GP-GE-001

SHORT-TERM TESTS
OF SUPPLY AND INJECTION WELLS
AT THE RAFT RIVER TEST SITE

Editor and Coordinator,

E. S. Brown

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ABSTRACT

This report presents the results of the short-term tests of the hydrothermal supply and injection wells for the first 5 MW power plant at Raft River. These tests were performed between November 1978 and January 1979 at the Raft River Geothermal Test Site. The site is operated for the Department of Energy, Idaho Falls Operations Office, by EG&G Idaho, Inc., under contract number EY-76-C-07-1570. The short-term tests provided a preliminary assessment of the characteristics of wells RRGP-4, RRGP-5, RRGI-6, and RRGI-7, and they established pump criteria for the follow-on, long-term tests.

The short-term (72-hour) test program was completed on schedule in January 1979. It was the first in a series of three supply and injection (S&I) test programs. The second, or long-term (500-hour) test program will begin in March 1979, and it is scheduled for completion on December 10, 1979 (Milestone M030C of the Management Plan). The third, or S&I-integrated test program is scheduled for completion on April 8, 1980 (Milestone M042C). Timely completion of the tests will allow the 5 MW(e) Pilot Geothermal Power Plant to begin operation on October 20, 1980.

SUMMARY

Short-term tests were performed during the 3-month period between November 1978 and January 1979 on wells RRGP-4, RRGP-5, RRGI-6, and RRGI-7. RRGP-4 and RRGI-7 are currently being evaluated as candidates for well stimulation.

The most important objective was to obtain pump-selection criteria for the long-term tests. The following summary results:

TABLE I

PUMP CRITERIA FOR THE LONG-TERM TESTS

Well	Pump Criteria
RRGP-4	Insufficient flow to warrant pump
RRGP-5	37.8 lps (600 gpm) with pump set @ 304.8 m (1000 ft.)
RRGI-6	Inject at up to 94.6 lps (1500 gpm)
RRGI-7	Inject at 25.5 lps - 32.5 lps (400-510 gpm)

Another major objective was the estimation of borehole flow characteristics:

TABLE II

BOREHOLE FLOW CHARACTERISTICS

Well	Injection or Flow Characteristics	Maximum Temperature (°F) Observed	Boundaries or Interference
RRGP-4	Test not stable enough	254	None Observed
RRGP-5	Q/s_{10} = 0.11 lps/kPa/cycle	254	Possible boundary; no interference observed
RRGI-6	Q/s_{10} = 0.38 lps/kPa/cycle	209[a]	One boundary possible (requires further evaluation); interference doubtful
RRGI-7	Q/s_{10} = 0.03 lps/kPa/cycle	[b]	Slight possibility of interference @ RRGI-6

[a] Observed on flow test of RRGI-6.
[b] No artesian flow.

In addition, operating experience was gained in preparation for the long-term test program. Hardware and instrumentation were checked out, and many deficiencies were identified and corrected. Operators were trained, and procedures were improved from test to test.

The above data supplements that obtained between 1975 and 1978 on wells RRGE-1, RRGE-2, and RRGE-3. Earlier information on these three wells can best be summarized as follows:

TABLE III

PUMP CRITERIA FOR RRGE-1, 2, AND 3

Well	Pump Criteria
RRGE-1	50.5 lps (800 gpm) with pump set at 244 m (800 ft)
RRGE-2	34.1 lps (540 gpm) with pump set at 244 m (800 ft)
RRGE-3	27.4 - 34.1 lps (435 -540 gpm) with pump set at 244 m (800 ft)

I. INTRODUCTION

Seven supply and injection (S&I) wells have been drilled in the Raft River Known Geothermal Resource Area (KGRA). The drilling began January 5, 1975, with the drilling of RRGE-1[a]. RRGE-1 confirmed the existence of a medium-temperature resource (145^{o}C or 293^{o}F) and secured the continuance of the drilling program. Drilling continued for three years with the completion of: RRGE-2 in 1975; RRGE-3 in 1976; RRGP-4 in 1977; RRGP-5, RRGI-6, and RRGI-7 in 1978. Drilling ended with the deepening of RRGP-4 in the fall of 1978. Figure 1 shows the location of the wells[b].

The design of the S&I system includes three production wells, two injection wells and a standby well of each type. The system will be an integral part of the 5-MW(e) Pilot Geothermal Power Plant; it is required to supply 155 lps (2450 gpm) and inject 134 lps (2125 gpm). (The difference will be lost to cooling-tower evaporation.) An additional 25.2 lps (400 gpm) will also be needed for other experiments.

The minutes of the November 22, 1978, DOE-EG&G meeting on the 5-MW(e) power plant S&I system recorded the definition of the production and injection wells for the First 5-MW(e) Power Plant as follows:

> Wells #1, #2, and #3 are the production wells and well #5 is The backup production well. Wells #6 and #7 are the injection wells and well #4 will be converted to a backup injection well. Both well #4 and #7 will be involved in stimulation programs. EG&G will initiate a planning effort to affect the S&I system as defined.

The short-term (72-hour) test program for the S&I wells was completed on schedule in January 1979. This report covers the testing period between

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[a]"RRGE" stands for Raft River Geothermal Experimental Well; an "I" or a "P" in place of the "E" would indicate the well was intended for Injection or Production purposes.

[b]Figures are contained in Appendix A.

November 1978 and January 1979, and it documents the short-term testing of RRGP-4, RRGP-5, RRGI-6, and RRGI-7. The most important objective was to obtain pump selection criteria. Other objectives were to estimate injection or borehole flow characteristics, gain operating experience, and check out hardware and instrumentation in preparation for the follow-on long-term tests.

Short-term testing of RRGE-1 and -2 is documented in Lawrence Berkeley Laboratory report, Reservoir Evaluation Test on RRGE-1 and RRGE-2, Raft River Geothermal Project, Idaho, by T. N. Narasimhan and P. A. Witherspoon[1]. RRGE-3 testing will be reported and published as a TREE document in the near future.

II. TESTS AND PRELIMINARY ASSESSMENTS

1. RRGP-5 SEVENTY-TWO-HOUR FLOW TEST, NOVEMBER 1-7, 1978

1.1 Test Description

The RRGP-5 72-Hour Flow Test began November 1, 1978. It included wellbore warmup, three one-hour pulse tests, and a 72-hour constant-rate artesian production test. To preheat the wellbore, RRGP-5B was flowed at 13 lps (200 gpm) for 30 minutes. Once the discharge water temperature stabilized, the well was flowed at 1.3 lps (20 gpm) to maintain thermal quasi-equilibrium. Three pulse tests at 2.5 lps (40 gpm), 12 lps (190 gpm), and 19 lps (280 gpm) were run for one hour each, with a one-hour recovery period. During recovery periods the well flowed at approximately 1.3 lps (20 gpm) to maintain thermal quasi-equilibrium in the wellbore. The 72-hour production test was conducted at 8.8 lps (140 gpm), and the recovery period began after testing. Instrument recorder failure caused the loss of the first portion (one hour) of recovery data after the 72-hour flow test.

To conduct the test, Raft River Field Operations built and instrumented a flow line from the RRGP-5 wellhead to the RRGP-5 pond (see Figure 2). A U-tube manometer across an orifice plate monitored the flow rate. This was used to meet Reservoir Engineering flow-control requirements ($\pm$ 3% of flow rate with adjustments at the wellhead valve). A 1.9-cm (3/4-in.) line made slight adjustments in discharge manageable, and it was also used for water sampling. The wellhead and flow line were also instrumented for pH, conductivity, temperature, and pressure.

Other instrumentation was used for gathering observation-well and RRGP-5 downhole data. The wellhead pressure on RRGE-1, RRGE-2, USGS-2, and MW-1 was recorded with digiquartz pressure transducers[a]. The downhole pressure/temperature probe failed after being run downhole. It was removed from the wellbore and the test plan requirements for it deleted. The probe was subsequently sent back to the manufacturer for testing and repair.

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[a] USGS-2 and MW-1 are monitor wells.

Appendix B is an execution copy of FET-14A-78, the test plan for producing RRGP-5. Access to the raw data (not included in Appendix B) may be obtained by contacting the manager of EG&G's Geothermal Electric Division.

1.2 Preliminary Test Assessment

A modified nonequilibrium analysis of the 2.52 lps (40 gpm) and the 12.0 lps (190 gpm) pulse tests suggests the presence of a recharge boundary. The 2.52 lps (40 gpm) pulse test did not stress the aquifer sufficiently to produce adequate pressure drawdown for quantitative hydrogeologic analysis, but the 17.7 lps (280 gpm) pulse test did stress the borehole artesian capacity of RRGP-5B. This was indicated by the appearance of steps in the data, as shown in Figure 3 (the displacement of the 2.52 lps (40 gpm) data after 15 minutes was probably due to human error).

In addition, the first 60 minutes of the production test functioned as a fourth pulse test. The production test data again suggests a recharge boundary, as shown by the declining pressure indicated in Figure 4. An additional test would be necessary, however, to confirm the presence of a boundary; instrument failure caused the break in data after 42 minutes[2].

The 12.0 lps (190 gpm) and 17.7 lps (280 gpm) pulse test data are thermally affected for at least the initial minute. It is assumed from experience that the other tests were also thermally affected, although this is not obvious from the data. It has been shown that corrected data are required for quantitative evaluation, but correction for thermal effects was not possible due to failure of the downhole temperature-pressure probe[3].

Well losses of 0.17 sec^2/m^5 (63 sec^2/ft^5) for the initial pulse, 0.2 sec^2/m^5 (8.6 sec^2/ft^5) for the second pulse, and 0.06 sec^2/m^5 (24 sec^2/ft^5) for the final pulse, were estimated using Jacob's formula[4]. Well losses of less than 0.01 sec^2/m^5 (5 sec^2/ft^5) are indicative of an efficient well, and well losses greater than 0.03 sec^2/m^5 (10 sec^2/ft^5) are indicative of a clogged well[5]. The well-loss data estimated by Jacob's formula do not provide conclusive results concerning RRGP-5B borehole flow conditions. A generally linear productivity relationship is suggested by the specific capacity (s_c) data as shown in (Figure 5) if the 17.7 lps (280 gpm) pulse test is disregarded.

It is possible that the 17.7 lps (280 gpm) pulse test does not lie on the apparent linear trend because the high production rate may have induced lower-partial-pressure water into the well. Imprecise manual control of discharge rate, in order to maintain constant wellhead pressure, may also have caused the displacement. Figure 5 suggests that the well losses within RRGP-5B are insignificant at low rates.

RRGP-5B recovered initial wellhead pressure in less than 7% of the production time, following the 2.52 lps (40 gpm) and 12.0 lps (190 gpm) pulse tests. Following the 72-hour production test, the well was fully recovered one hour after shut-in. Rapid recovery is usually indicative of an ineffective and poorly constructed well. Following the 17.7 lps (280 gpm) pulse test, RRGP-5B recovered in approximately the same amount of time as was allowed for production.

The data from the production and recovery portion of an aquifer test (Figure 6) should theoretically overlie each other. In this case the difference between production and recovery data is approximately 21 kPa (3 psi) for each test. This small difference could be caused by a combination of factors, such as small discharge rate variations, normal instrument error, or well losses. Figure 6 may indicate that well losses within RRGP-5B are insignificant at low discharge rates. Note that production data were recorded in psia, while recovery data were recorded in psi, a difference of approximately 88.3 kPa (12.8 psi). This difference was taken into account when graphing the corrected recovery data.

The discharge rate divided by drawdown per log cycle (Q/s_{10}) of an ideal well is constant, independent of discharge rate (Q). Figure 7 indicates no relationship between Q/s_{10} and Q, but Q/s_{10} changes. If the 2.52 lps (40 gpm) recovery, 12.0 lps (190 gpm) production, and 17.7 lps (280 gpm) production data points (30% of the data) are disregarded due to large errors related to thermal effects, a linear trend can be approximated. Figure 7 suggests that RRGP-5B was not performing ideally, perhaps due to fracture-controlled groundwater flow, in comparison to the theoretical flow through a porous medium.

Recovery data at RRGP-5B (Figure 8) may suggest a recharge boundary during the 2.52 lps (40 gpm) and the 12.0 lps (190 gpm) pulse tests. However, the break in slope should occur at the same time on both production and recovery data. The failure of the suggested boundary to occur at concurrent times implies: (a) that the suggested boundary is a nonideal or a leaky boundary; (b) that an aquifer(s) is nonhomogenous; or (c) that no recharge boundary exists. The data may appear as a recharge boundary due to instrument error. The recovery data from the 17.7 lps (280 gpm) pulse test are not suggestive of a recharge boundary. Future tests will assist interpretation.

It is assumed, but not apparent, that all recovery data were thermally affected. The effect of wellbore cooling would be to decrease the slope of data plotted as corrected recovery. Table IV lists the slopes of drawdown and recovery per log cycle (s_{10}) of the 72-hour test. Flatter slopes apparently occurred more during recovery than during production. Pressure changes measured within the wellbore provide more reliable data collection; however, this was not possible due to failure of the pressure-temperature probe.

Although instrument failure and normal instrument error make it difficult to draw definitive conclusions, the 72-hour production data at RRGP-5B (Figure 4) suggest a recharge boundary after 30 minutes. The data after 160 minutes may also suggest a recharge boundary. The initial recovery data, collected after one hour of shut-in time, showed that the well had fully recovered.

Table IV also lists the drawdown per log cycle of the initial linear trend for the results of the 72-hour test. The u condition ("u" is the condition where a straight line is approached on the curve) was satisfied in less than a quarter of a minute. The results could not be used in calculating the intrinsic transmissivity of the aquifer(s) penetrated.

Wells RRGE-1, RRGE-2, MW-1, and USGS-3 were used as observation wells during the 72-hour test. Digiquartz pressure transducers were used to measure

TABLE IV

TEST RESULTS, 72-HOUR TEST, RRGP-5B

Test	s_{10} kPa/cycle	s_{10} psi/cycle	Q/s_{10} l/s/kPa/cycle	Q/s_{10} gpm/psi/cycle
2.52 l/s (40 gpm) production	20.7	(3)	0.1209	(0.28)
2.52 l/s (40 gpm) recovery	48.3	(7.01)	0.0518	(0.12)
8.83 l/s (140 gpm) production	79.3	(11.50)	0.1110	(0.26)
8.83 l/s (140 gpm) recovery	(Data missing because of instrument failure)			
12.0 l/s (190 gpm) production	134	(19.44)	0.0892	(0.21)
12.0 l/s (190 gpm) recovery	114	(16.53)	0.1055	(0.24)
17.7 l/s (280 gpm) production	179	(25.96)	0.1060	(0.24)
17.7 l/s (280 gpm) recovery	165	(23.93)	0.1148	(0.26)

wellhead pressures. Geologic relationships indicate RRGP-5B, RRGE-1, and RRGE-2 penetrate the same fault zone and perhaps the same aquifer(s).

The wellhead pressure of RRGE-2 declined from November 1 to 7, 1978 (Figure 9). This is believed to be a seasonal trend. If RRGE-1 and RRGE-2 penetrate the same or similar aquifers, an analogous trend should be apparent in the RRGE-1 data. Figure 9 shows the irregular nature of RRGE-1 data. Perhaps the discharge rate at RRGE1 was not sufficiently constant; RRGE-1 provides water for several experiments and for space heating. Quantitative analysis of the RRGE-1 data was not attempted, because of this data scatter.

Drawdown in RRGE-1 (Figure 10) appears to have occurred after 140 minutes of production. The apparent drawdown may be related to RRGP-5B production or to a seasonal trend occurring within the aquifer(s). The data points occurring above the apparent trend after 2800 minutes, maybe related to control of RRGE-1 discharge rates. Data indicate that the u assumption was satisfied after 3600 minutes of production, after which a modified nonequilibrium analysis could be employed. A nonequilibrium analysis, which involves log-log curve matching to standard-type curves, is not met by Figure 11. This may indicate that the apparent drawdown is not related to RRGP-5B production. Figure 11 indicates that RRGE-1 discharge is not maintained at a constant rate.

A semilog plot of wellhead pressure at RRGE-2 (Figure 12) begins to decline after approximately 120 minutes of production. Data suggest that RRGP-5B would have to be produced for 8900 minutes (6.15 days) before the u assumption would be satisfied. The data cannot, therefore, be analyzed with the modified nonequilibrium method. The nonequilibrium method (Figure 13) does not yield a recognizable type curve. The pressure decline in RRGE-2 may not be related to RRGP-5B, as the apparent decline appears sooner and is of greater magnitude than RRGE-1, which is physically closer to RRGP-5B. It is possible, however, with fracture-controlled flow, for distant wells to show greater response than nearby wells[6]. The pressure decline at RRGE-2 is probably related to a seasonal trend or to cooling from a previous test. The effect on RRGE-2 of variations in the rate of discharge from RRGE-1 cannot be evaluated at this time.

Pressure changes greater than 0.7 Pa (0.1 psia) were not observed at MW-1 or USGS-3 during the pulse or 72-hour test. Therefore, RRGP-5B did not affect MW-1 or USGS-3 when produced at 8.83 lps (140 gpm) for 72 hours.

1.3 Conclusions

RRGP-5B is not capable of producing an artesian flow of greater than 17.7 lps (280 gpm) for extended periods; RRGP-5B did not have sufficient wellhead pressure to maintain the 17.7 lps (280 gpm) pulse for more than 45 minutes.

The test data may suggest a recharge boundary. This boundary may be the same recharge boundary implied by the results of testing of RRGE-1[7]. Additional testing of RRGP-5B must be conducted before the existence of a recharge boundary can be confirmed.

Because pressure data were thermally affected, the local intrinsic transmissivity of the aquifer(s) penetrated by RRGP-5B could not be calucualated. Future tests must be conducted with a downhole temperature-pressure probe within the well.

Well losses within RRGP-5B appear to be insignificant at flow rates less than 12.0 lps (190 gpm). Well losses at rates higher than 17.7 lps (280 gpm) cannot be estimated at this time.

The effect on RRGE-1 and RRGE-2 of producing RRGP-5B could not be quantitatively determined. The RRGE-5B testing did not affect MW-1 nor USGS-3.

Additional production tests using a pump should be performed at RRGP-5B A long-term (20-day) test at 38 lps (600 gpm) should be conducted. This production rate will provide a rigorous basis for evaluating productivity predictions. Pulse tests should be conducted in conjunction with the long-term test. The pulse tests would provide valuable additional information on the performance of RRGP-5B. The pulse and long-term tests must be conducted with a downhole temperature-pressure probe in RRGP-5B. Temperature-depth profiles should be plotted during additional tests of the well. The temperature profiles may supply additional information concerning the recharge boundary suggested by the 72-hour test.

Figures 14 and 15 are predictions of pump-setting depth versus production rate for the proposed 20-day production test of RRGP-5B. The predictions are based upon the 8.83 lps (140 gpm) 72-hour constant-rate production test. The graph simulating a recharge boundary and 2-barrier boundaries are not directly indicated by the data, but experience implies their presence.

2. RRGI-6 TWENTY-FOUR HOUR FLOW TEST, NOVEMBER 9-10, 1978

2.1 Test Description

Prior to injection testing of RRGI-6, Raft River Field Operations and Fluid Experiment and Testing Branches conducted a flow test consisting of a 96-hour preheat, two pulse tests and a 24-hour artesian flow. Raft River Field Operations constructed and instrumented a flow line from the RRGI-6 wellhead to the pond (see Figure 16). To calculate flow rates a differential pressure gauge and a manometer containing an antifreeze-water mixture measured the differential pressure across an orifice plate. An in-line conductivity probe and water samples provided information on pH, conductivity, HCO_3^-. $CaCO_3$, Na^+, and Cl^- concentrations. Wellhead pressure was monitored and recorded with a digiquartz pressure transducer, pressure computer, and a thermal printer. The downhole pressure/temperature probe was not available so downhole data could not be recorded.

During testing RRGI-6 flowed at a rate from 38 to 56 lps (60 to 89 gpm) for 96 hours in an attempt to achieve thermal equilibrium in the wellbore during testing. After the preheat, a constant-rate pulse test at 13.2 lps (207 gpm) ran for 53 minutes, followed by a recovery period. The second one-hour pulse test consisted of a variable-rate constant-head test. Rates varied from 10.8 lps (170 gpm) to over 22.6 lps (354 gpm). The final portion of the test ran for over 24 hours at 10.8 lps (170 gpm).

Appendix C is an execution copy of FET-12A-78, the test plan for producing RRGI-6.

2.2 Preliminary Test Assessment

The wellhead pressure during the first pulse test at 13.2 lps (207 gpm) declined to 177 kPa (25.7 psi) during the initial 4.3 minutes of flowing, but it increased to 188 kPa (27.25 psi) at 52 minutes (Figure 17). Since $u < 0.01$ after approximately 0.1 minutes, the data would normally be expected to plot as a straight line. However, increasing wellhead pressure is a common occurrence when well heat-up causes the density of the bore-hole fluid to decrease.

Wellhead temperature data are also indicated in Figure 17. The wellhead temperature increased from less than 73.0^{0}C (163.4^{0}F to 98.2^{0}C (208.7^{0}F)- a change of 25.2^{0}C (45.3^{0}F). An approximation technique was used to correct for the changing borehole-fluid densities relative to the wellhead pressure after nine minutes of flow. The corrected wellhead pressure data, which are plotted as x symbols in Figure 18, have a slope over one log cycle (s_{10}) of 18.1 kPa/log cycle (2.62 psi/log cycle), which results in a Q/s_{10} ratio of 0.731 lps/kPa/log cycle (79.0 gpm/psi/log cycle. The intrinsic transmissivity, kh is directly related to Q/s_{10} and the viscosity of the aquifer fluids. Since the temperature of the receiving zone(s) is not known, the Q/s_{10} ratio was used to relate the test data to an aquifer characteristic.

The ratio of Q/s_{10} for the May 1, 1978, injection test at 51.0 lps (800 gpm) was 0.274 lps/kPa/log cycle (29.6 gpm/psi/log cycle). The greater value for Q/s_{10} for the November 9, 1978, test could result because of the much lower viscosity for the 51.7^{0}C (125^{0}F) water injected in the May 1, 1978, test. Because of significantly different conditions in the vicinity of the wellbore during the tests of May 1, 1978, and November 9, 1978, considerable caution must be exercised in comparing the results of the tests. In principle, more accurate estimates of the aquifer characteristics can be expected from the November 9, 1978, test results.

Recovery data were collected for the RRGI-6 test (Figure 19). In Figure 19, t is the elapsed time since the discharge of 13.2 lps (207 gpm) began and t' is the elapsed time since the flow of 13.2 lps (207 gpm) was terminated. A linear regression through the data from t/t' = 18.3 (t' = 3 minutes) to t/t' = 2.86 (t' = 28 minutes), has a slope, s_{10}, of 17.2 kPa/log cycle (2.50 psi/log cycle). This results in a Q/s_{10} ratio of 0.766 lps/kPa/log cycle (82.8 gpm/pis/log cycle). Since the well is shut in during recovery, temporally-dependent density changes in the borehole fluid are much less than during well discharge (Figure 18). In the following flow test, for example, the wellhead temperature recovered to 94.50^{0}C (202.1^{0}F) after one minute of flowing at 22.6+ lps (354+ gpm). A more accurate estimate of Q/s_{10} can be expected using recovery data. Since the water in the wellbore is slowly cooling during recovery, the slope of the recovery data collected at the wellhead will be less than that in the aquifer(s). This relationship actually resulted because the value for s_{10} during recovery, 17.2 kPa/log cycle

(250 psi/log cycle), is slightly less than s_{10} during drawdown-18.1 kPa/log cycle (2.62 psi/log cycle). Drawdown recovery data following the 53-minute discharge at 13.2 lps (207 gpm) result in a slope s_{10} of 17.2 kPa/log cycle (2.50 psi/log cycle) and a Q/s_{10} ratio of 0.766 lps/kPa/log cycle (82.8 gpm/psi/log cycle).

The next pulse test, which continued for 60 minutes, began 65 minutes after terminating the flow test reported above. This was a constant-drawdown/variable-discharge test. The resulting four values for discharge rates, which ranged from 22.6 lps (354 gpm) to 10.8 lps (170 gpm), were not sufficient to permit a quantitative evaluation of the s_{10} or Q/s_{10} values.

The next constant-rate flow test continued for 1442 minutes at a flow rate of 10.8 lps (170 gpm), following 82 minutes of recovery from the constant-drawdown test. Little of the data are of any value, since no pressure response was noted using the digiquartz pressure transducer when the well was shut-in (Figure 18). Because there are no means for determining which data are valid, and since there are no obviously linear portions of data having a slope, s_{10}, somewhat similar to those for the 13.2 lps (207 gpm) test, an analysis to determine aquifer characteristics was not undertaken.

Observation well hydrographs for monitor wells 3, 4, 5, 6, and 7; RRGI-7; and RRGE-3 are presented in Figures 21 through 27, respectively. The water levels in the monitor wells declined from the beginning of the flow-test period to the 1000 hours point on November 19, 1978, then increased during the remainder of the flow test period. Much, if not all, of this water level decline was probably caused by earth tides and by increasing barometric pressure (from 1400 hours on November 9, 1978, to 1100 hours on November 10, 1978: Figure 28). Insufficient hydrograph and barometric-pressure data have accumulated to date to permit the removal of these components from the hydrographs for the monitor wells. It is concluded that the hydrographs for RRGI-7 and RRGE-3 (Figures 26 and 27, respectively) do not indicate significant interference effects with RRGI-6. Because of the rapidly declining pressure at RRGE-3 due to freeze-line shut-in, the above conclusion is tenuous. However, it can be concluded that neither the monitor wells nor RRGI-7 responded to the withdrawal of water at RRGI-6 to a degree markedly greater than the hydrograph responses induced by barometric-pressure fluctuations and earth tides.

