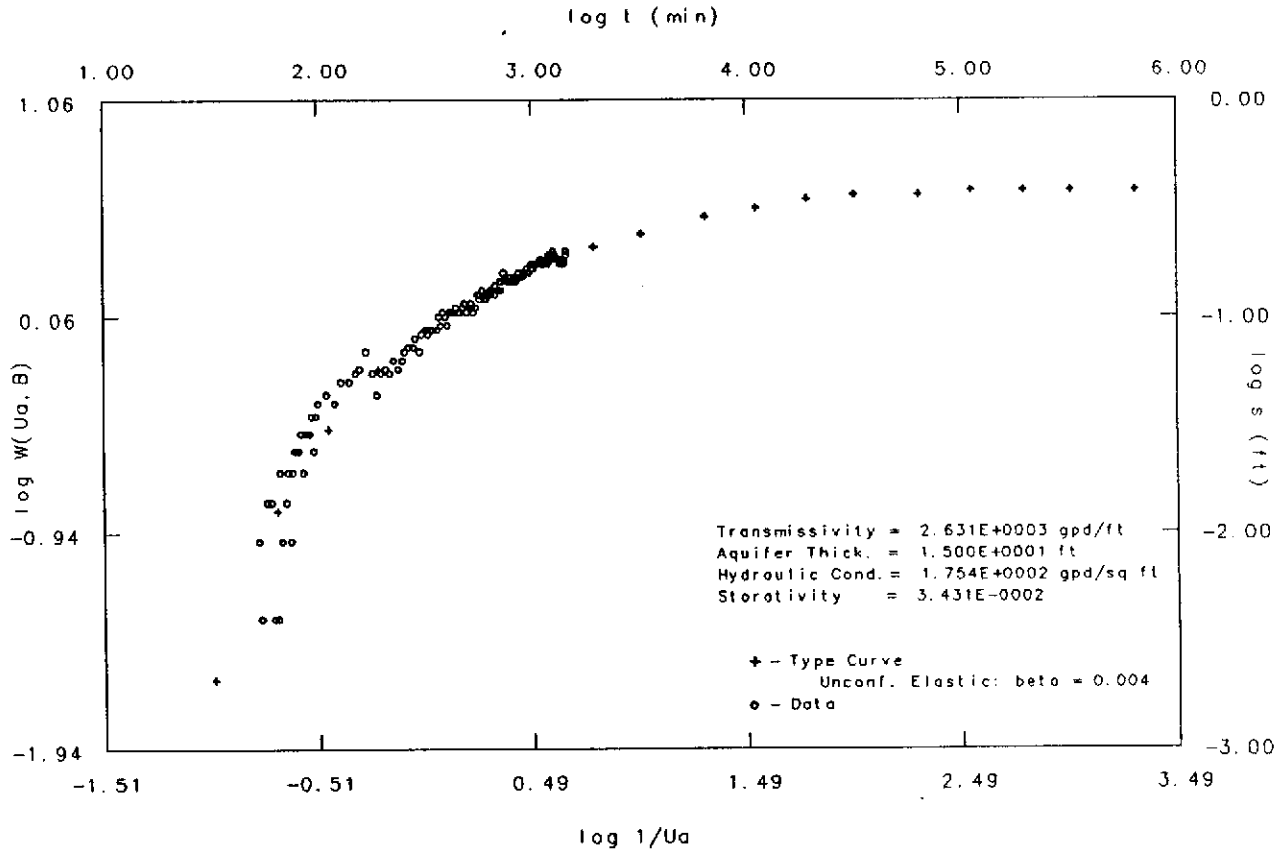

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WELL U-3 – Graphical Well Analysis Plot
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PLATE
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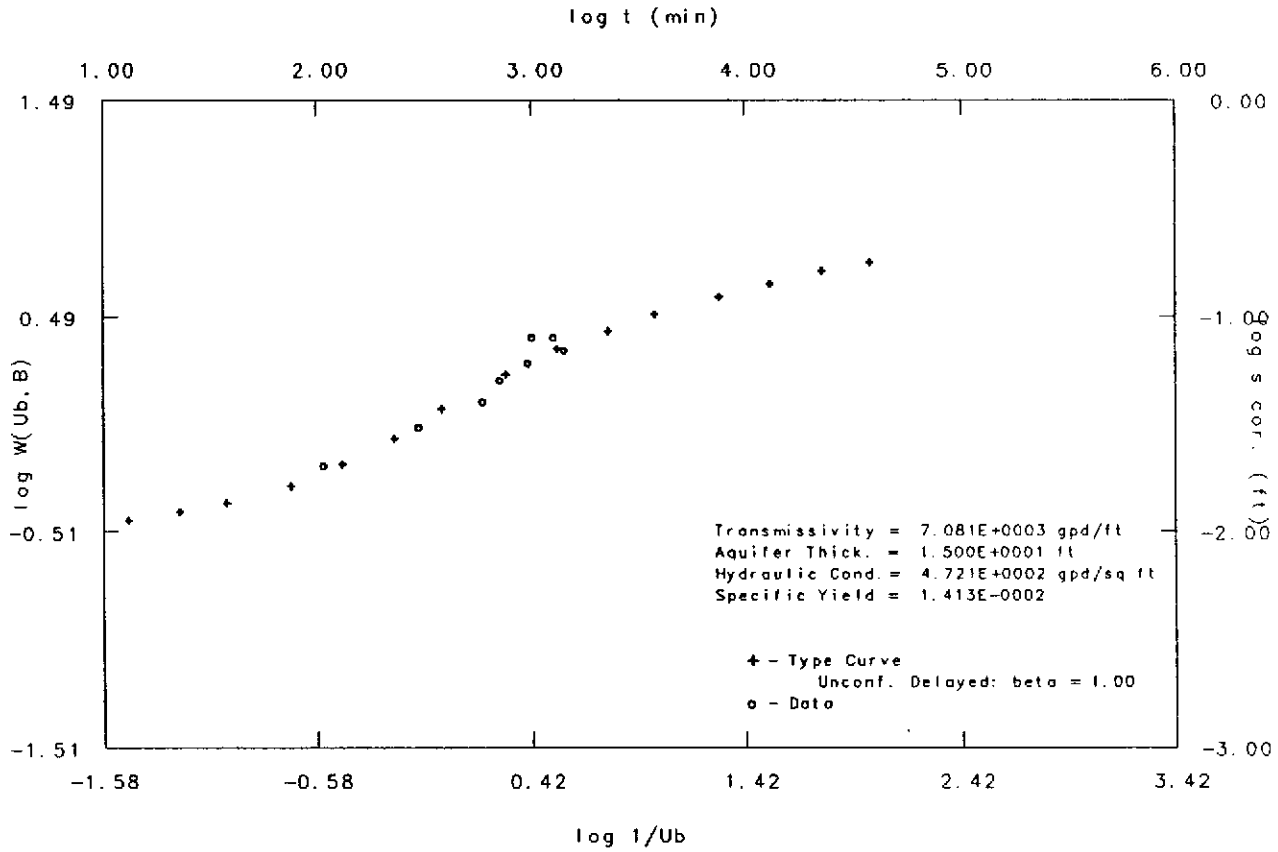