2.3 Conclusions

Freeflow test drawdown and recovery data for a 13.2 lps (207 gpm) discharge for 53 minutes, results in slopes on a semilogarithmic graph of 18.1 kPa/log cycle (2.62 psi/log cycle) and 17.2 kPa/log cycle (2.50 psi/log cycle) respectively. Corresponding Q/s_{10} values are 0.731 and 0.766 lps/kPa/log cycle (79.0 and 82.8 gpm/psi/log cycle), respectively. Pressure responses at monitor wells 3, 4, 5, 6, and 7; RRGI-7; and RRGI-3 do not suggest any interference effects similar in magnitude to barometer pressure and earth tide effects.

3. RRGI-7 INJECTION TEST, NOVEMBER 16-22, 1978

3.1 Test Description

RRGI-7 injection test began November 16, 1978. Water from the RRGE-1 pond was piped to RRGE-3 and then through a temporary line to the RRGI-7 pond. A subcontractor's (Halliburton) oil-field pumper truck used suction line to take water from the pond and inject it into the well (see Figure 28). The pumper truck controlled injection at 253 lps (400 gpm), as determined by the pump stroke rate. Pumping continued for 5-1/2 hours, when the subcontractor's pumps failed, forcing the test to be delayed until the following day. The test beginning November 17 held a constant injection rate of 253 lps (400 gpm) for about 65 hours.

Raft River Field Operations installed instrumentation for the test. A pressure gauge monitored wellhead pressure. Because of the suction problems with the subcontractor's injection pumps, in-line conductivity, pH, and temperature probe measurements were not possible. Water samples collected from the RRGI-7 pond were analyzed for pH, conductivity, turbidity, and undissolved solids.

Appendix D is an execution copy of FET-27-78, the test plan for injecting RRGI-7.

3.2 Preliminary Test Assessment

The maximum decrease in wellhead pressure due to the injection of water at a temperature of 14.4^{o}C (58^{o}F) with no subsequent heating in the wellbore (utilizing previous borehole temperature data) would be: 48.1 kPa (6.98 psi) if the aquifer receiving the water were at the base of the casing-at a depth of 618.7 m (2030 ft); 192.1 kPa (27.86 psi) if the aquifer were at a depth of 889.7 m (2919 ft) at the midpoint of the open borehole; and 304.1 kPa (44.10 psi) if the aquifer were at the bottom of the borehole. The greatest rate of accumulation of error in the wellhead pressure due to the injection of cold water would occur at the beginning of the test, when maximum-temperature water would be injected into the receiving zone(s). Injection at 25.5 lps

(400 gpm) would result in a downhole fluid velocity of 0.314 mps (1.03 fps). Since the well has 618.7 m (2030 ft) of casing, it would take 32.9 minutes for the injected water to reach the bottom of the casing. Thus, 32.9 minutes is the minimum time required for steady-state borehole fluid densities to develop. In reality, however, it would take additional time for density differences to disappear; heat transfer through the surrounding casing and through the borehole wall rock would heat the wellbore fluid. For convenience, it will be assumed that the cumulative error due to temporally dependent borehole fluid densities is 192.1 kPa (27.86 psi). The declining wellhead pressures observed between 1 and 40 minutes after pumping began (Figure 29), are believed to be caused by changing borehole fluid densities and do not represent the actual aquifer pressure buildup.

On the other hand, the linear pressure-buildup segment between 136 and 246 minutes after injection began (Figure 29) probably represents actual aquifer pressure buildup. Based on a previous injection test beginning August 2, 1978 (resulting in an estimate for kh of 2304 md-m (7559 md-ft), the time required for $u \leq 0.01$ is 3.13 minutes. Thus, assuming an ideally behaving-aquifer with no hydrologic boundaries, the aquifer pressure build-up data should plot as a linear regression on Figure 29.

The beginning of the linear data segment was visually estimated to be 136 minutes, with the end of the linear segment occurring at 246 minutes. After 246 minutes, a considerable scattering of the data occurred, and it is possible that the data followed a trend having a lower value for the slope. The slope per log cycle time, s_{10}, of the data between 136 and 246 minutes after pumping began is 826.7 kPa/log cycle (119.9 psi/log cycle) with a ratio of Q/s_{10} of 0.0309 lps/kPa/log cycle (3.34 gpm/psi/log cycle). The ratio of Q/s_{10} compares favorably with the previously determined value of 0.0347 lps/kPa/log cycle (3.75 gpm/psi/log cycle) for the 53.6 lps (840 gpm) step of the injection test beginning August 2, 1978. The following equation defines pressure buildup beginning at 136 minutes:

bubbler pressure = -601.7 + 826.7 (log t-1)

where: bubbler pressure in in kPa and t is in minutes, or

bubbler pressure = -87.27 + 119.9 (log t-1)

where: bubbler pressure is in psia and t is time in minutes

This equation predicts a wellhead pressure 3882 kPaa (562 psia) or ≈3792 kPag (≈550 psig) after five uears of continuous injection at 25.5 lps (400 gpm) with no hydrologic boundary or interference effects. This is a preliminary estimate based only on the projection of 110 minutes of data to five years. This value corresponds to the 4137 kPag (600 psig) value obtained from the 53.6 lps (840 gpm) test beginning August 2, 1978, in which water of a slightly lower density was injected than in the November 16, 1978, test. Greater well losses when injecting at 53.6 lps (840 gpm) would result in overestimated wellhead pressure for injection rates of less than 53.6 lps (840 gpm). Thus, the predicted wellhead pressures after five years of injection based on the two injection tests referred to above are within expected errors. In conclusion, based on 110 minutes of data from the November 16, 1978, injection test at RRGP-7, the Q/s_{10} of 0.0309 lps/kPa/log cycle (3.34 gpm/psi/log cycle) and the predicted wellhead pressure of 3792 kPag (550 psig) after five years of injection do not differ substantially from the values derived from previous tests.

Projections based on the data for the 25.5 lps (400 gpm) test can be used to estimate corresponding injection rates and wellhead pressure for a 20-day injection test. Based on the 25.5 lps (400 gpm) test, an injection rate of 25.5 lps (400 gpm) would result in a wellhead pressure of 2261 kPaa (328 psia) after 20 days of injection with nointerference or boundary effects. Similarly, an injection rate of 32.5 lps (510 gpm) would result in a wellhead pressure of 2882 kPaa (418 psia) after 20 days of continuous injection and 4826 kPaa (700 psia) after five years of continuous injection. It is recommended that an injection rate between 25.5 lps (400 gpm) and 32,5 lps (510 gpm) be used for 20-day tests.

The pressure buildup data for the 3883-minute, 25.5 lps (400 gpm) injection test beginning November 17, 1978, are probably of little value, because an initial rapid buildup in bubbler pressure supports the hypothesis that air was being injected along with the water. Bubbler pressures during the initial 40 minutes of injection on November 17, 1978, should have been less than those for the test beginning November 16, 1978, because the water in the borehole was at a lower temperature on the earlier date. The test beginning November 16, 1978, would cool the borehole fluid and the surrounding casing, grout, and rock below pretest temperatures. As a result, the test beginning 743 minutes later would start with a lower bubbler pressure. The field test data confirm these hypotheses.

The bubbler pressure prior to the second test was atmospheric (83.70 kPaa (12.14 psia), indicating a water level below the end of the bubbler tube. However, prior to the test beginning November 16, 1978, the bubbler pressure was 103.0 kPaa (14.94 psia). Consequently, the test beginning November 17, 1978, which had an injection rate equal to that of the test beginning November 16, 1978, would be expected to have a lower bubbler pressure throughout the injection period.

Pressure differences between the November 16, 1978, and November 17, 1978, test data during the period from 40 to 120 minutes after pumping began, stabilized at approximately 414 kPa (60 psi) (Figure 29). The higher bubbler pressure for the November 17 test would result if the average specific gravity of the fluid in the 218.7 m (2030 ft) of casing were 0.9311 gm/cm^3 (58.12 lb/ft^3), rather than the 0.9993 gm/cm^3 (62.38 lb/ft^3) that would be expected for 14.4^{o}C (58^{o}F) water. A specific gravity of 0.9311 gm/cm^3 (58.12 lb/ft^3) could result either from 132^{o}C (270^{o}F) water, which is not possible, or from the development of a 42.4 m (139 ft) column of air in the wellbore. Since air leaks were noted at the wellhead, the development of an air column in suggested. However, if air and water were separating, the stabilization of the bubbler pressure differences at 414 kPa (60 psi) between the November 16 and 17 data at approximately the time required for the injected water to enter the open borehole (≈32 minutes), would be somewhat fortuitous. Still, stabilization of the pressure differences between the bubbler pressure data for the November 16, and the November 17, tests would be expected if the injected water with entrained air entered a receiving zone(s) with no significant aquifer plugging.

Erratic pressure fluctuations occurring after 120 minutes could be caused by a variable ratio of injected air and water. Thus, the more rapid initial pressure buildup for the November 17, data can best be explained by air entrainment in the injected water. The data collected after 77 minutes appears to fluctuate from the overall data trend much more than that which occurred prior to the 77-minute point and during the preceding test on November 16, 1978. This fluctuation in pressure is not due to a digiquartz-pressure-recorder malfunction, as the wellhead pressure monitored by a Heise pressure gauge also exhibited similar pressure fluctuations (Figure 30). A malfunction in the injection pump which resulted in a temporally dependent, volumetrically effective injection rate of water and air would appear to be likely.

The declining pressure-buildup trend after approximately 1000 minutes of injection can also be readily explained by a temporally declining, volumetrically effective injection rate. It would be very unusual for normal, natural, background wellhead pressure trends to decrease by 82.7+ kPa (12+ psi) during a period of 3000 minutes. No significant declines in wellhead prssures were noted in surrounding observation wells. The 82.7+ kPa (12+ psi) decrease was estimated assuming the fortuitous occurrence at 1000 minutes of a linear, constant-head recharge boundary effect or a hydrologic boundary having a similar effect. Although temperature data are not available, the temperature of the injected water was probably less then 32.3^{o}C (90^{o}F) during the entire test. The increase in the temperature from 15.6^{o}C (60^{o}F) to 32.2^{o}C (90^{o}F) would result in a 34.5 kPa (5 psi) increase in bubbler pressure, due to borehole fluid density changes.

The pressure decline that would result from a decreased water viscosity is not known, but it would be capable of causing the observed pressure decline only if a linear, constant-head recharge boundary or a boundary having a similar effect were encountered at approximately 1000 minutes. Earthquake effects, which could induce pressure fluctuations of this magnitude, were not noted at any of the other seven observation wells. Hydrofracturing of the formations at this wellhead pressure is also very unlikely because of the low wellhead pressure of 917.0 kPaa (133 psia) compared to the estimated minimum pressure of 4826 kPa (700 psi) required for hydrofracturing. In addition, hydrofracturing during this test is unlikely, because the aquifer(s) was previously subjected to wellhead pressure of 1331 kPaa (193 psia) during the test beginning August 2, 1978 (which is 414 kPa (60 psi) greater than during the November 17 test).

The aquifer pressure difference would be greater if air were contained in the injection water for the November 17, 1978, test. Although it is possible for an increasing temperature of the injected water to produce a declining water bubbler pressure after injecting for 1000 minutes, if fortuitous boundary effects occur, the most plausible explanation for the observed bubbler pressure decline is a temporally declining, volumetrically effective injection rate due to air entrainment.

Wellhead pressure data at RRGE-3 (Figure 31) illustrate the profound effect on wellhead pressures caused by heating and cooling the wellbore fluid by manipulating the flow (± 0.64 lps (± 10 gpm)) from the freeze line. Pressures changes in excess of 152 kPa (22 psi) can be induced. At least three days are required for stabiliation of borehole fluid densities following freeze line shut-in. During the period from November 11 to 13, the linear trending wellhead pressure declined at approximately 1.72 kPa/day (0.25 psi/day) (Figure 31). The abrupt pressure increase on November 13 and 14 was probably caused by opening and then closing the freeze line. Beginning on November 17 as indicated in Figure 32, the wellhead pressure increased at approximately 0.758 kPa/day (0.11 psi/day) for at least nine days. The injection into RRGI-7 appears to have had no influence on the water level trend of RRGE-3, as evidenced by the nine-day linear trend. A linear trend would not be expected if significant interference occurred. In conclusion, the injection into RRGI-7 from November 16 to 20 produced no readily discernible interference at RRGE-3.

Wellhead pressure data are available for only a short time prior to the beginning of injection. Beginning at approximately noon on November 19, 1978, the wellhead pressures appear to be slightly greater (0.62 kPaa (0.09 psia)) than those which would have resulted had the linear trend of 0.758 kPaa/day (0.11 psia/day) beginning at noon on November 16 and continued until noon November 23 (Figure 33). The marked change in the slope of the data trend beginning at noon on November 23, however, suggests a complex data trend with several influential phenomena. Therefore, the postulated response of the wellhead pressure at RRGI-6 to the injection at RRGI-7 is very tenous.

Hydrographs for monitor wells 3, 4, 5, 6, and 7 are contained in Figures 34 through 41. Since these are the first hydrographs obtained for the monitor wells, the records for MW-3 and -4 begin on November 21, 1978, rather than November 13, 1978. The hydrographs for MW-5, -6, and -7 (Figures 36, 38, and 40) are very similar except for a two-hour phase lag for the MW-5 data. The hydrograph for MW-6 has a different vertical scale than the others. Somewhat similar trends also occur for the monitor well hydrographs for the period from November 21 to 29 (Figures 34, 35, 37, 39, and 41). Based on the similarity of the hydrographs from widely scattered wells at distances from RRGI-7 ranging from 548.6 m (1800 ft) to 1097 m (3600 ft), and because of the lack of a marked water level increase, especially at MW-7, which is the closest monitor well to RRGI-7, it is concluded that injection into RRGI-7 caused little or no pressure response in the monitor wells.

3.3 Conclusions

Based on 110 minutes of data beginning 136 minutes after injection began at a rate of 25.5 lps (400 gpm), the slope of the data per log cycle on a semilogarithmic wellhead bubbler pressure build-up graph is 826.7 kPa/log cycle (119.9 psi/log cycle). The ratio Q/s_{10} is 0.0309 lps/kPa/log cycle (3.34 gpm/pis/log cycle), with a 6.71 m (22 ft) bubbler tube. The predicted wellhead bubbler pressure after five years of continuous injection at 25.5 lps (400 gpm) is 3794 kPag (550 psig), assuming no interference with nearby wells. A second 3882 minute injection test at 25.5 lps (400 gpm) resulted in erroneous data, presumably caused by a temporally dependent, volumetrically effective injection rate attributable to air entrainment in the injected water. Based on this test experience, use of commercial oil field pumper trucks is not recommended. No interference effects were observed at RRGI-3. Effects, if any, at monitor wells 3, 4, 5, 6, and 7 were masked by water-level changes induced by varying barometric pressures and earth tides. There is a remote possibility of interference effects of approximately 0.62 kPa (0.09 psi) at RRGI-6.

4. RRGP-4AB FLOW TEST, NOVEMBER 28 - DECEMBER 2, 1978

4.1 Test Description

The RRGP-4AB flow test began on November 29, 1978. Artesian flow was used in an attempt to preheat the RRGP-4AB wellbore. RRGP-4AB sustained the artesian flow for only 10 minutes. Testing later showed the wellbore did not preheat to an isothermal condition. Following preheat, a 0.63 lps (10 gpm) flow was established in an attempt to maintain thermal quasi-equilibrium and allow the well to recover. The test consisted of allowing the well to artesian flow at 0.93 lps (15 gpm), beginning once recovery from the preheating was apparent. The test was termined after 18 hours due to the combination of low production rate, low wellhead pressure and flashing in the discharge line. Pulse tests were cancelled due to the rapid decline of wellhead pressure.

Raft River Field Operations constructed and instrumented a flow line from the wellhead to the RRGP-4AB pond (see Figure 42). Reservoir Engineers monitored the discharge rate by means of a strip-chart pressure recorder, recording the pressure differential across an orifice. The recorder indicated the discharge held constant at 1.6 lps (25 gpm). Measurements with a 1.32 l (5 gal) bucket and stop watch showed it to vary between 0.95 lps (15 gpm) and 2.8 lps (45 gpm). The low flow rate was at the limits of the measuring and recording instruments.

Appendix E is an execution copy of FET-10A-78, the test plan prepared for producing RRGP-4AB.

A thermocouple measured wellhead temperature, and a digiquartz pressure transducer and a Heise pressure gauge measured wellhead pressure at RRGP-4AB. The Hewlett-Packard downhole temperature-pressure probe was not used because it was out-of-service for repair. Digiquartz pressure transducers and continuous recorders collected observation well data at RRGE-1, RRGP-5B, MW-1, and USGS-3.

4.2 Preliminary Test Assessment

Wellhead pressure increased for more than four minutes after production began (Figure 43). This was caused by the thermal effects of hotter, lower density water entering the wellbore[3]. Thermally affected data cannot be used for qualitative or quantitative analysis without computer corrections. It may be possible to obtain interpretable data with a downhole temperature-pressure probe, if wellhead temperature cannot be brought to equilibrium. Discharge water temperature stabilized after 300 minutes at 110^{o}C (230^{o}F). Borehole geophysical logs had recorded a maximum downhole temperature of 123^{o}C (254^{o}F).

The method of shut-in is believed to have caused the linear trend in the initial minute and a half of recovery data (Figure 44). A valve located approximately eight meters (25 ft) down the discharge line was used to shut-in the well, rather than the valve at the wellhead. The line was apparently partially filled with air, causing a lag in pressurizing the system. This valve was chosen for shut-in, so that temperature measurements could be obtained during recovery. The data plot as a continuous curve after four and a half minutes, and cannot be analyzed by the modified nonequilibrium method. The data are unquestionably thermally affected.

A nonequilibrium analysis (Figure 45) was employed in an attempt to interpret the recovery data. Although not commonly applied to production well data, the nonequilibrium method should be applicable to recovery data, as well losses do not occur during recovery. The data do not match any standard-type curve.

No interference effects are apparent between wells RRGE-1, RRGP-5B, and RRGP-4AB (Figure 46). The observation wells are assumed to penetrate the same geologic structure and perhaps the same or similar aquifers. The differing curves raise questions about observation well activity. RRGE-1 provides stabilized artesian flow at ±3% of a preset rate; RRGP-5B had been shut-in since the RRGP-5B 72-hour test from November 1 to 7, 1978. The inconsistent RRGE-1 data suggest that either the discharge rate from RRGE-1 was not maintained within the ±3% flow-stabilization limits, or the limits are not exact enough for the production of required hydrogeologic data.

A graph of RRGE-1 wellhead pressure (Figure 49) was constructed to investigate the possibility that the inconsistency in data was related to a natural phenomenon, such as earth tides or the barometric efficiency of the aquifer(s) penetrated. Wellhead pressure data were scrutinized for temporal trends. No temporal trends are apparent. No pressure response at well RRGE-1 is recognized during the RRGP-4AB production or recovery (Figures 47 and 48).

Wellhead pressure changes greater than 690 Pa (0.1 psi) were not observed at USGS-3 and MW-1 (Figure 50) during the RRGP-4AB production test. USGS-3 and MW-1 were apparently not affected by the production of RRGP-4AB at 0.95 lps (15 gpm).

4.3 Conclusions

It is estimated that pumping RRGP-4AB at 6.2 lps (100 gpm) would result in 3.6 x 10^3 kPa (520 psi) of drawdown over one day of production (Figure 51). The extrapolation was derived by linear extension of the production test data, assuming no boundaries and utilizing simple ratios of production rates. The estimate contains inherent errors due to the non-Darcian response of fractured wells, control of discharge rate, and possible flashing in the discharge line during the test. Additional testing of RRGP-4AB is required before a final decision concerning the well is resolved. It is recommended that future testing consist of short duration production or injection tests, with rate and duration based on Figure 51. The tests could serve as a basis for comparison if it is decided to stimulate the well.

No effects of the test were seen in the observation well. The rate and the length of the test cannot be considered sufficient to yield interference data suitable for qualitative or quantitative analysis.

5. RRGE-2 TO RRGI-6 SEVENTY-TWO HOUR SUPPLY AND INJECTION TEST January 9-19, 1979

5.1 Test Description

Testing began on January 9, 1979, after a 3-week, 6.3 lps (100 gpm) artesian wellbore warm-up flow from RRGE-2 to RRGI-6. During this period, the wellbore achieved quasi-thermal equilibrium. The downhole temperature-pressure probe was lowered into the RRGI-6 well, and two one-hour pulse tests at 52 lps (820 gpm) and 47 lps (750 gpm) were run. After well recovery and equipment maintenance, the 72-hour, 44 lps (700 gpm) test started. Five hours into testing, a fire broke out in the RRGI-6 pump panel. Repairs were made and the test was restarted. After running a temperature log, the downhole temperature-pressure probe was reinserted. It functioned satisfactorily for 12 hours and then failed. The probe could not be repaired. During recovery following the 72-hour injection, a transite pipe gasket in the pipeline from RRGE-2 to RRGI-6 failed, but this caused no delay or loss of test data. Final pulse testing at 46.0 lps (730 gpm) and 50.0 lps (800 gpm) was completed January 19, 1979.

Most of the instrumentation and hardware for this test were constructed as permanent installations. All piping, strainers, pumps, and related hardware (see Figure 52) installed for this test were designed as part of the permanent supply-and-injection system, and all hardware performed satisfactorily. A mobile test trailer for instrumentation became the on-site laboratory. It housed recorders for pH, conductivity, oxidation-reduction, temperature, and pressure, and it contained a transducer computer with recorder. For pressure out of the range of the pressure transducer, engineers substituted a pressure gauge in the wellhouse. The downhole temperature-pressure probe gave downhole data through the initial pulse tests and for part of injection testing. The pH, conductivity, oxidation-reduction meters, and a sample tap located in the RRGI-6 pumphouse gave back-up geochemical data and provided a check on the accuracy of recordings.

Appendix F is an execution copy of FET-22C-78, the test plan for injecting RRGI-6.

5.2 Preliminary Test Assessment

Detailed analysis of RRGI-6 data is now under way. This work will be reported in the Advanced Programs milestone report to be issued February 15, 1979. The following analysis is based upon a very preliminary evaluation designed to address the primary objective of pump selection criteria. Borehole characteristics will be addressed in detail in the February 15 report. Use of the downhole temperature-pressure probe has allowed for a more thorough analysis of early wellbore changes.

The pulse and 72-hour-duration injection tests into RRGI-6 while pumping RRGE-2 have furnished data on the hydrologic characteristics of the RRGI-6 aquifer (Figure 53). The pulse tests before and after the 72-hour injection do not suggest any increase in well losses. Downhole and wellhead data collected after 300 minutes of injection suggest a Q/s_{10} ratio of 0.3783 lps/kPa/log cycle (41.35 gpm/psi/log cycle), where Q is the effective injection rate of 42.9 lps (680 gpm) and s_{10} is the slope of the data per log cycle on a semilogarithmic plot of pressure versus time since injection began.

5.3 Conclusions

Expected wellhead pressure after 20 days and 5 years of continuous injection of 125.5^{o}C (258^{o}F) water at 44.2 lps (700 gpm) are 1751 kPaa (254 psia) and 1972 kPaa (286 psia), respectively, assuming no interference or boundary effects. Injection rates for 20-day tests should be less than 94.62 lps (1500 gpm) until additional data on well performance at injection rates in excess of 50.5 lps (800 gpm) are available. Interference effects at monitor wells were less than normal water-level fluctuations due to barometric pressure changes, earth tides, and borehole fluid-density changes. Longer tests with higher injection rates will facilitate the analysis of interference effects, if any, on the monitor wells.

III. SEVENTY-TWO HOUR TEST PROGRAM CONCLUSIONS

The 72-hour test sequence provided valuable information as well as preparation for long term testing. The information allowed preliminary assessments of well performance to be made. Information on hardware and instrumentation proved the permanent system will function as required, showed ways to improve accuracy and efficiency during long term testing, and provided parameters needed for long term test system design. The RRGI-7 Injection Test experience showed that commercial oil-field pumper trucks are not reliable enough for well testing at the Raft River Test Site. The RRGP-4AB test proved that flow control and measurement is extremely difficult at low flow rates. Personnel performance in system operation and data collection improved with each test and will be invaluable as long term testing proceeds. Test procedures also improved to aid in efficiency for these and long term test plans.

Although the early tests encountered problems in performing a full 72 hour test and in interpreting the data, the final test (flowing RRGE-2 water and injecting into the RRGI-6 well) proved to be a very successful test. These test successes and improvements should help to ensure the favorable outcome of long term tests and the integrated tests planned before the 5MW Plant startup.

IV. REFERENCES

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2. R. W. Gould, personal communication, 1978.

3. W. L. Niemi, "Reservoir Engineering," in G. L. Blake, ed., Semiannual Progress Report for the Idaho Geothermal Program, Oct. 1, 1977, to March 31, 1978, TREE-1278 (July 1978) p 7.

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7. D. W. Allman, personal communication, 1978.

APPENDIX A

FIGURES

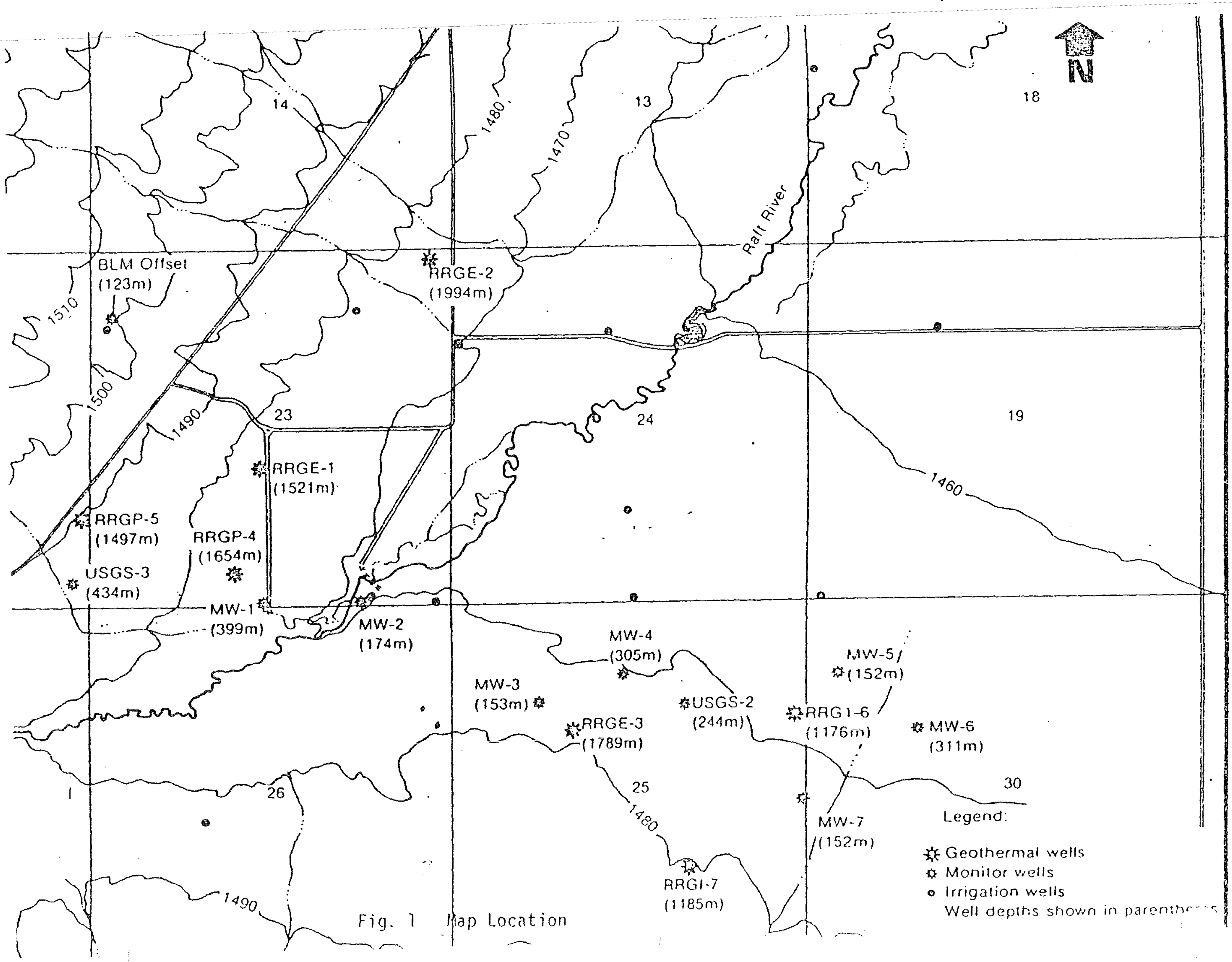


Fig. 1 Map Location

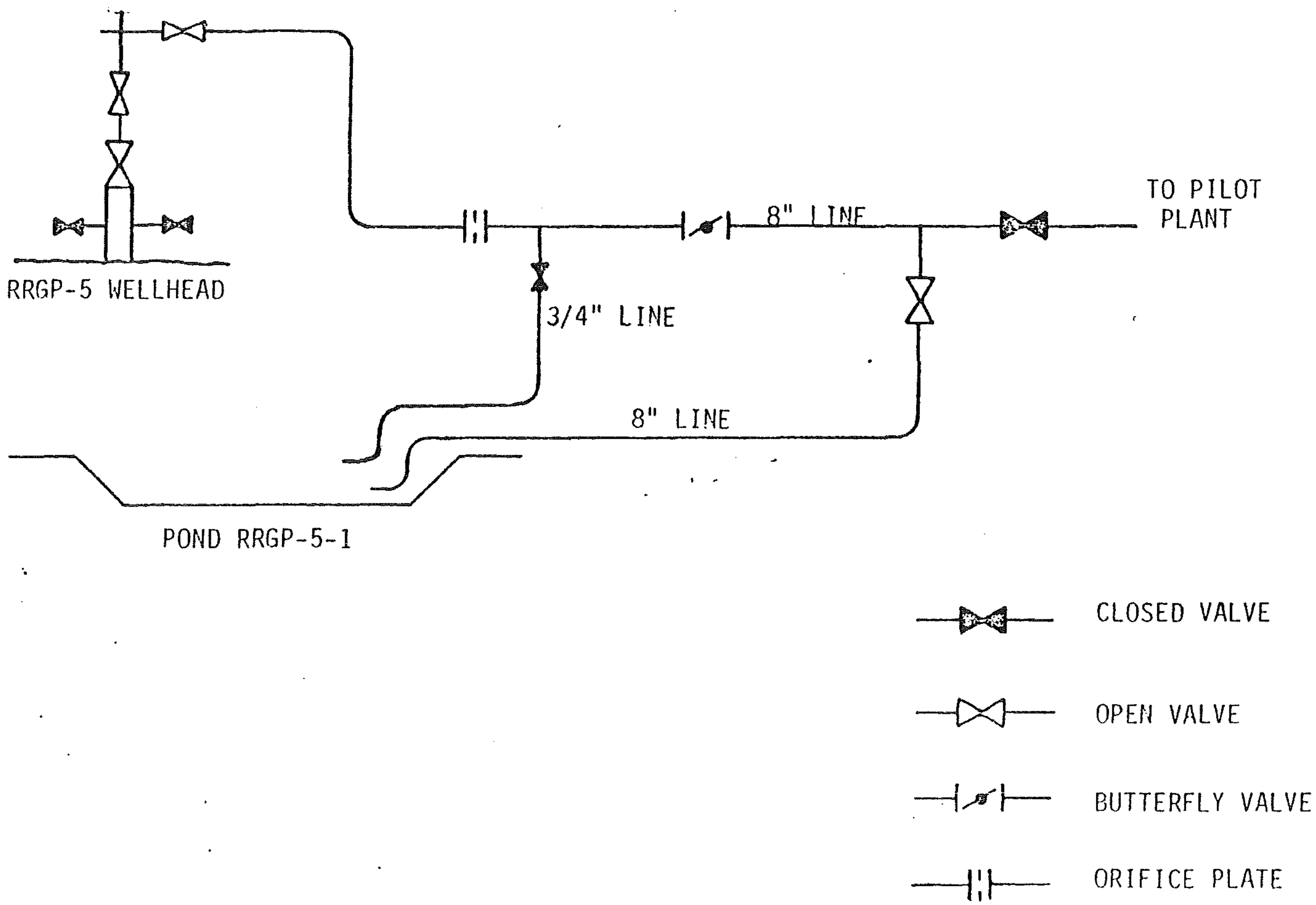


Fig. 2 RRGP-5 free-flow diagram.

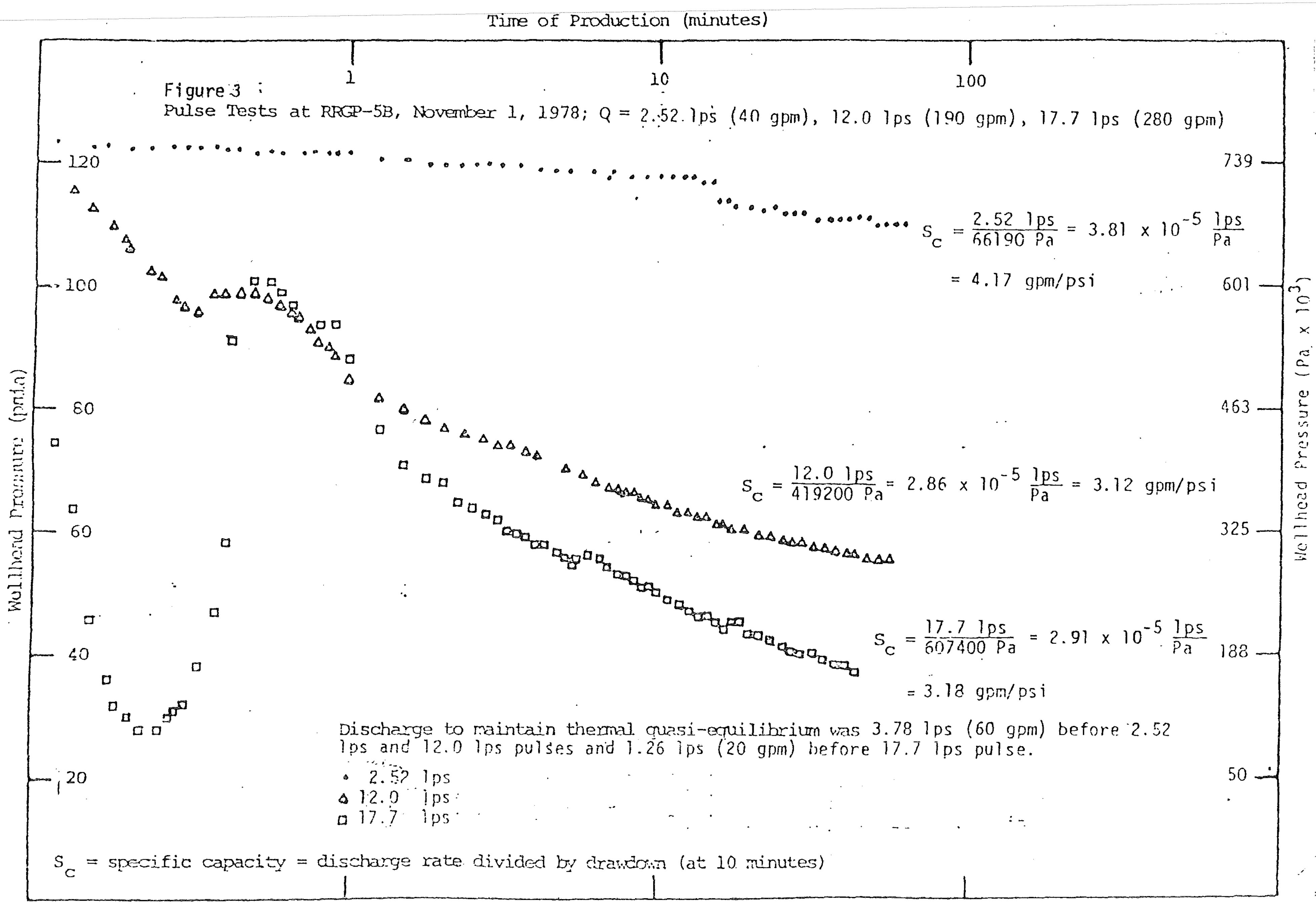


Figure 3 : Pulse Tests at RRGP-5B, November 1, 1978; Q = 2.52 lps (40 gpm), 12.0 lps (190 gpm), 17.7 lps (280 gpm)

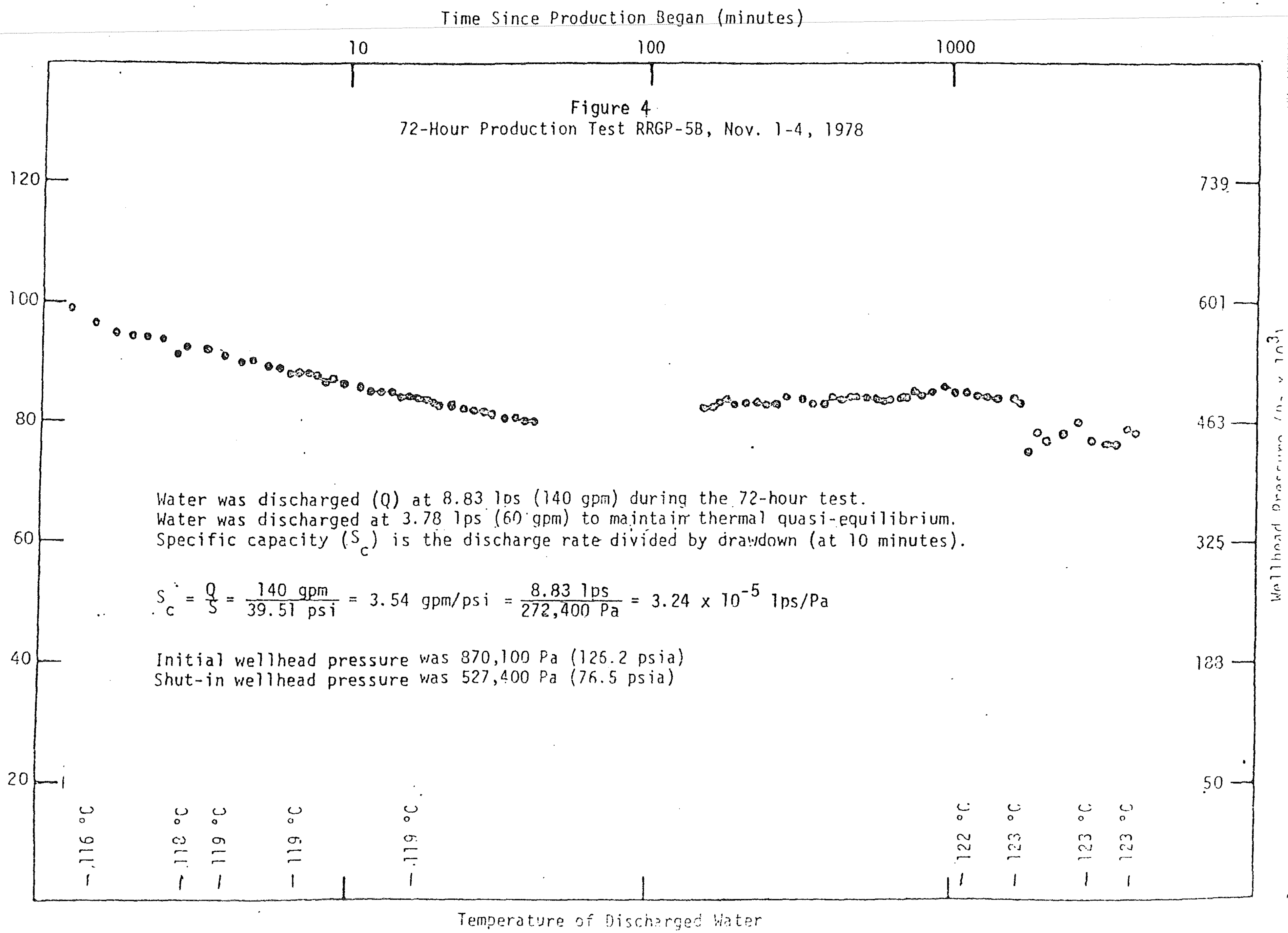


Figure 4

72-Hour Production Test RRGP-5B, Nov. 1-4, 1978

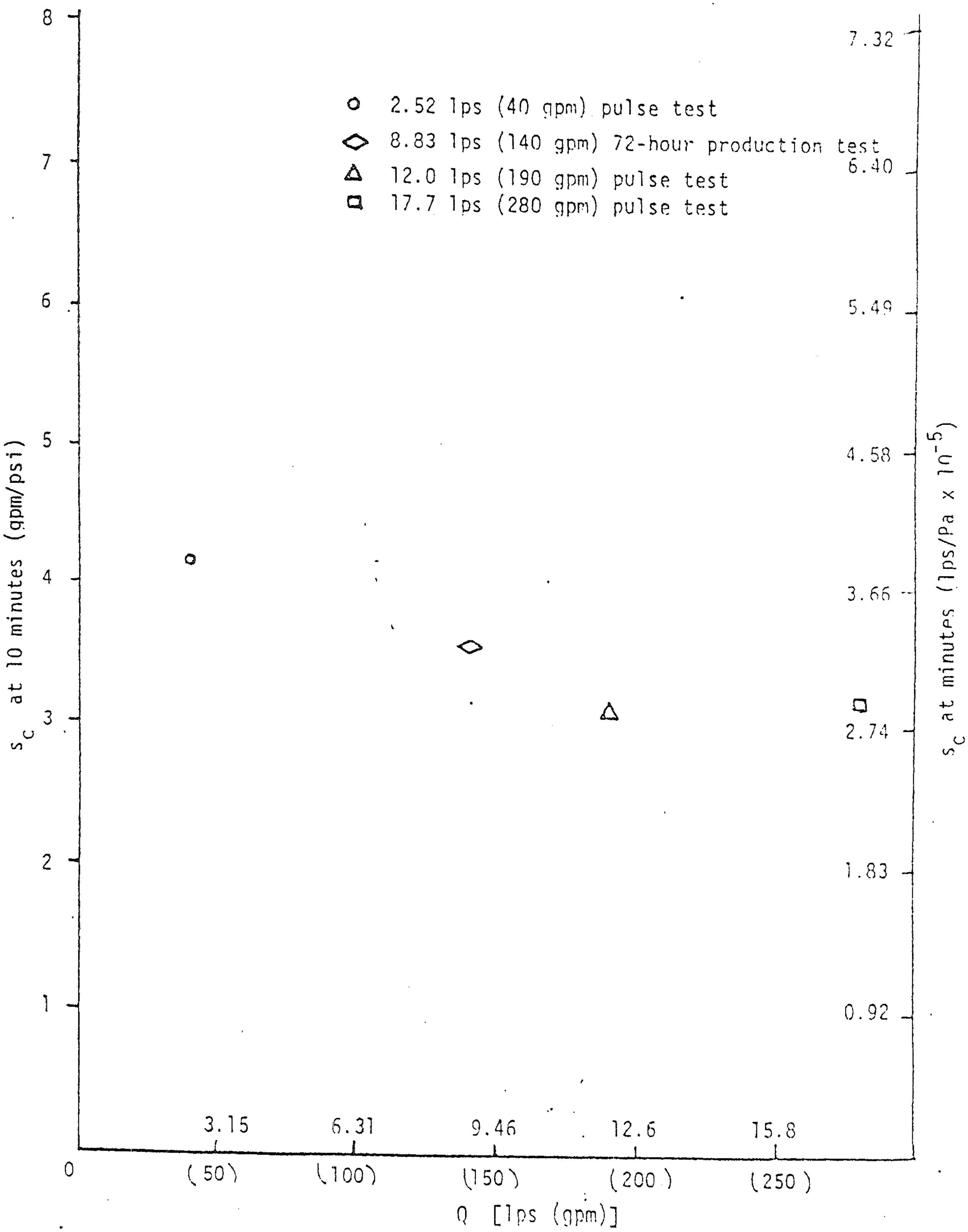
Water was discharged (Q) at 8.83 lps (140 gpm) during the 72-hour test.
Water was discharged at 3.78 lps (60 gpm) to maintain thermal quasi-equilibrium.
Specific capacity (S_c) is the discharge rate divided by drawdown (at 10 minutes).

$$S_c = \frac{Q}{S} = \frac{140 \text{ gpm}}{39.51 \text{ psi}} = 3.54 \text{ gpm/psi} = \frac{8.83 \text{ lps}}{272{,}400 \text{ Pa}} = 3.24 \times 10^{-5} \text{ lps/Pa}$$

Initial wellhead pressure was 870,100 Pa (126.2 psia)
Shut-in wellhead pressure was 527,400 Pa (76.5 psia)

Figure 5

RRGP-5B Specific Capacity (s_c) vs Discharge Rate (Q)



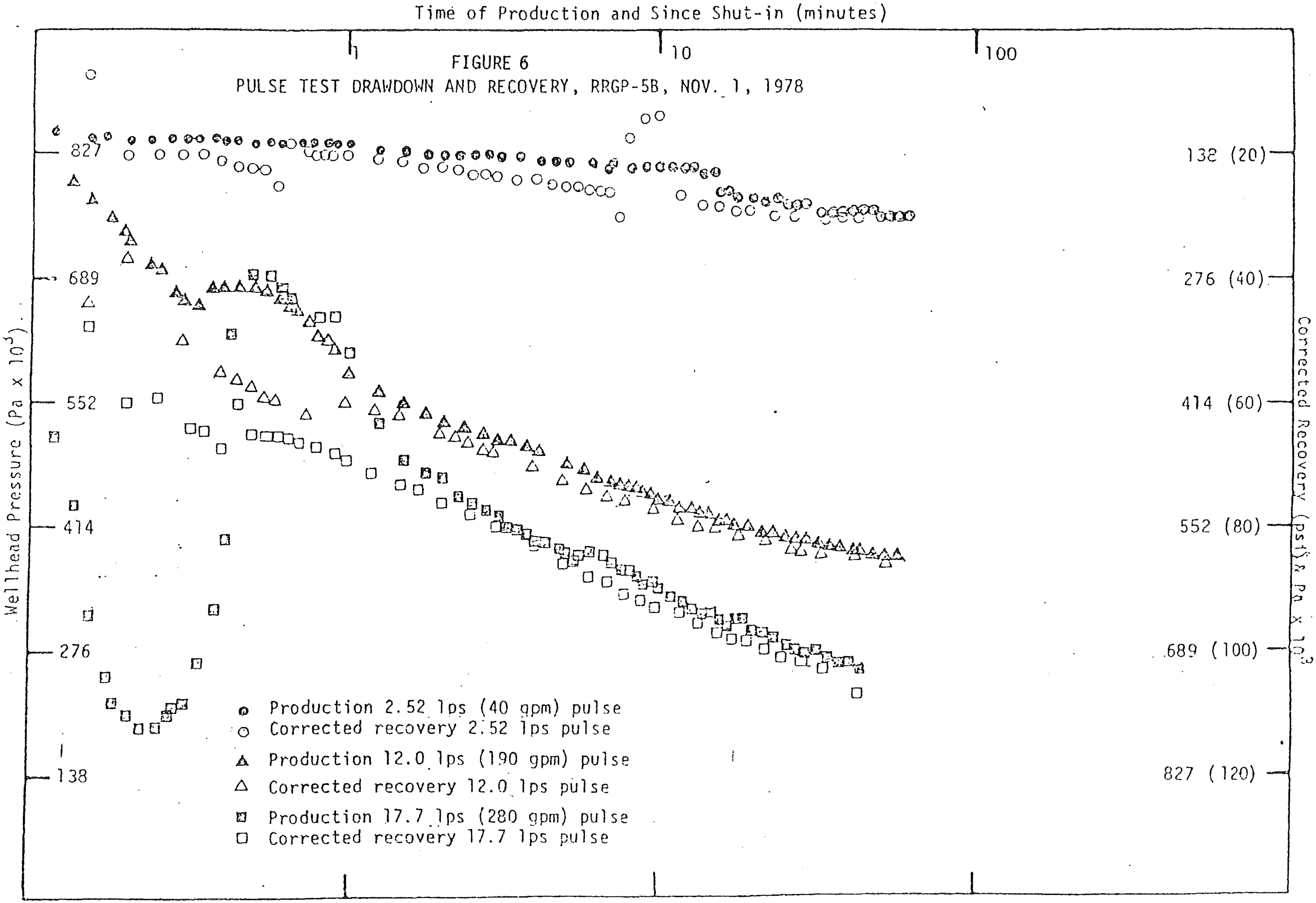
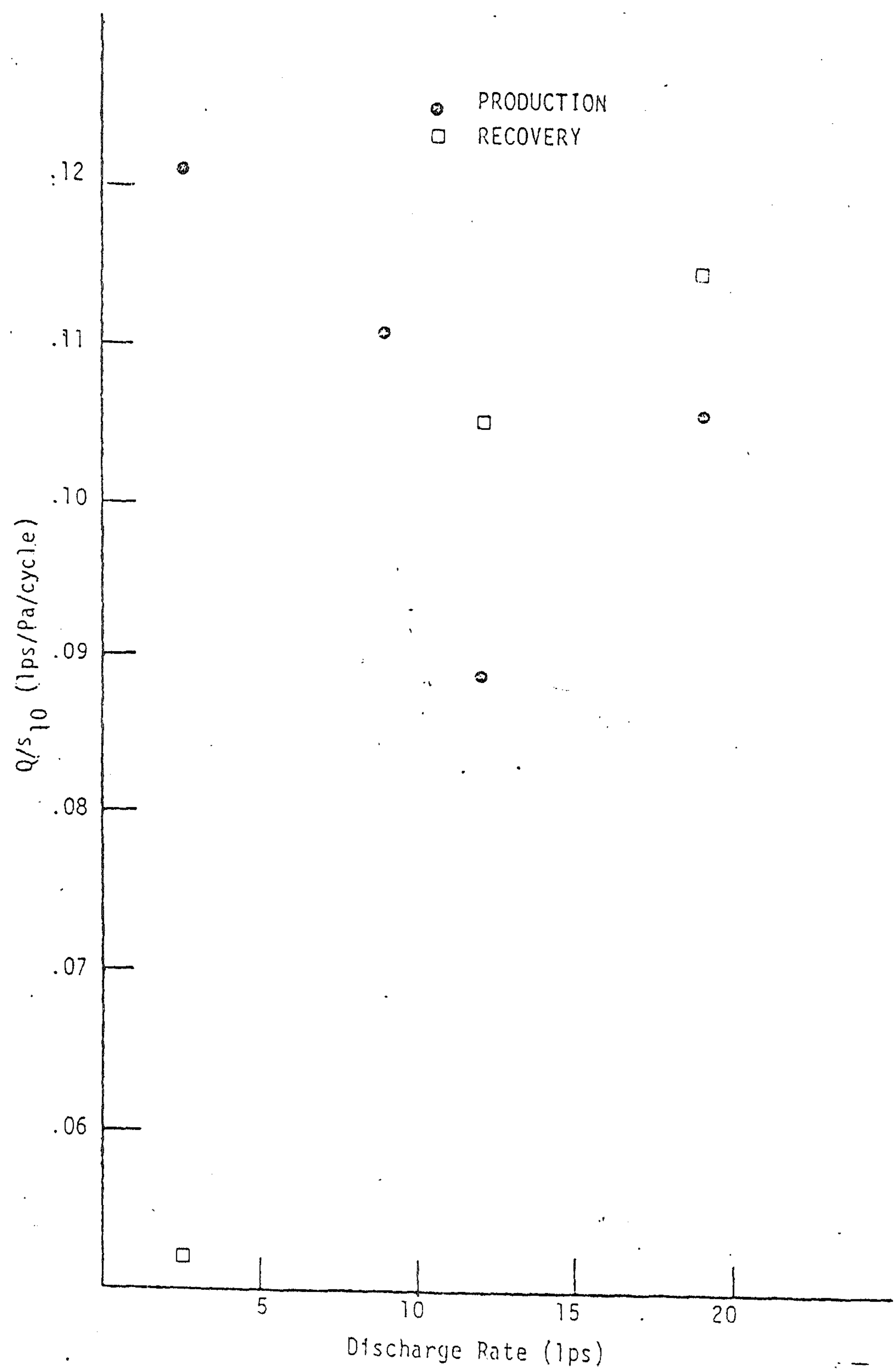