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WELL U-7 – Graphical Well Analysis Plot
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PLATE

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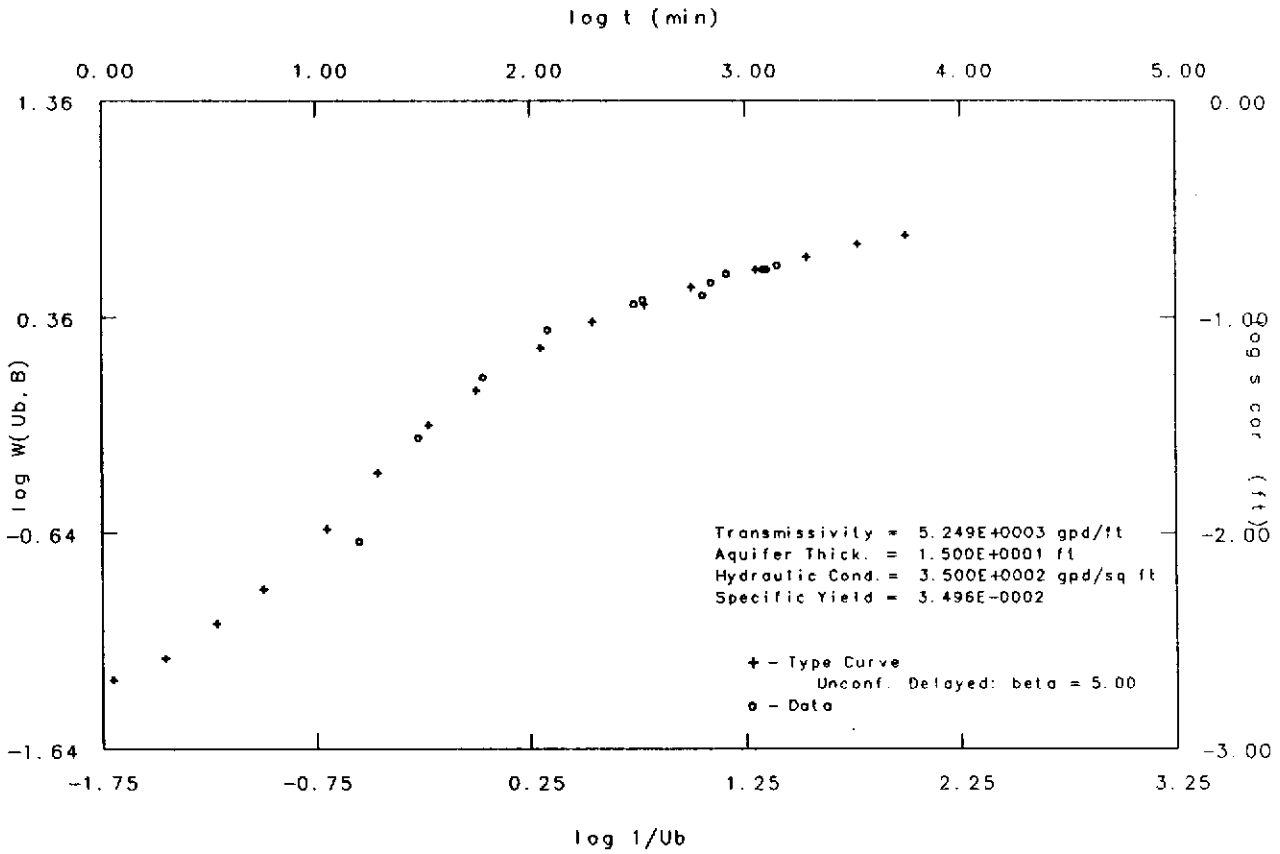

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WELL U-8 – Graphical Well Analysis Plot
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PLATE
J

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