Time of Production and Since Shut-in (minutes)
1
10
100
FIGURE 6
PULSE TEST DRAWDOWN AND RECOVERY, RRGP-5B, NOV. 1, 1978
Wellhead Pressure (Pa x 10^3)
827
689
552
414
276
138
Corrected Recovery (psi) & Pa x 10^3
132 (20)
276 (40)
414 (60)
552 (80)
689 (100)
827 (120)
Production 2.52 lps (40 gpm) pulse
Corrected recovery 2.52 lps pulse
Production 12.0 lps (190 gpm) pulse
Corrected recovery 12.0 lps pulse
Production 17.7 lps (280 gpm) pulse
Corrected recovery 17.7 lps pulse

FIGURE 7

GRAPH COMPARING DISCHARGE RATE DIVIDED BY DRAWDOWN PER LOG CYCLE VS DISCHARGE RATE



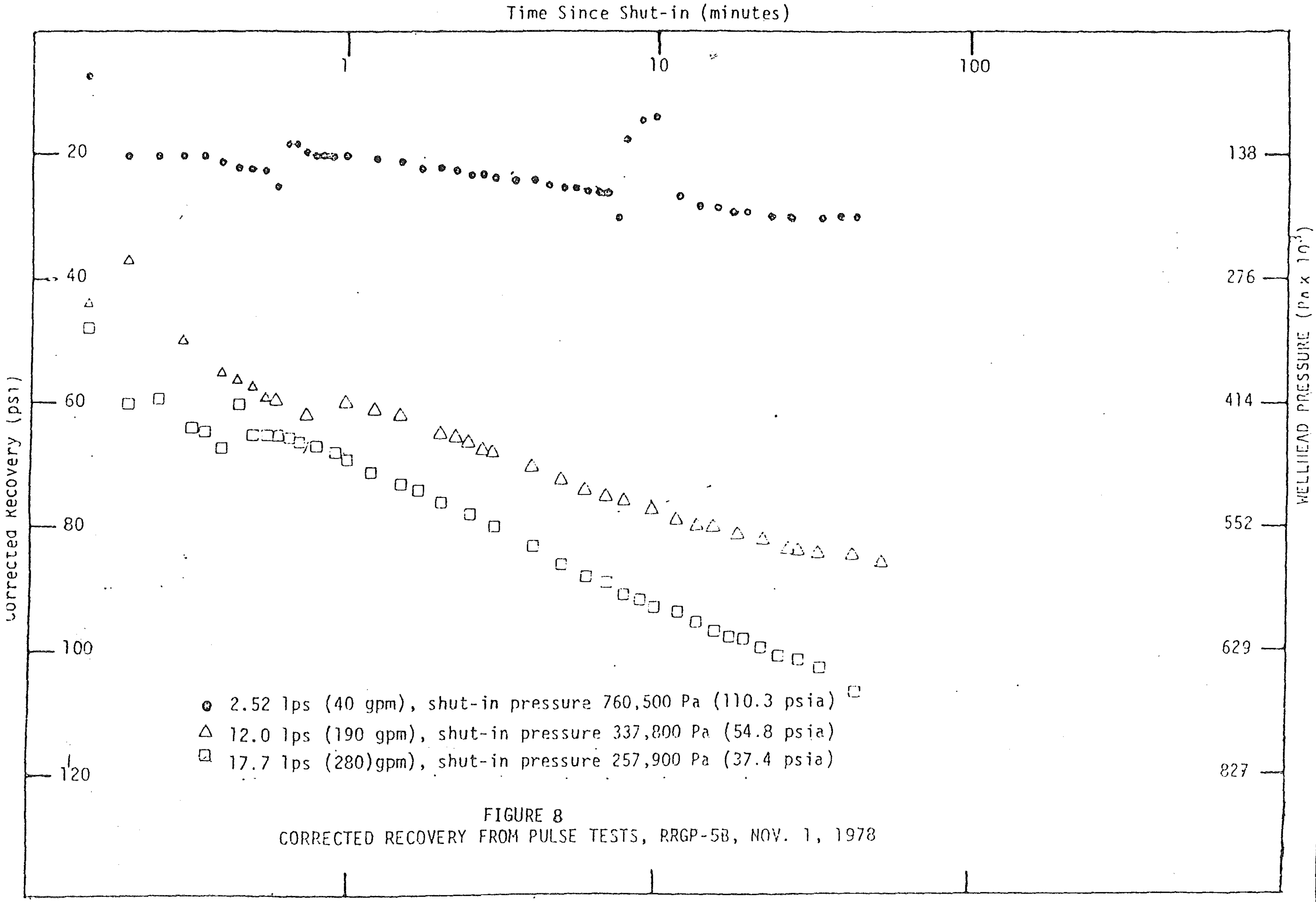
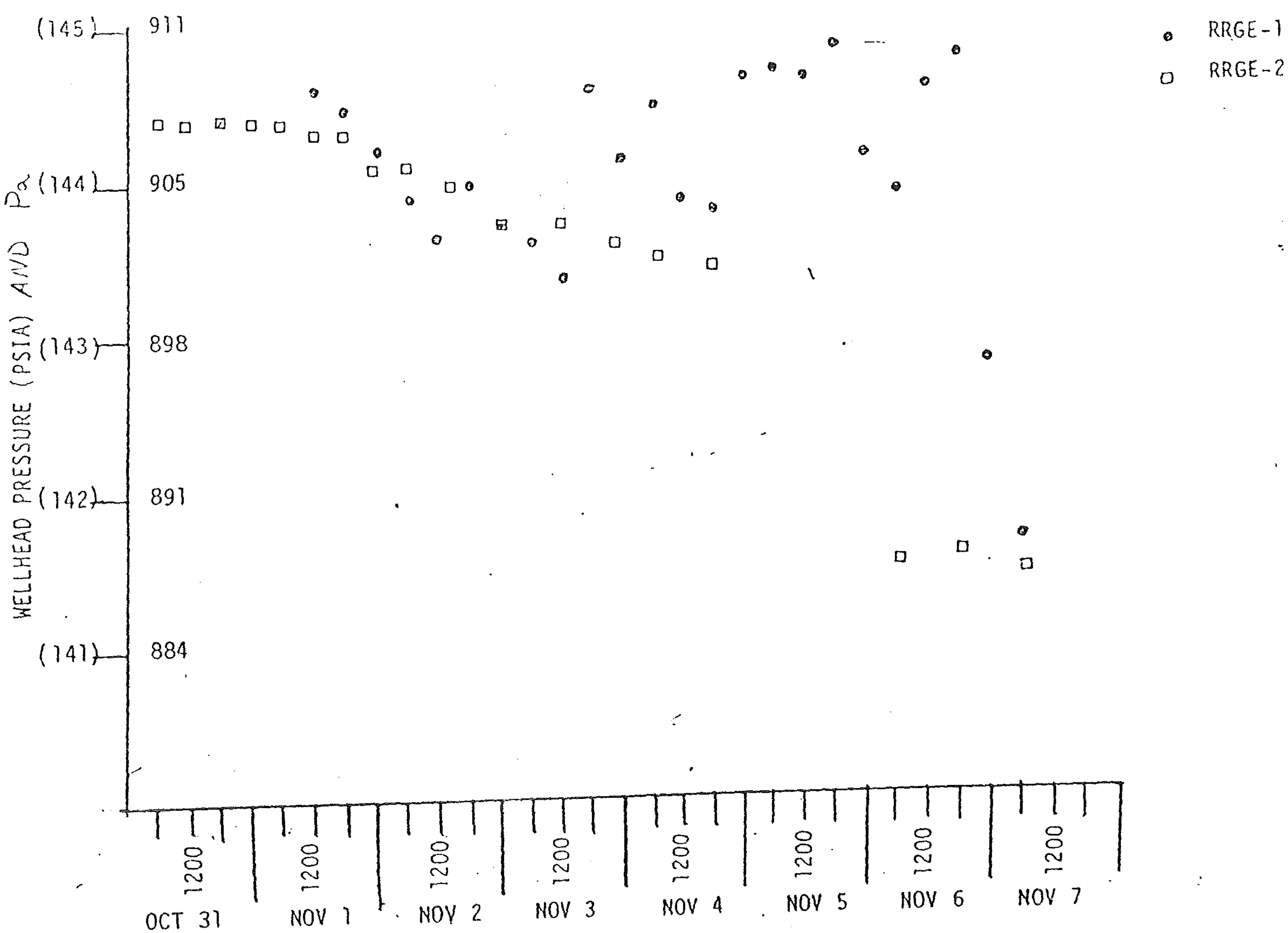


FIGURE 8
CORRECTED RECOVERY FROM PULSE TESTS, RRGP-5B, NOV. 1, 1978

FIGURE 9

WELLHEAD PRESSURE RRGE-1 AND RRGE-2, NOVEMBER 1 THRU NOVEMBER 7, 1978



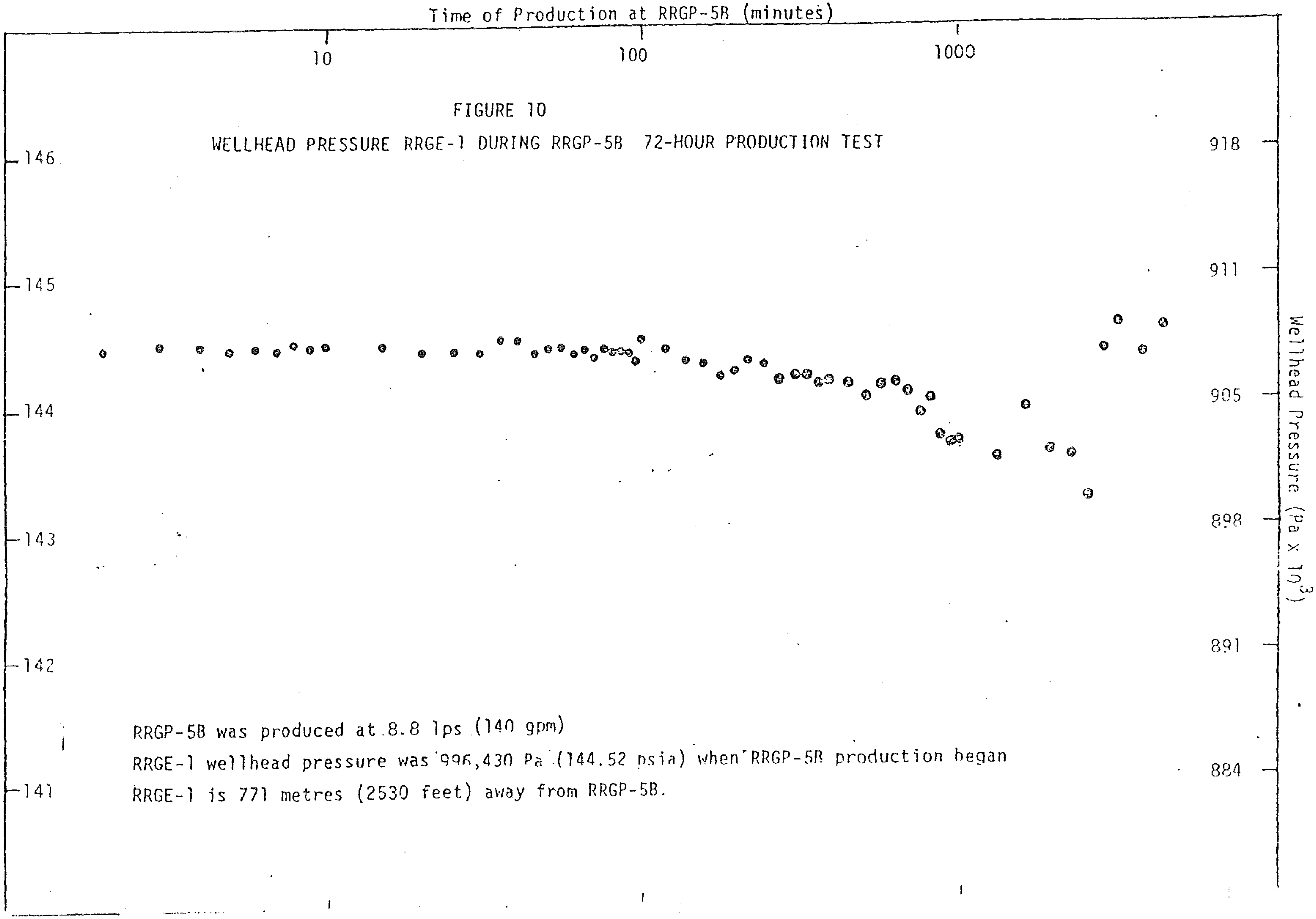
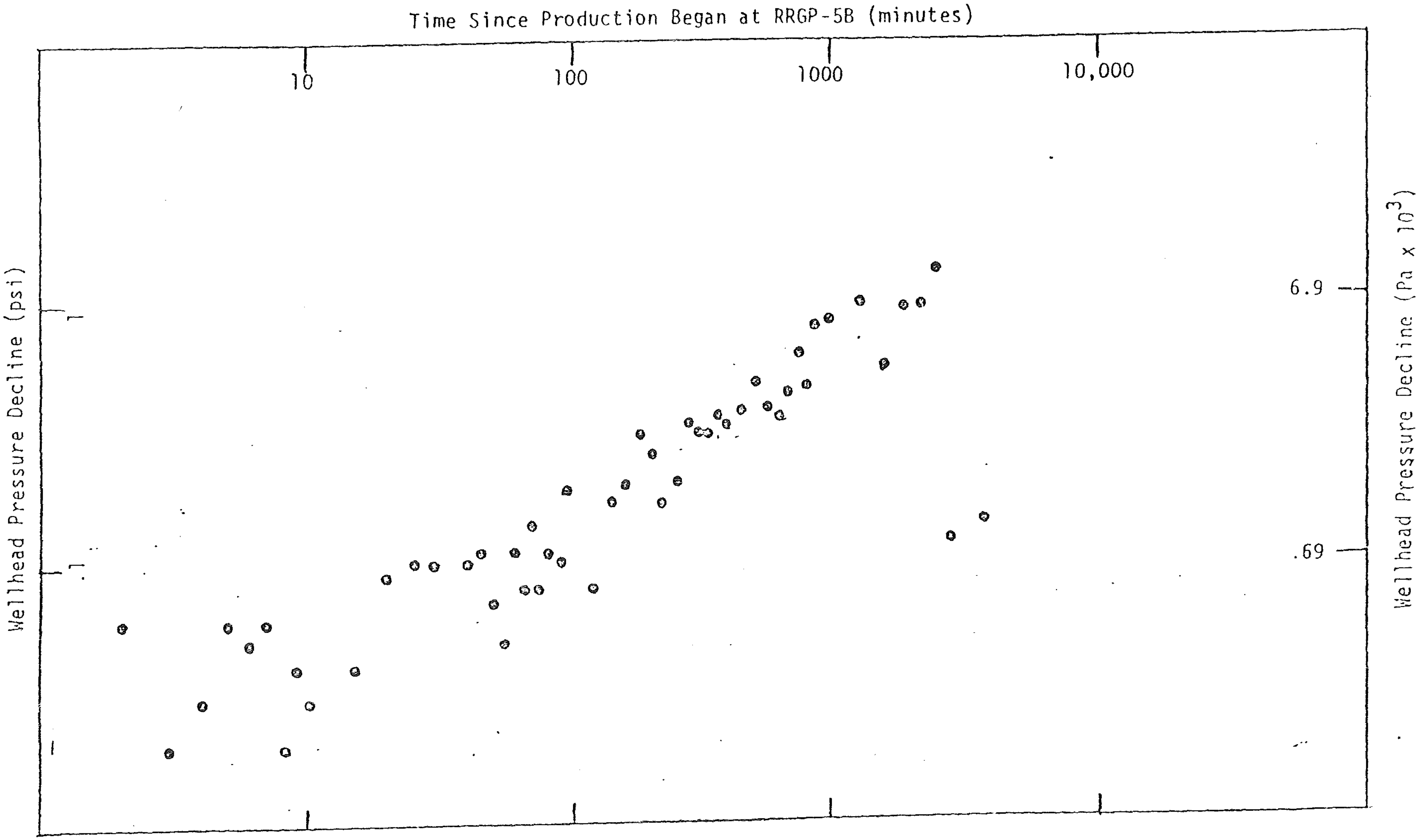


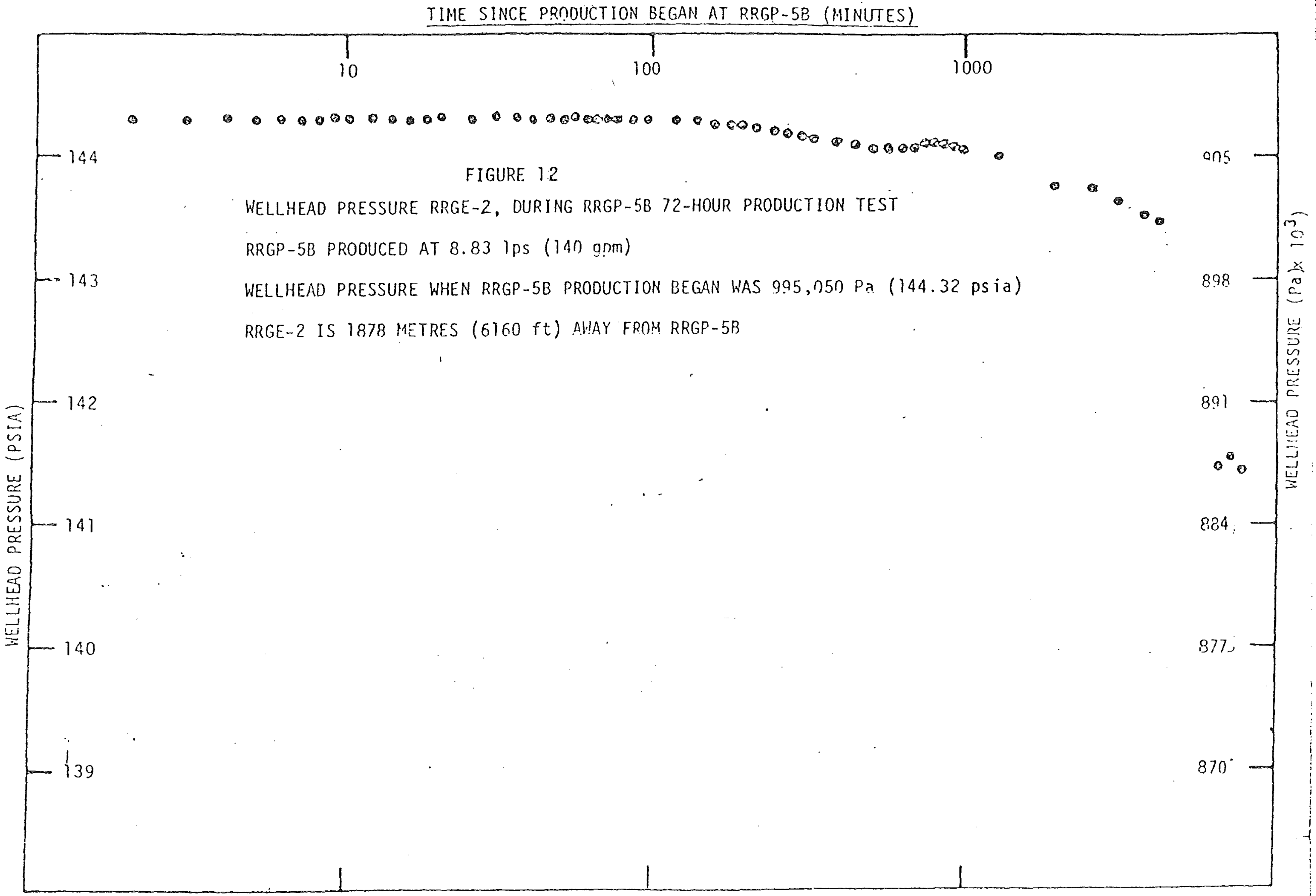
FIGURE 10

WELLHEAD PRESSURE RRGE-1 DURING RRGP-5B 72-HOUR PRODUCTION TEST

FIGURE 11

LOG-LOG GRAPH OF WELLHEAD PRESSURE CHANGE RRGE-1, NOV. 1-4, 1978; RRGP-5B PRODUCING 8.83 lps (140 gpm)




TIME SINCE PRODUCTION BEGAN AT RRGP-5B (MINUTES)
10
100
1000
FIGURE 12
WELLHEAD PRESSURE RRGE-2, DURING RRGP-5B 72-HOUR PRODUCTION TEST
RRGP-5B PRODUCED AT 8.83 lps (140 gpm)
WELLHEAD PRESSURE WHEN RRGP-5B PRODUCTION BEGAN WAS 995,050 Pa (144.32 psia)
RRGE-2 IS 1878 METRES (6160 ft) AWAY FROM RRGP-5B
WELLHEAD PRESSURE (PSIA)
144
143
142
141
140
139
WELLHEAD PRESSURE (Pa x 10^3)
905
898
891
884
877
870

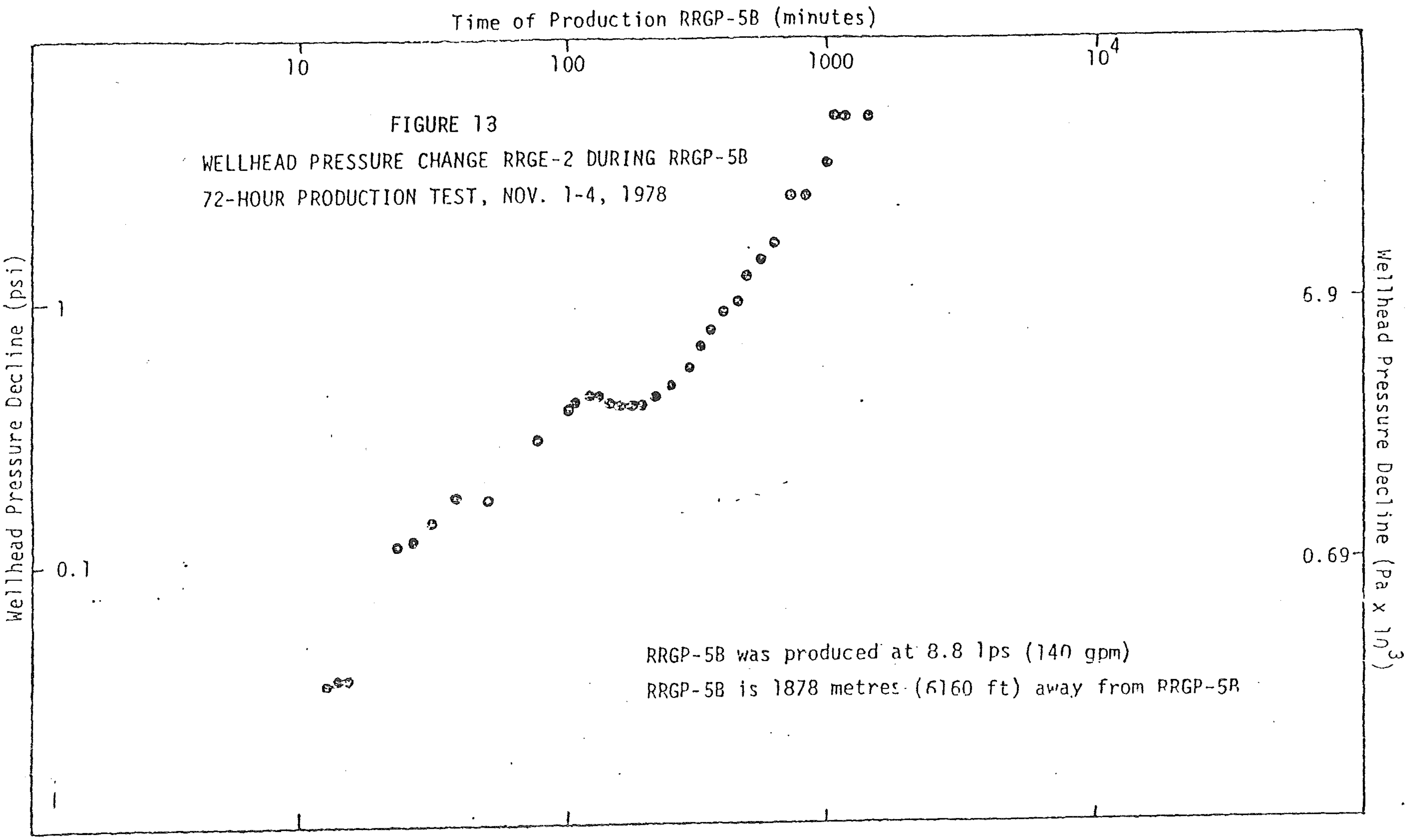
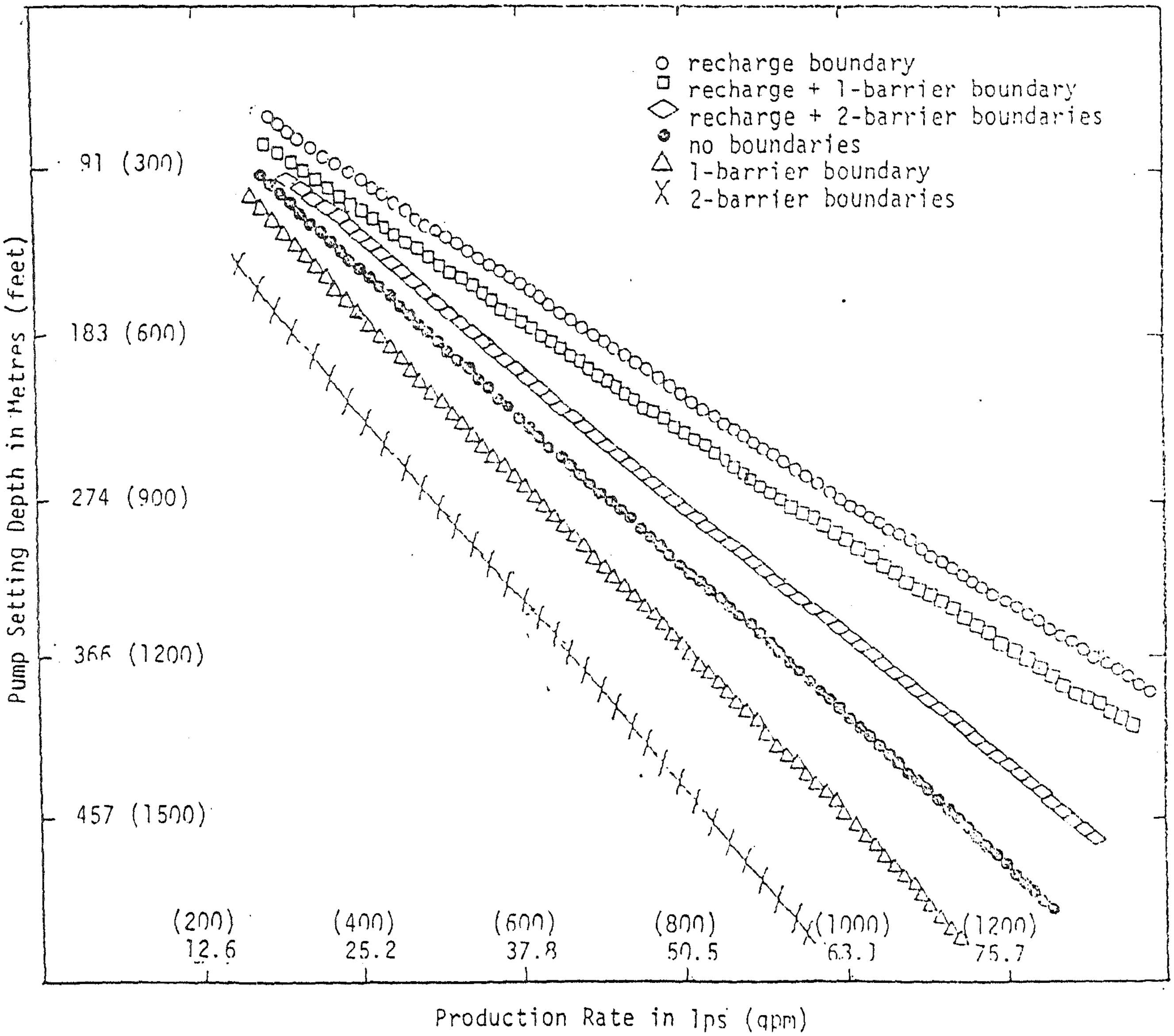


FIGURE 13

WELLHEAD PRESSURE CHANGE RRGE-2 DURING RRGP-5B 72-HOUR PRODUCTION TEST, NOV. 1-4, 1978

FIGURE 14

GRAPH OF PUMP SETTING DEPTH VS PRODUCTION RATE
FOR 20-DAY PRODUCTION TEST AT RRGP-5B



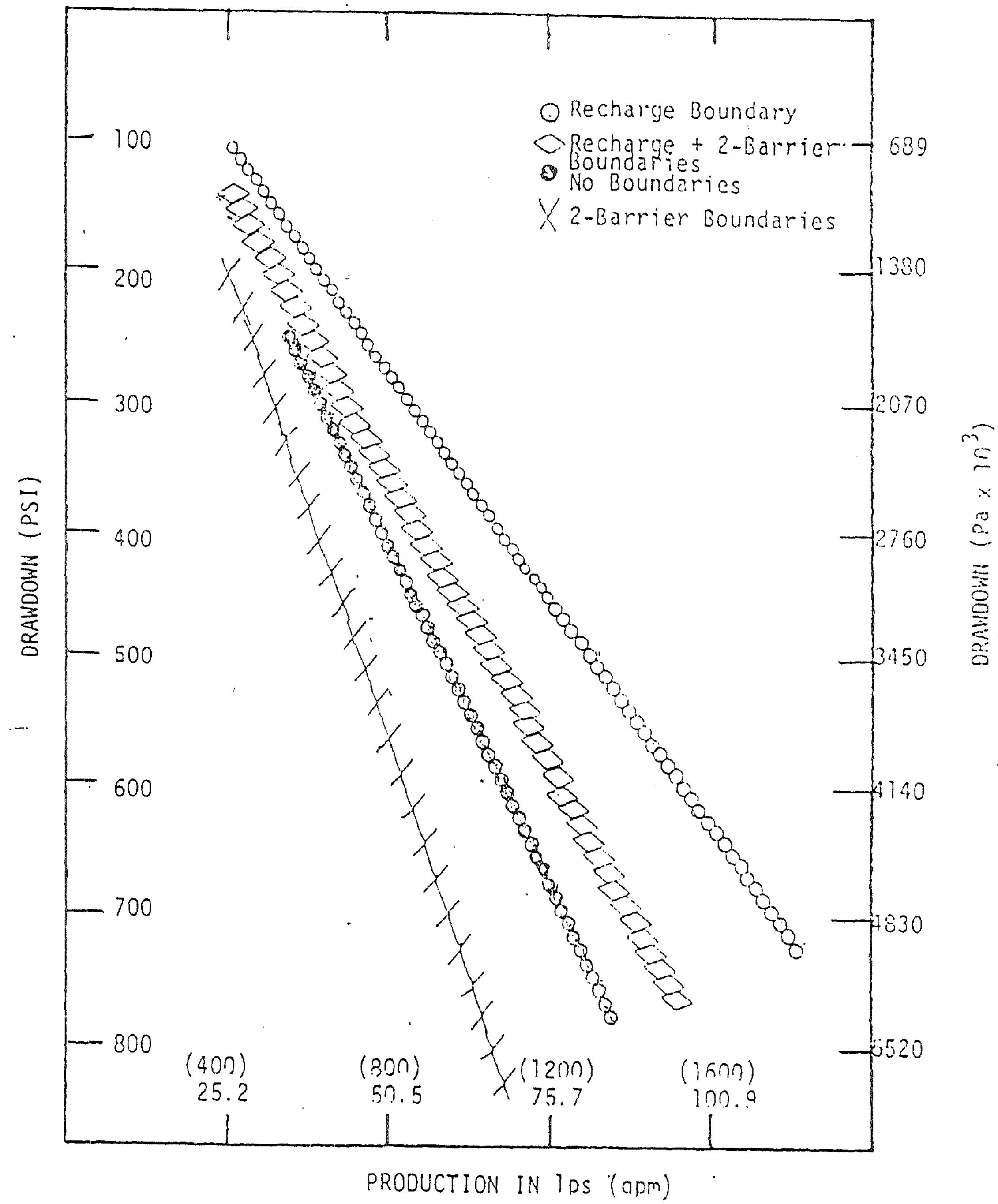
Based upon 72-hour, 8.83 lps (140 gpm) production test (Nov. 1-4, 1978)

Assumptions:
1) no well interference
2) 620,000 Pa (90 psi) must be maintained above pump bowls
3) an initial wellhead pressure of 793,000 Pa (115 psi)
4) 135 °C (275 °F) aquifer temperature

FIGURE 15

GRAPH OF PRODUCTION RATE VS DRAWDOWN

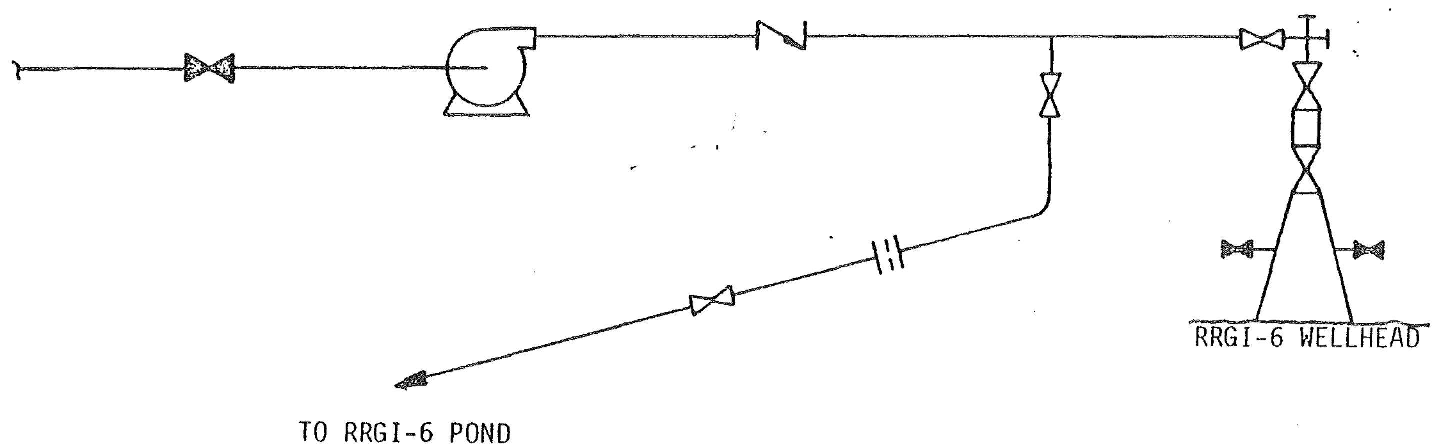
FOR 20-DAY PRODUCTION TEST AT RRGP-5B



BASED UPON 72-HOUR, 8.83 lps (140 gpm) PRODUCTION TEST (Nov. 1-4, 197

ASSUMES NO WELL INTERFERENCE

FIGURE 16 RRGI-6 FREE-FLOW DIAGRAM



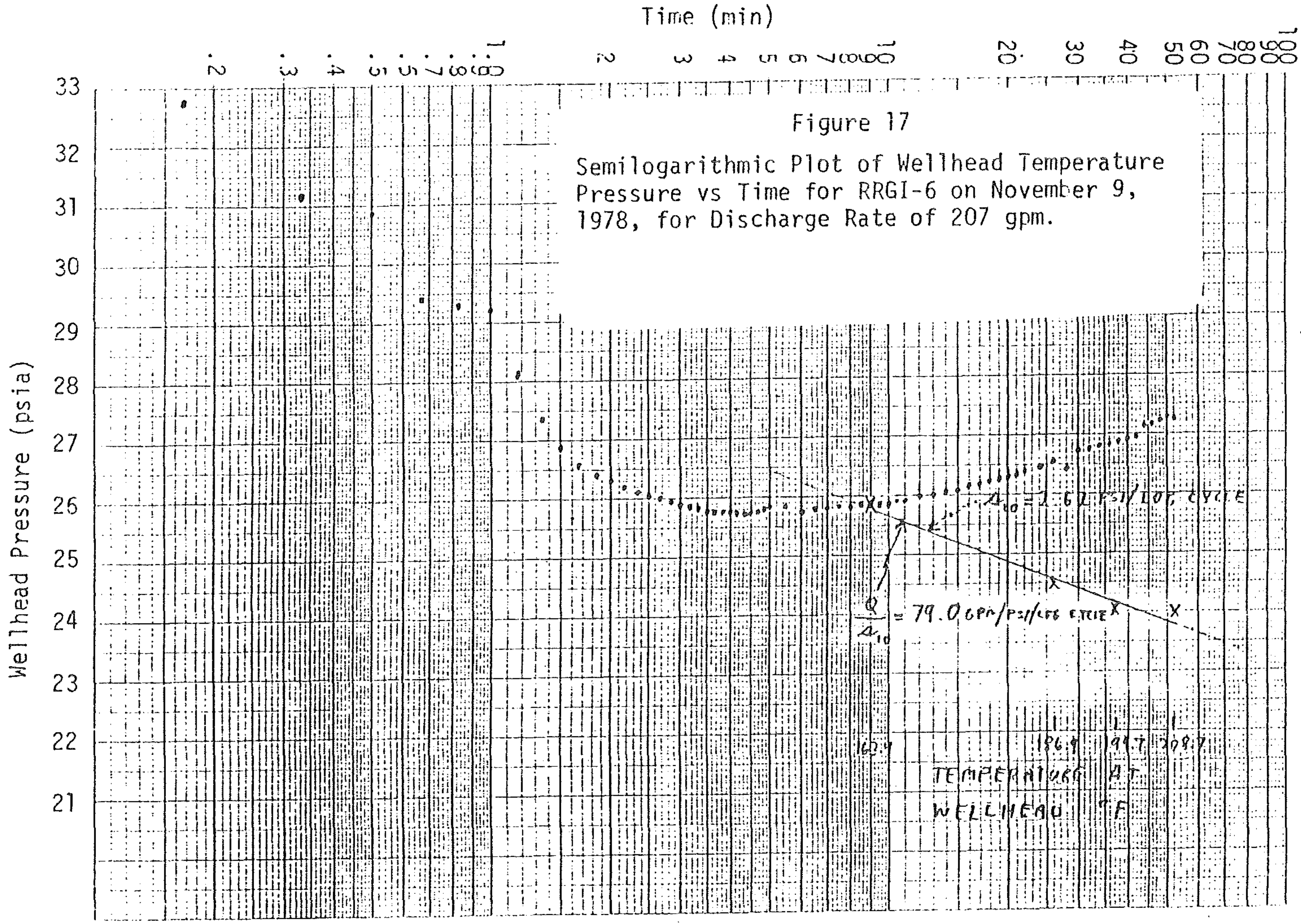


Figure 17

Semilogarithmic Plot of Wellhead Temperature Pressure vs Time for RRGI-6 on November 9, 1978, for Discharge Rate of 207 gpm.

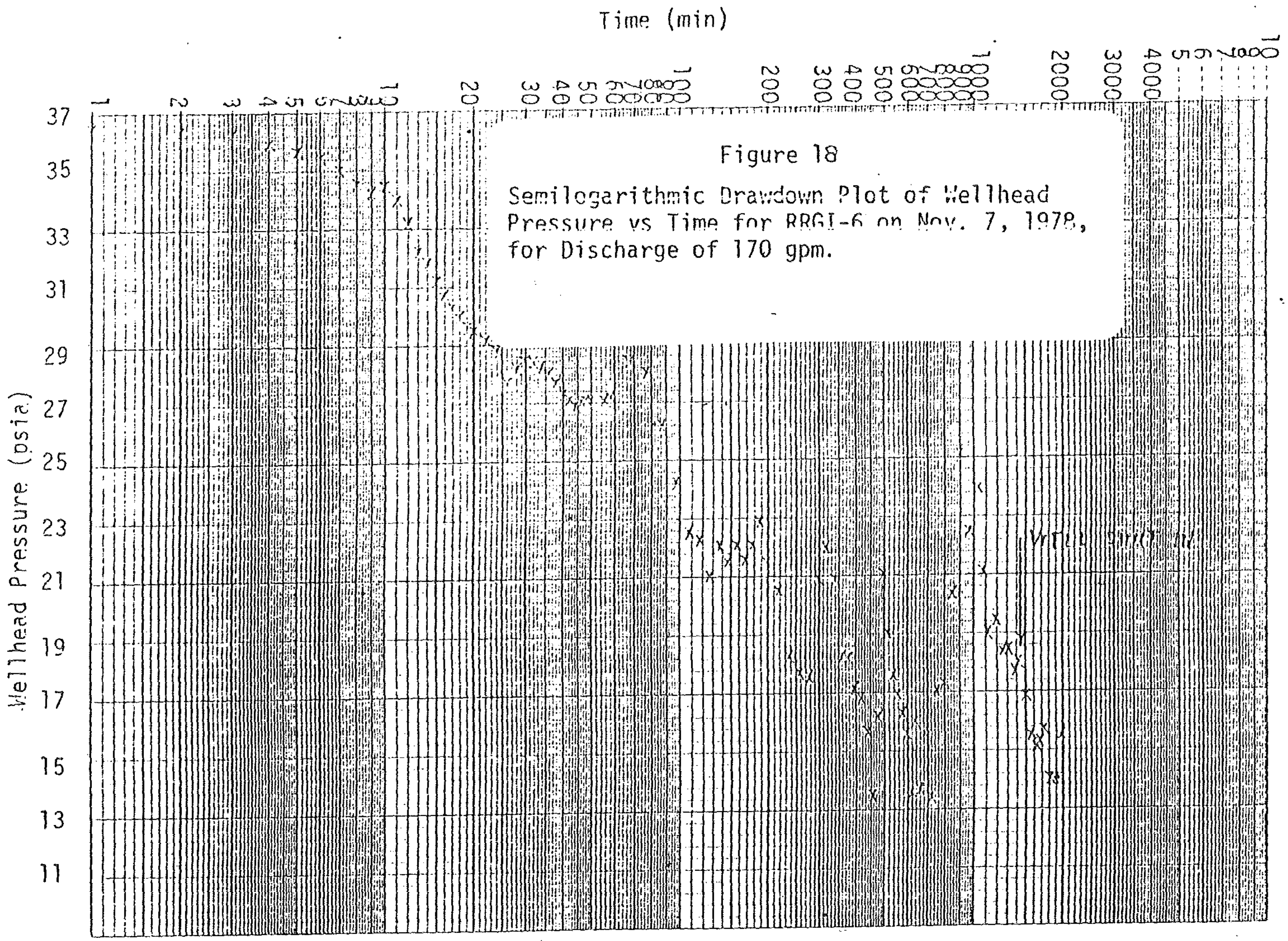


Figure 18

Semilogarithmic Drawdown Plot of Wellhead Pressure vs Time for RRGI-6 on Nov. 7, 1978, for Discharge of 170 gpm.

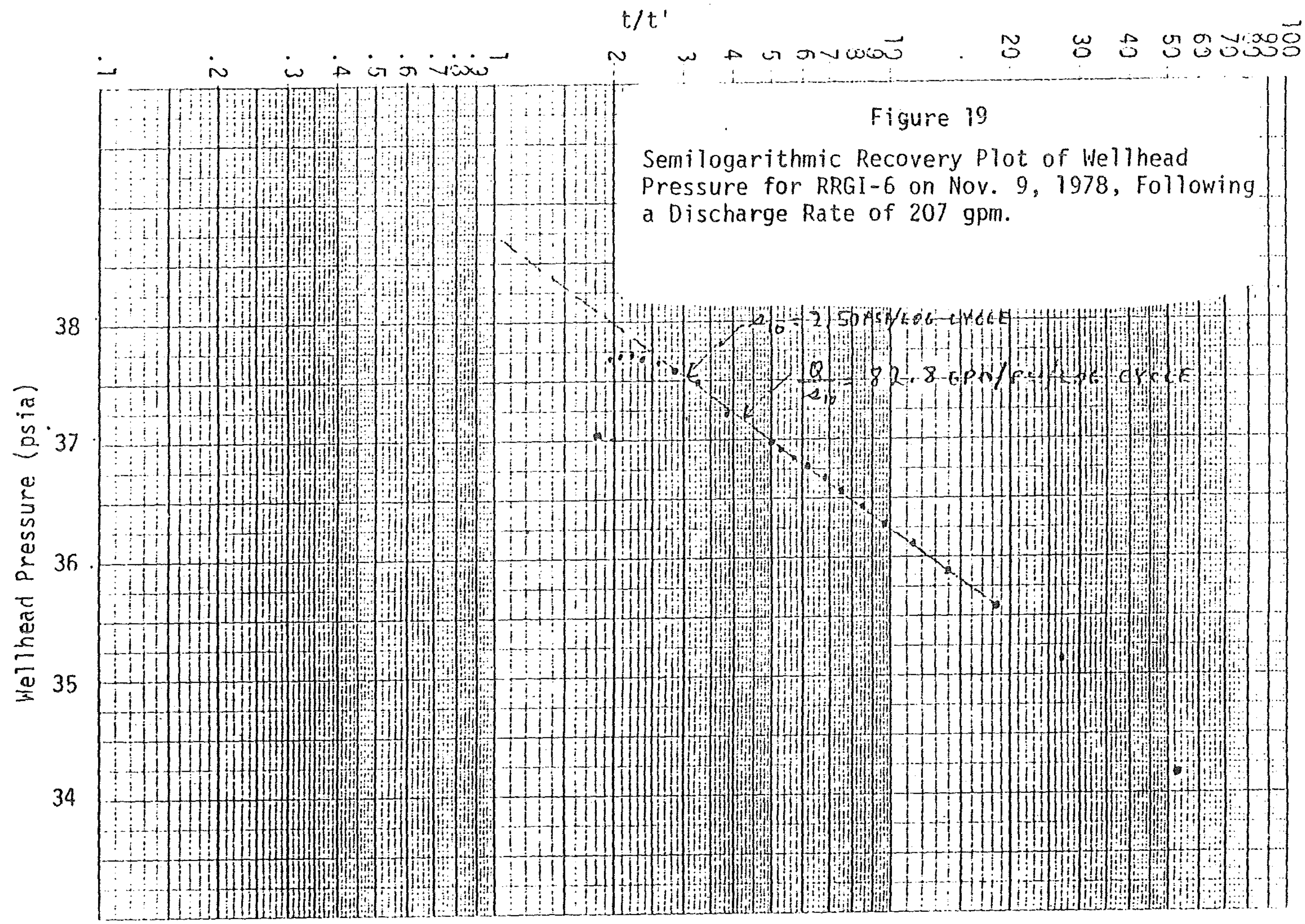


Figure 19

Semilogarithmic Recovery Plot of Wellhead Pressure for RRGI-6 on Nov. 9, 1978, Following a Discharge Rate of 207 gpm.

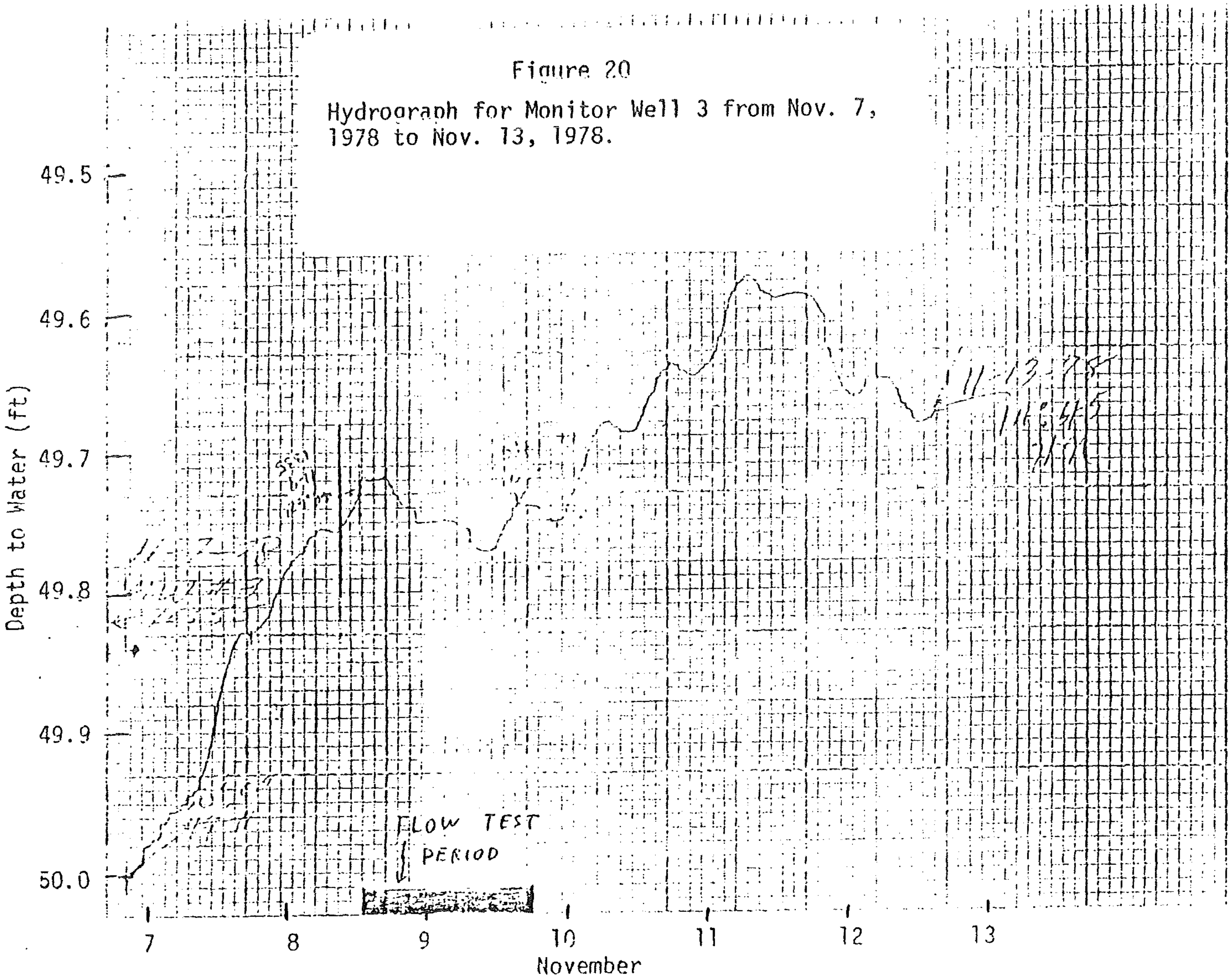


Figure 20
Hydrograph for Monitor Well 3 from Nov. 7, 1978 to Nov. 13, 1978.
Depth to Water (ft)
49.5
49.6
49.7
49.8
49.9
50.0
FLOW TEST PERIOD
7
8
9
10
11
12
13
November

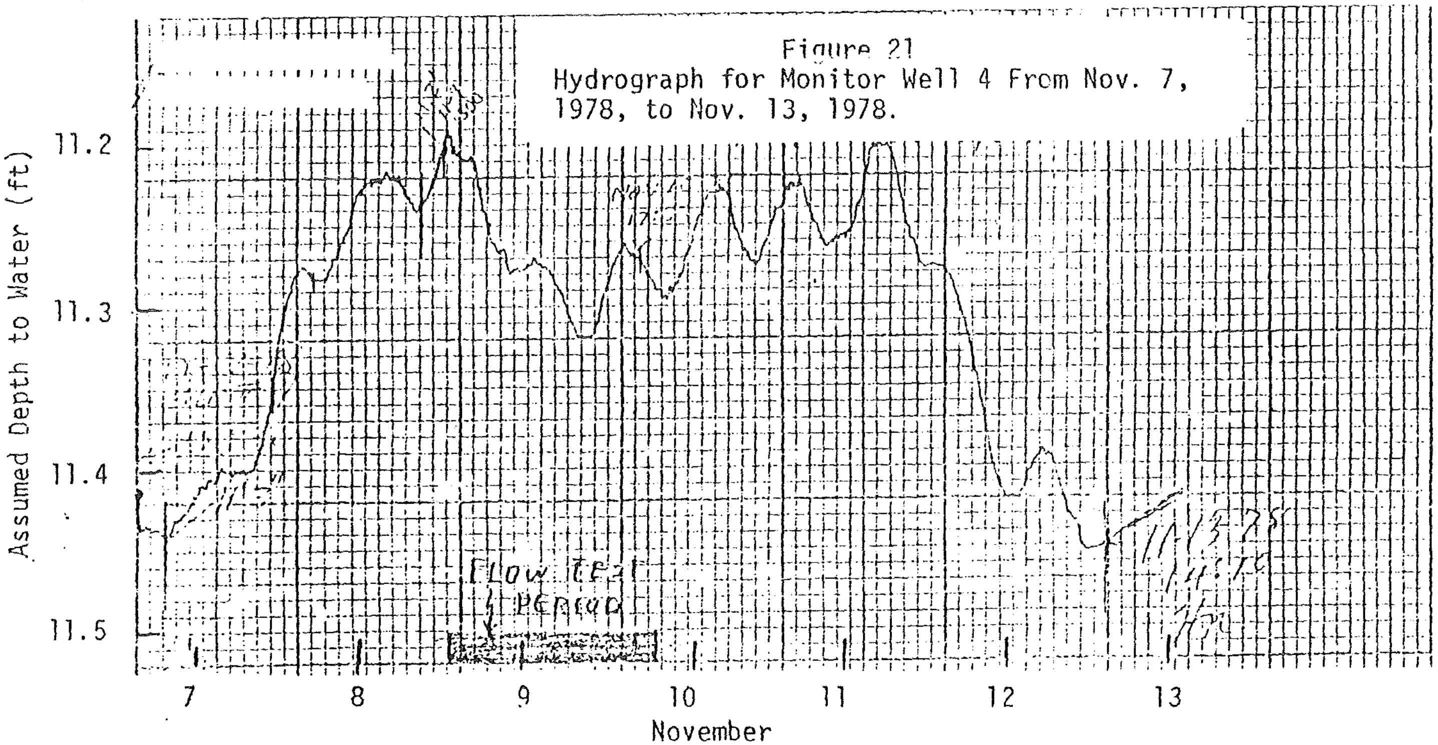


Figure 21
Hydrograph for Monitor Well 4 From Nov. 7, 1978, to Nov. 13, 1978.

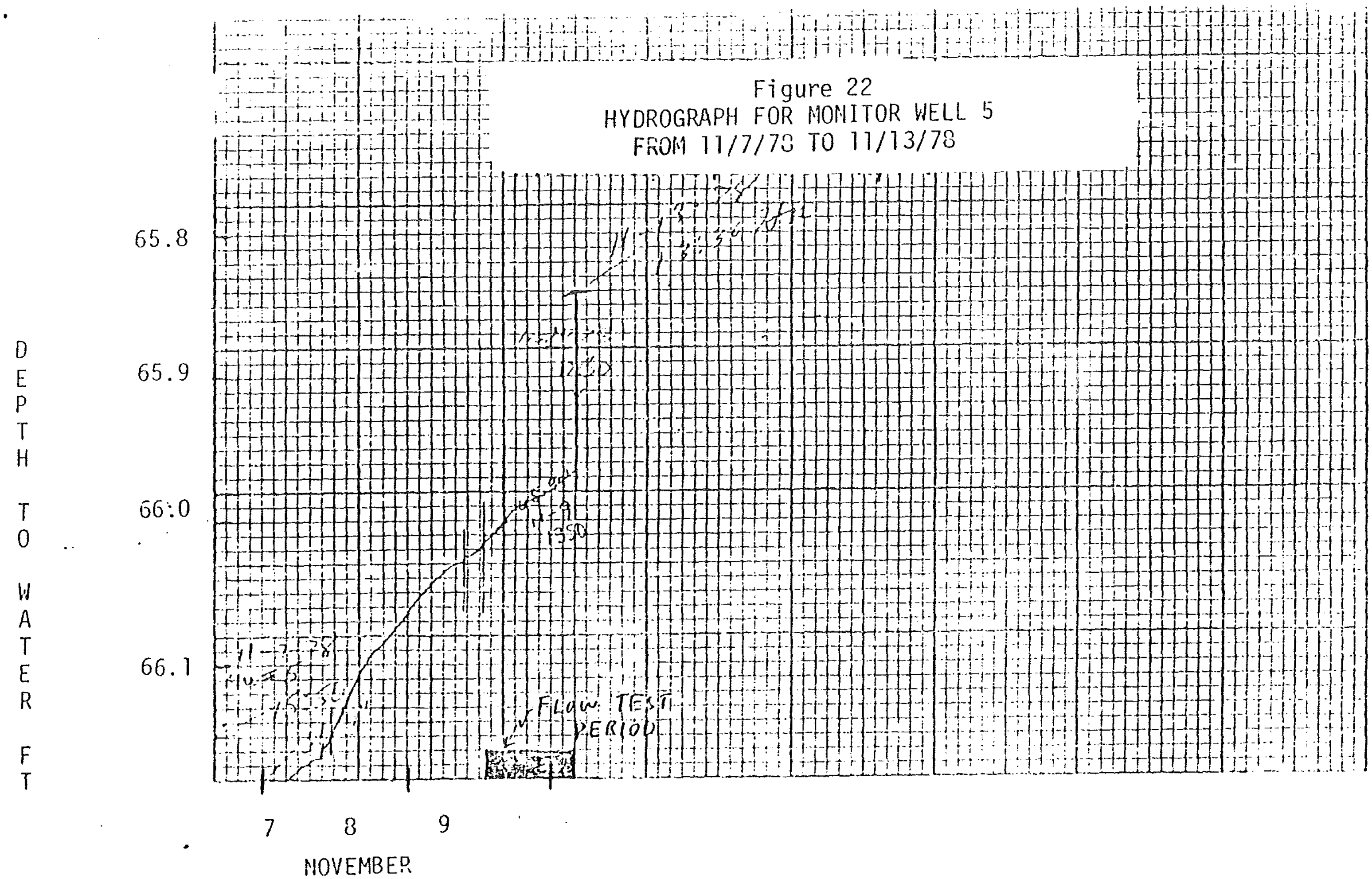


Figure 22
HYDROGRAPH FOR MONITOR WELL 5
FROM 11/7/78 TO 11/13/78

Figure 23

HYDROGRAPH FOR MONITOR WELL 6
FROM 11/7/78 TO 11/13/78

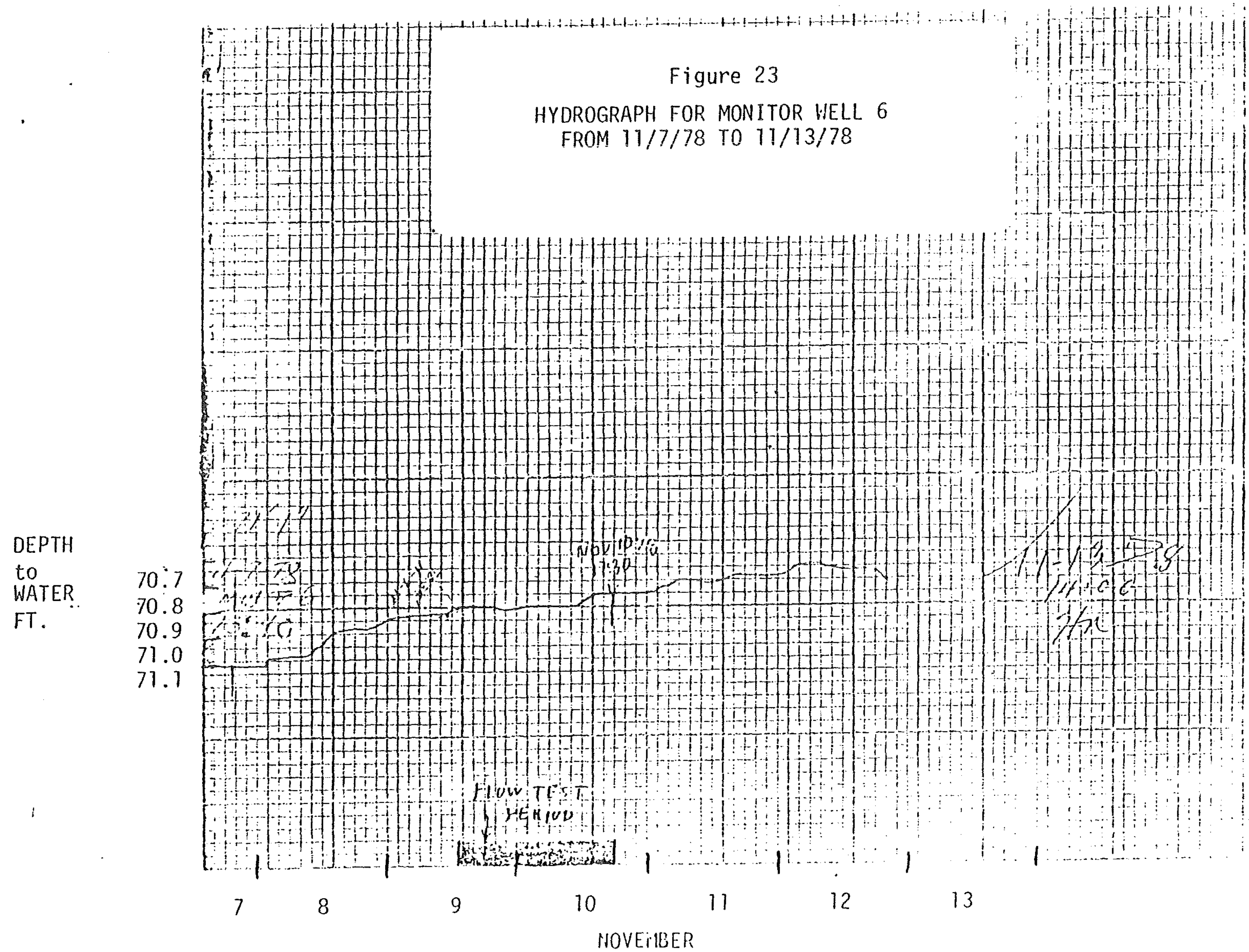
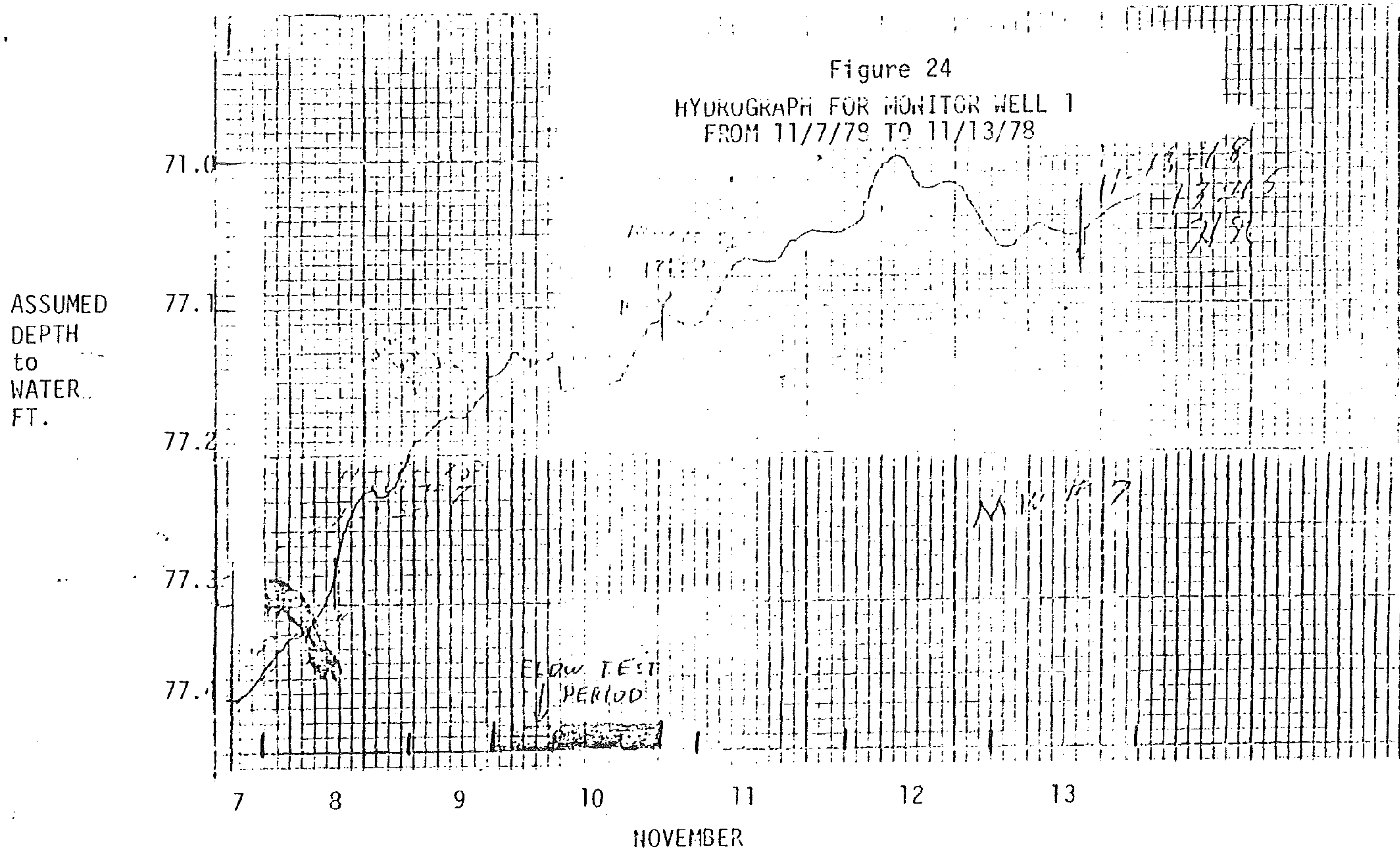


Figure 24

HYDROGRAPH FOR MONITOR WELL 1
FROM 11/7/78 TO 11/13/78



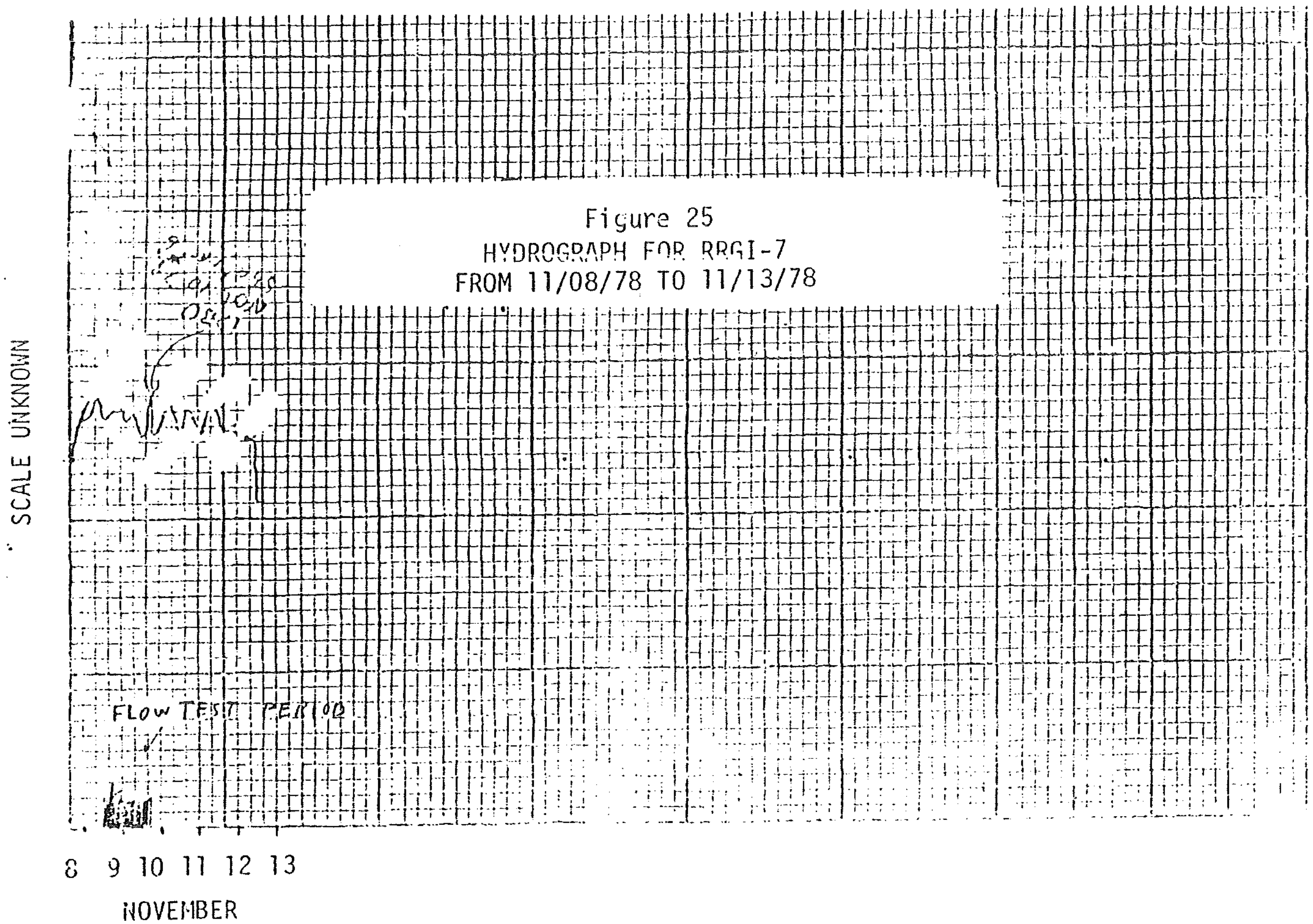


Figure 25
HYDROGRAPH FOR RRGI-7
FROM 11/08/78 TO 11/13/78

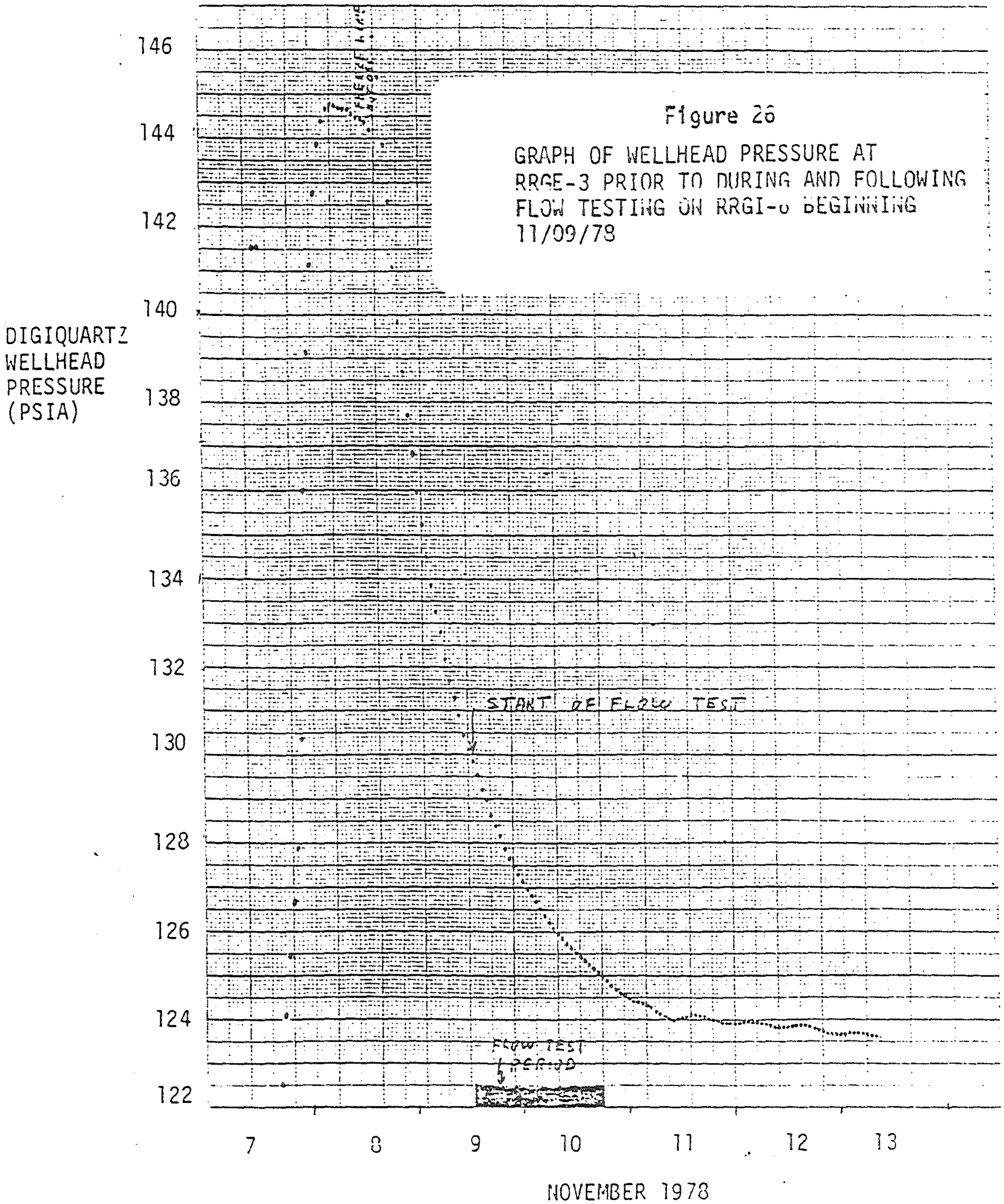


Figure 26

GRAPH OF WELLHEAD PRESSURE AT RRGE-3 PRIOR TO DURING AND FOLLOWING FLOW TESTING ON RRGI-6 BEGINNING 11/09/78

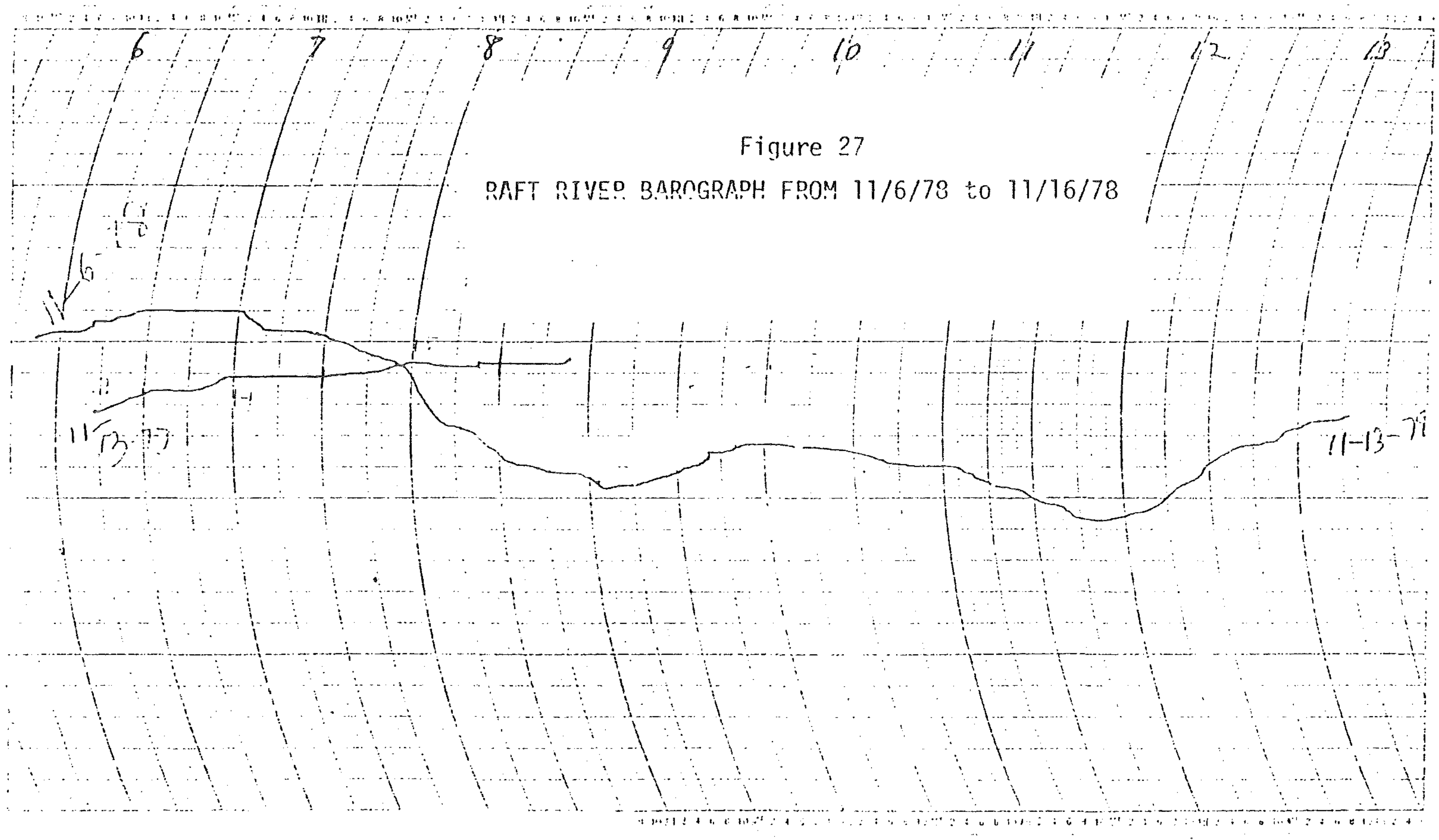
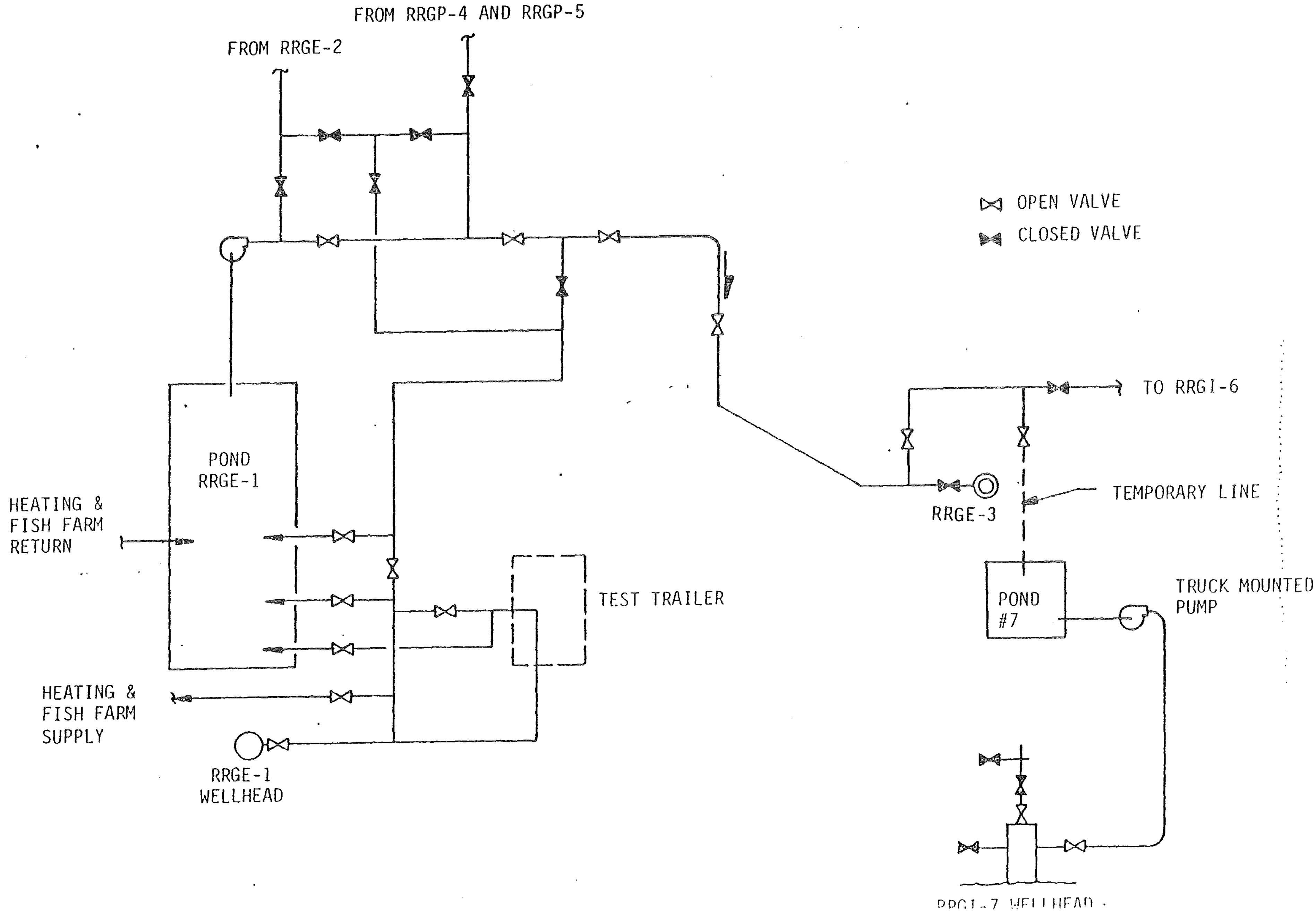


Figure 27

RAFT RIVER BAROGRAPH FROM 11/6/78 to 11/16/78

2½" OF CHART IS 1" OF PRESSURE

FIGURE 28 RRGI-7 :ION DIAGRAM



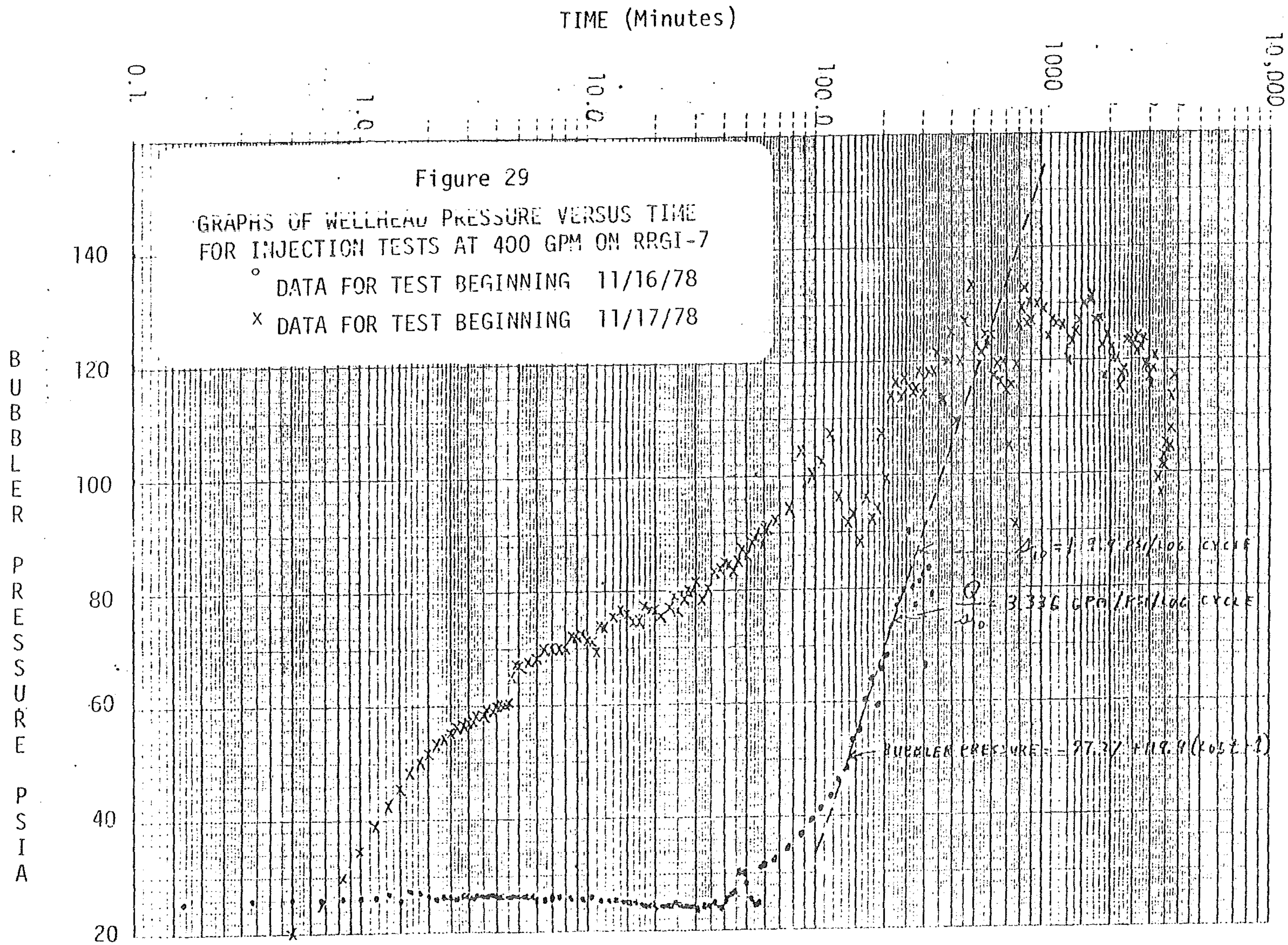


Figure 29

GRAPHS OF WELLHEAD PRESSURE VERSUS TIME FOR INJECTION TESTS AT 400 GPM ON RRGI-7

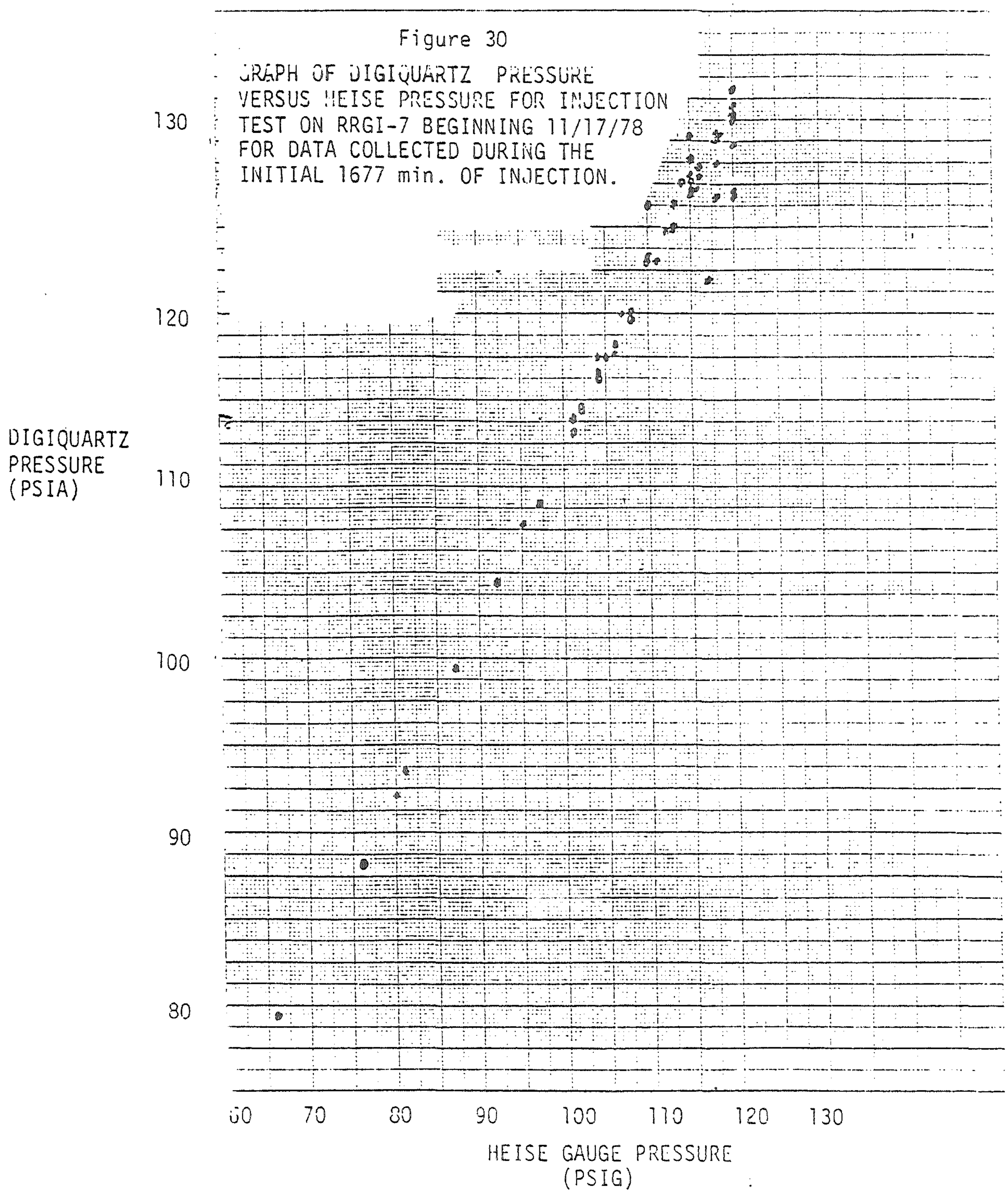


Figure 30

GRAPH OF DIGIQUARTZ PRESSURE VERSUS HEISE PRESSURE FOR INJECTION TEST ON RRGI-7 BEGINNING 11/17/78 FOR DATA COLLECTED DURING THE INITIAL 1677 min. OF INJECTION.

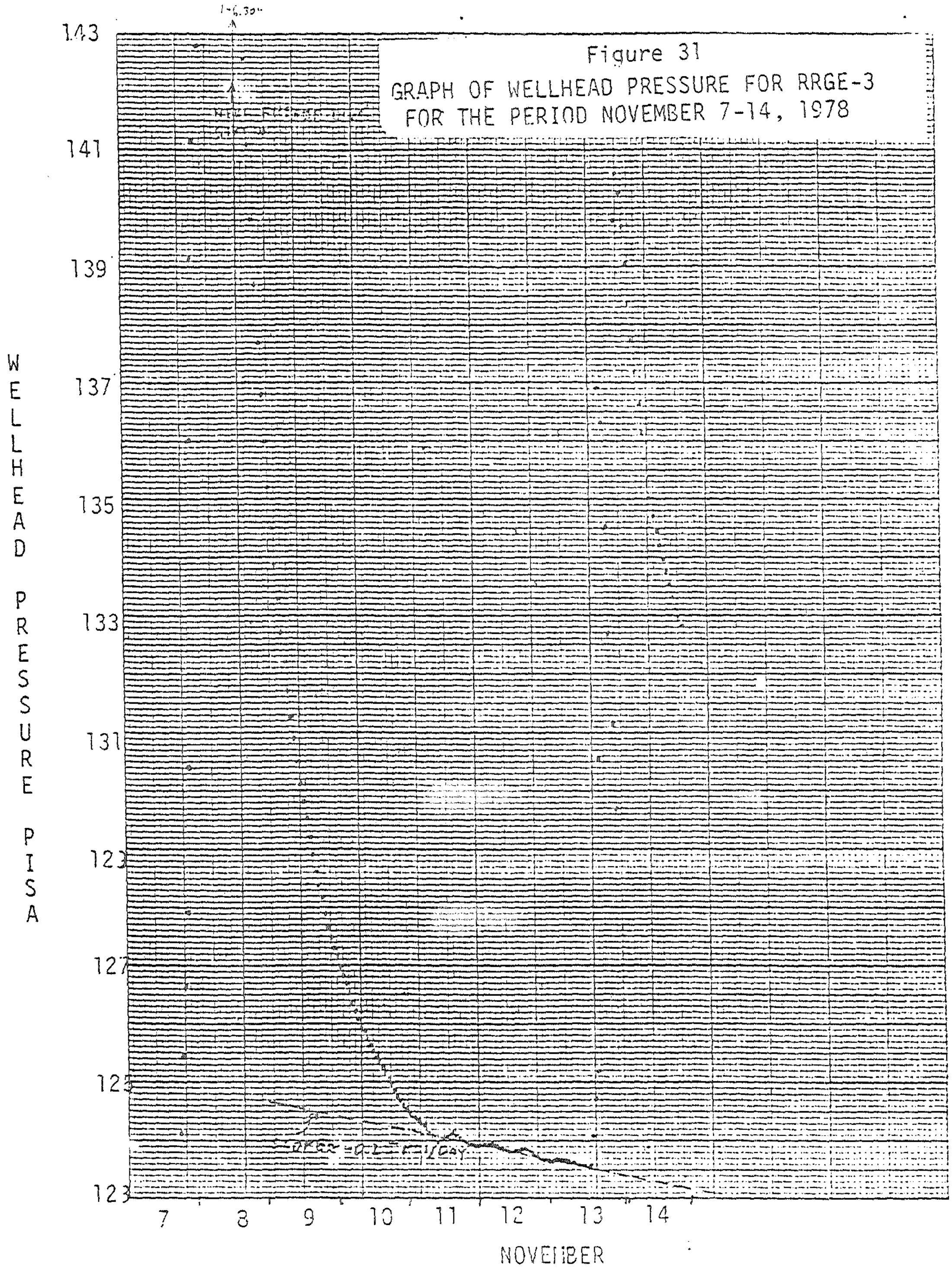


Figure 31

GRAPH OF WELLHEAD PRESSURE FOR RRGE-3 FOR THE PERIOD NOVEMBER 7-14, 1978

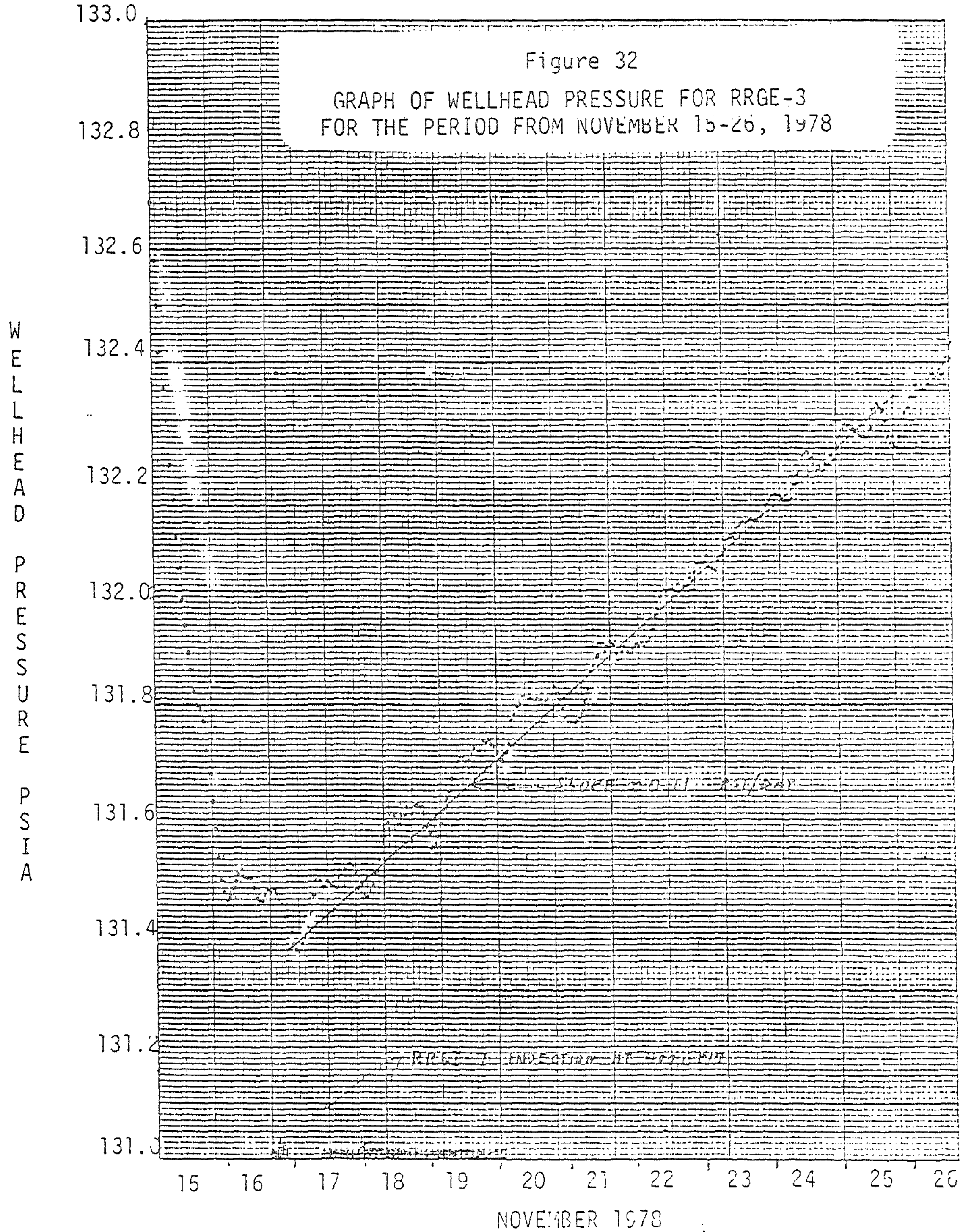


Figure 32

GRAPH OF WELLHEAD PRESSURE FOR RRGE-3
FOR THE PERIOD FROM NOVEMBER 15-26, 1978

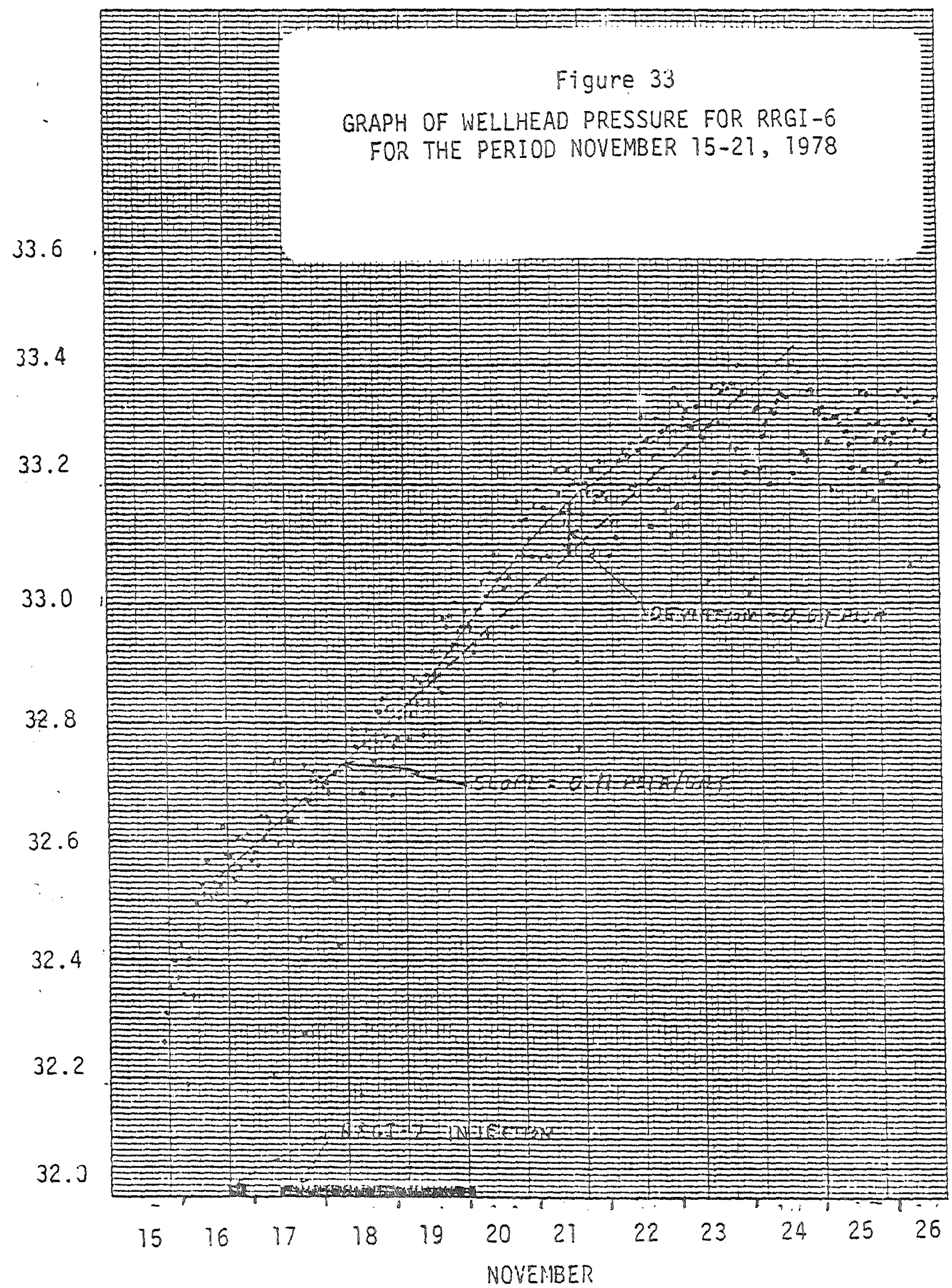
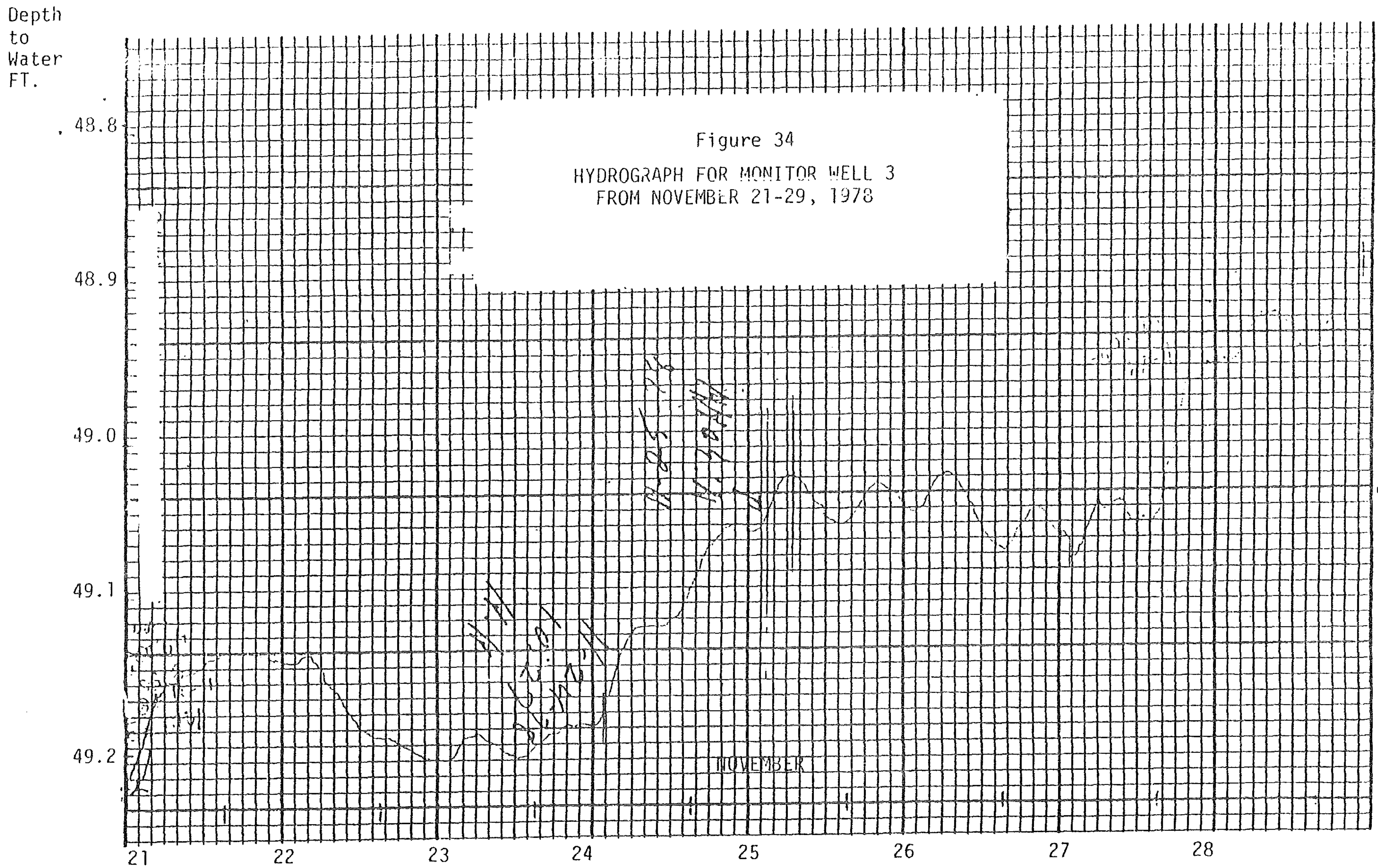


Figure 33

GRAPH OF WELLHEAD PRESSURE FOR RRGI-6
FOR THE PERIOD NOVEMBER 15-21, 1978


Depth to Water FT.
48.8
48.9
49.0
49.1
49.2
Figure 34
HYDROGRAPH FOR MONITOR WELL 3
FROM NOVEMBER 21-29, 1978
NOVEMBER
21
22
23
24
25
26
27
28

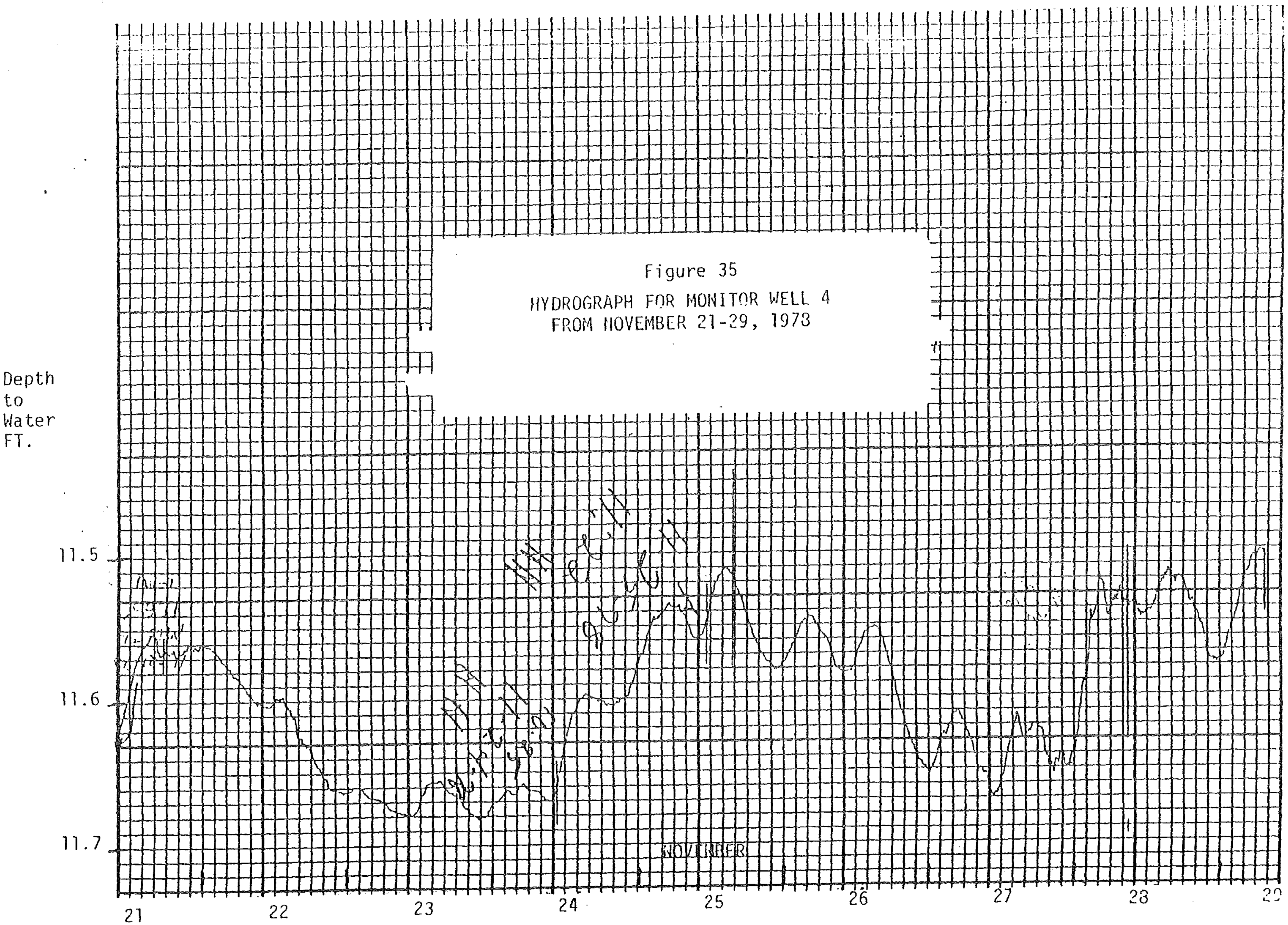


Figure 35
HYDROGRAPH FOR MONITOR WELL 4
FROM NOVEMBER 21-29, 1978
Depth to Water FT.
11.5
11.6
11.7
NOVEMBER
21
22
23
24
25
26
27
28
29

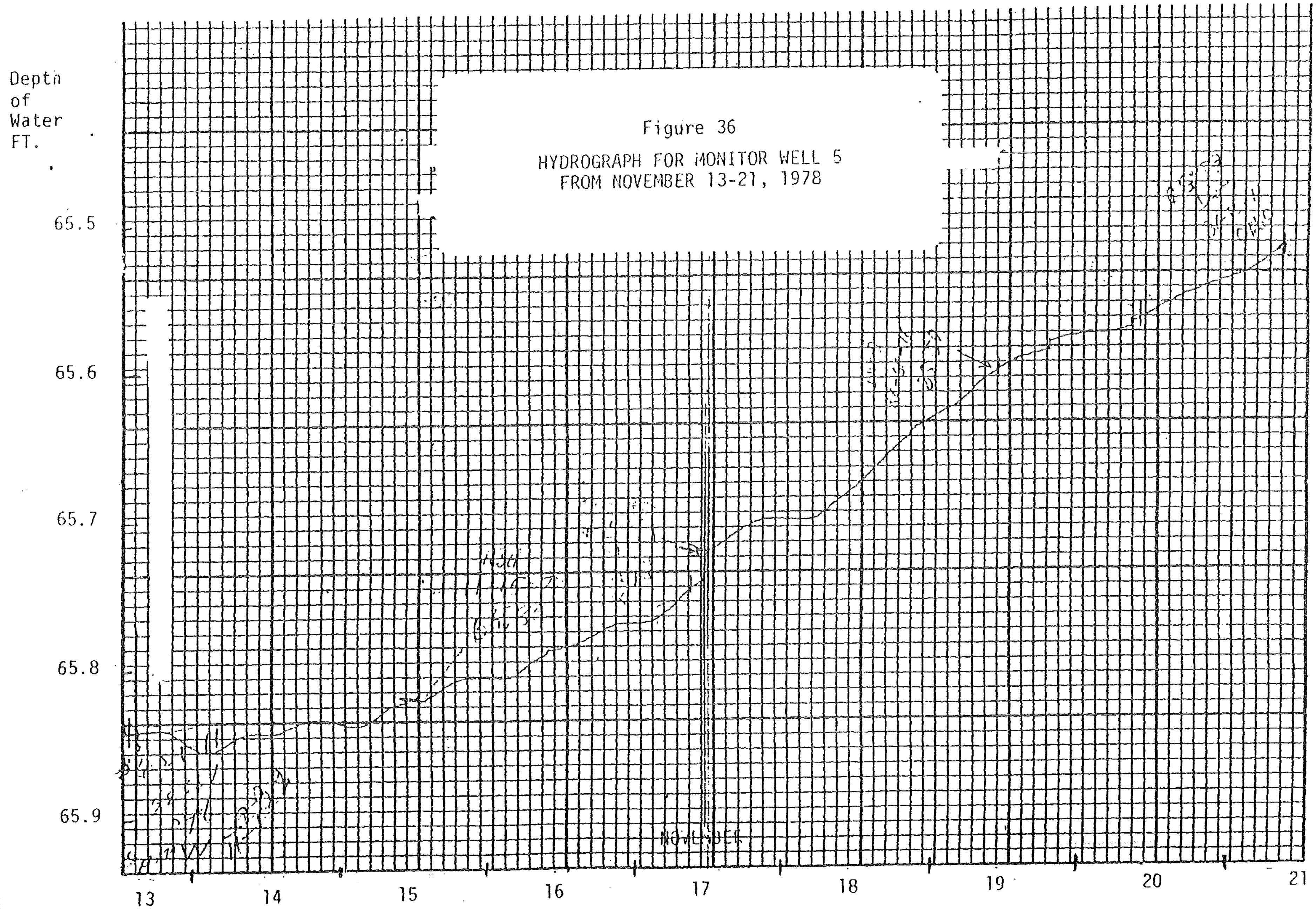


Figure 36
HYDROGRAPH FOR MONITOR WELL 5
FROM NOVEMBER 13-21, 1978
Depth of Water FT.
65.5
65.6
65.7
65.8
65.9
NOVEMBER
13
14
15
16
17
18
19
20
21

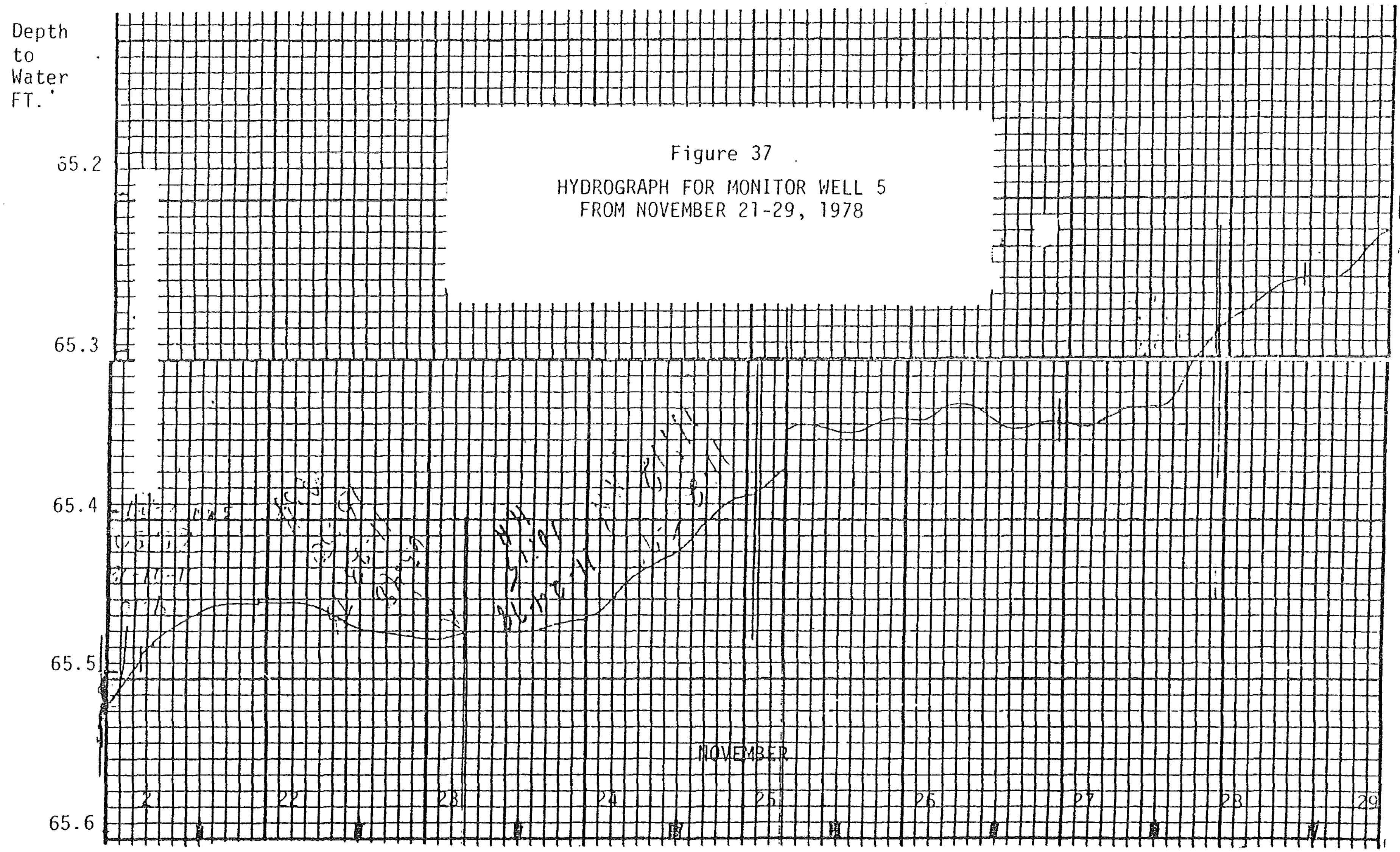
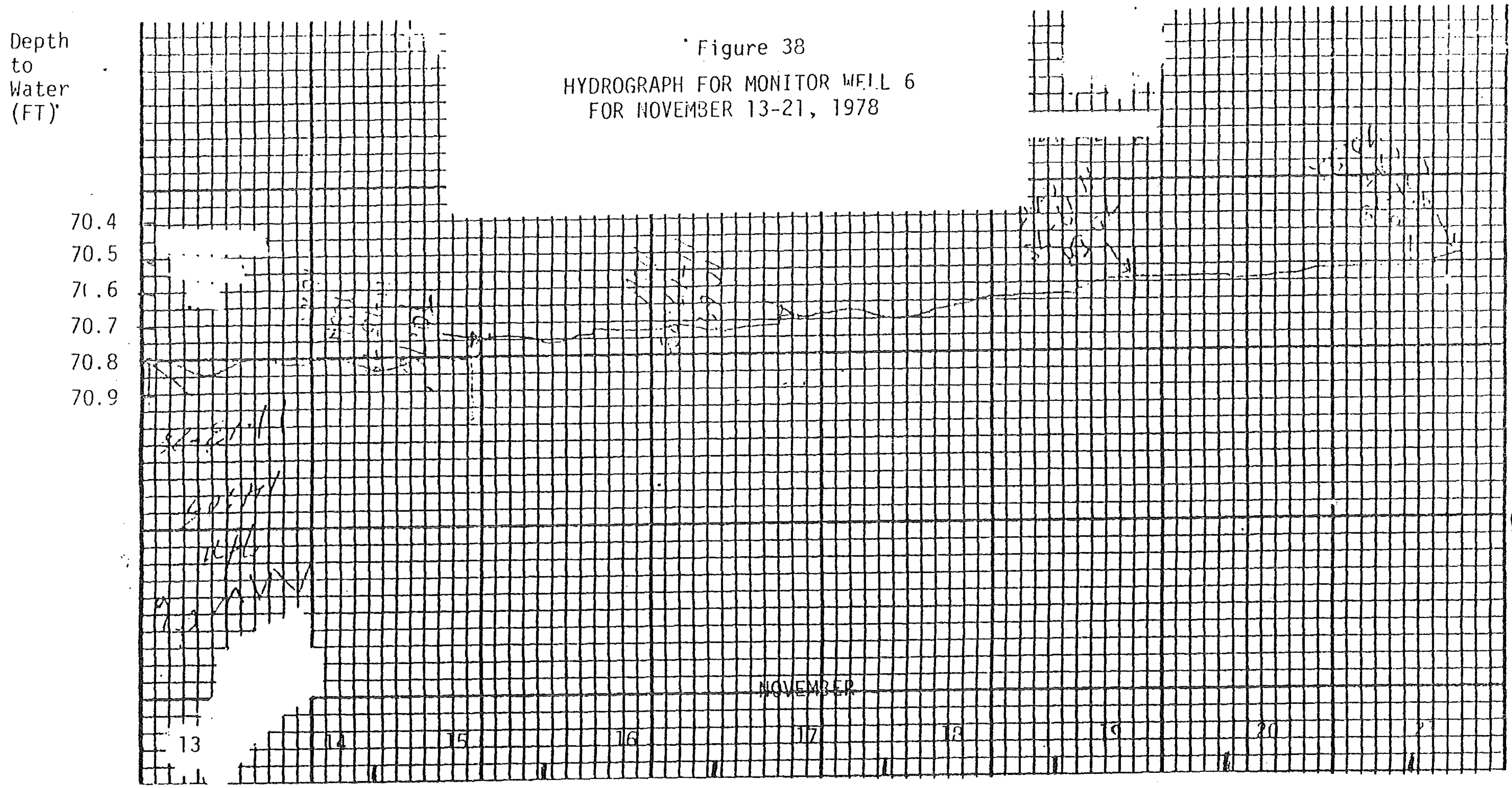


Figure 37

HYDROGRAPH FOR MONITOR WELL 5
FROM NOVEMBER 21-29, 1978

Figure 38

HYDROGRAPH FOR MONITOR WELL 6
FOR NOVEMBER 13-21, 1978



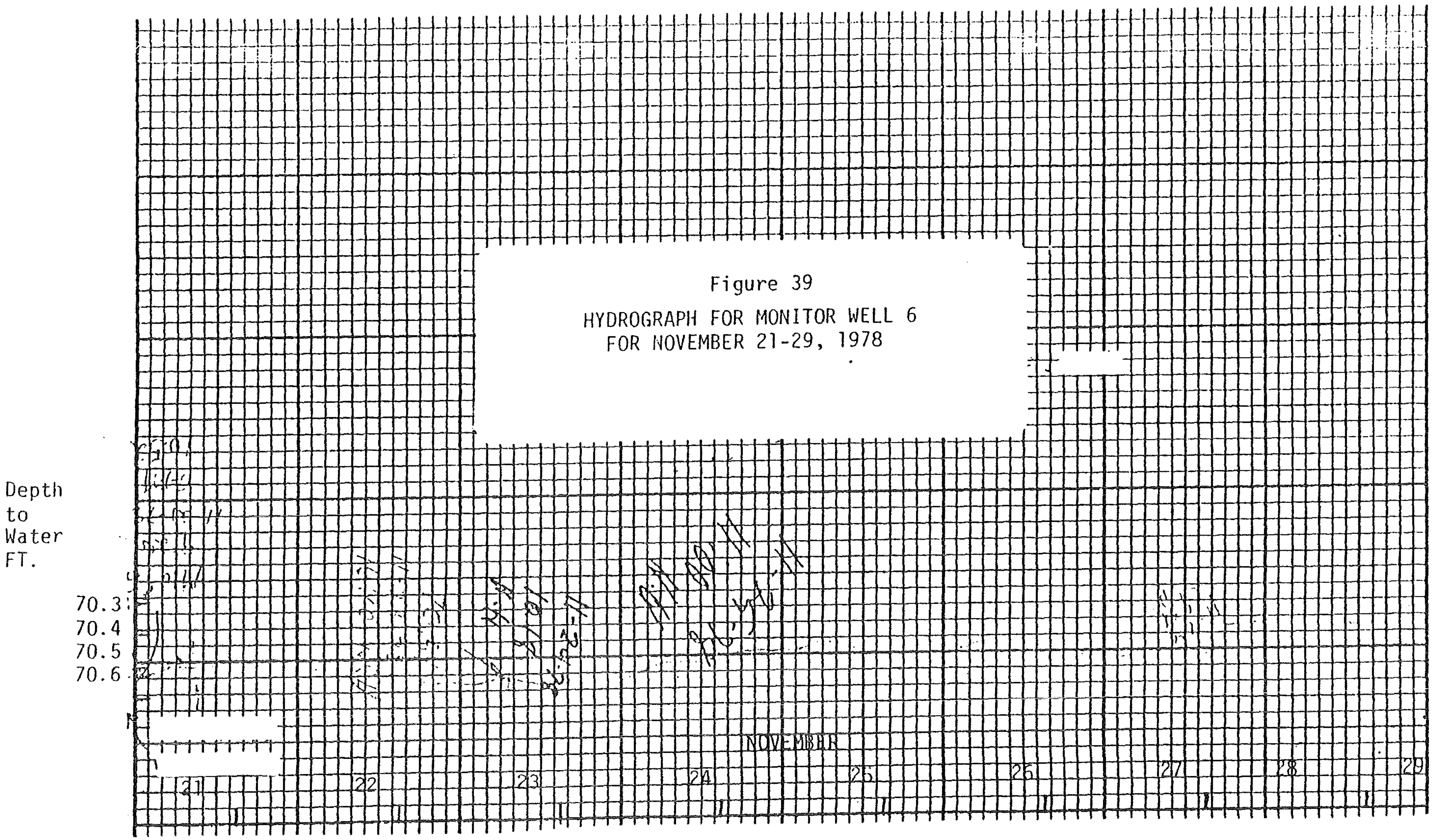


Figure 39

HYDROGRAPH FOR MONITOR WELL 6
FOR NOVEMBER 21-29, 1978

Figure 40

HYDROGRAPH FOR MONITOR WELL 7
FOR NOVEMBER 13-21, 1978

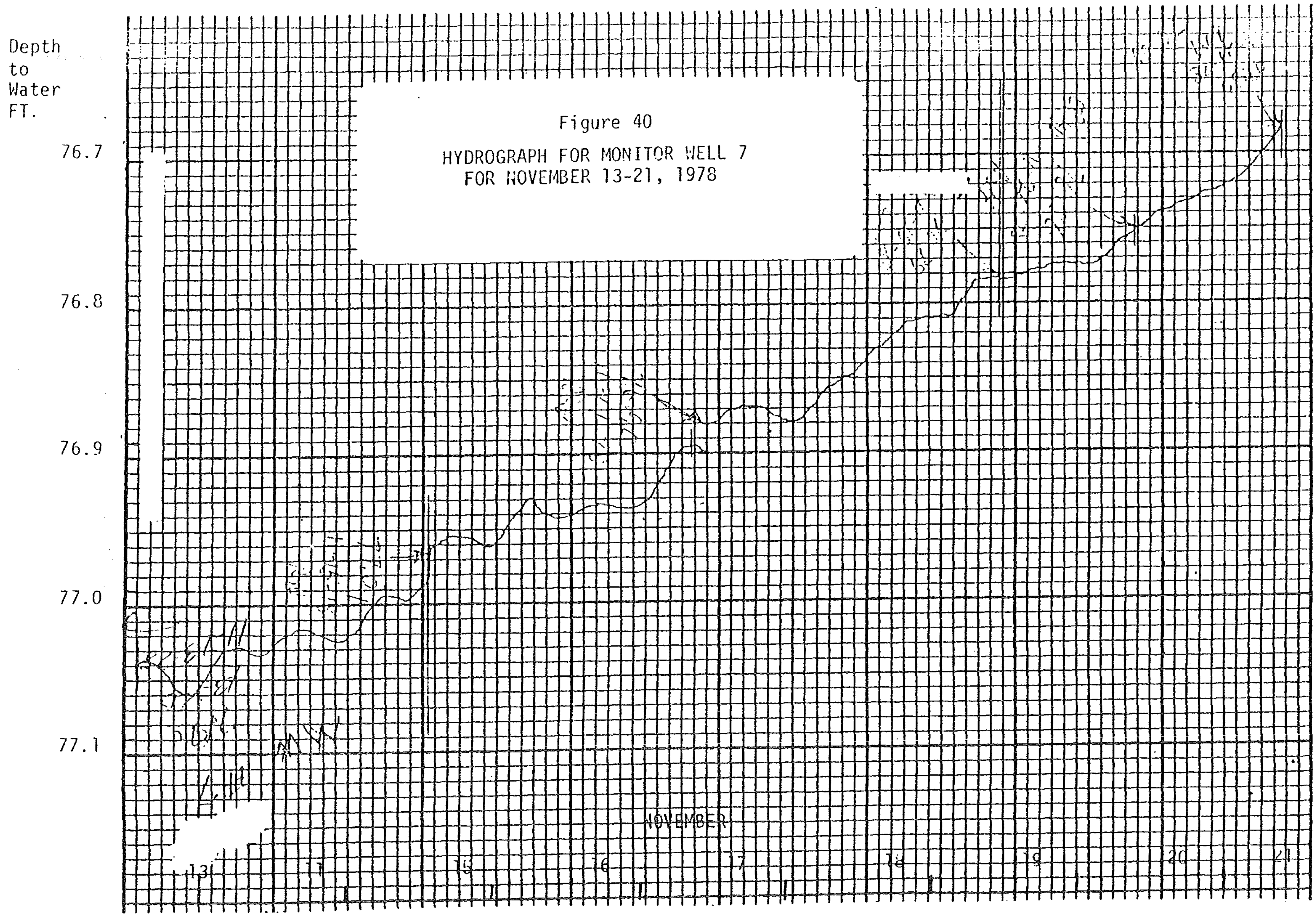


Figure 41

HYDROGRAPH FOR MONITOR WELL 7
NOVEMBER 21-29, 1978

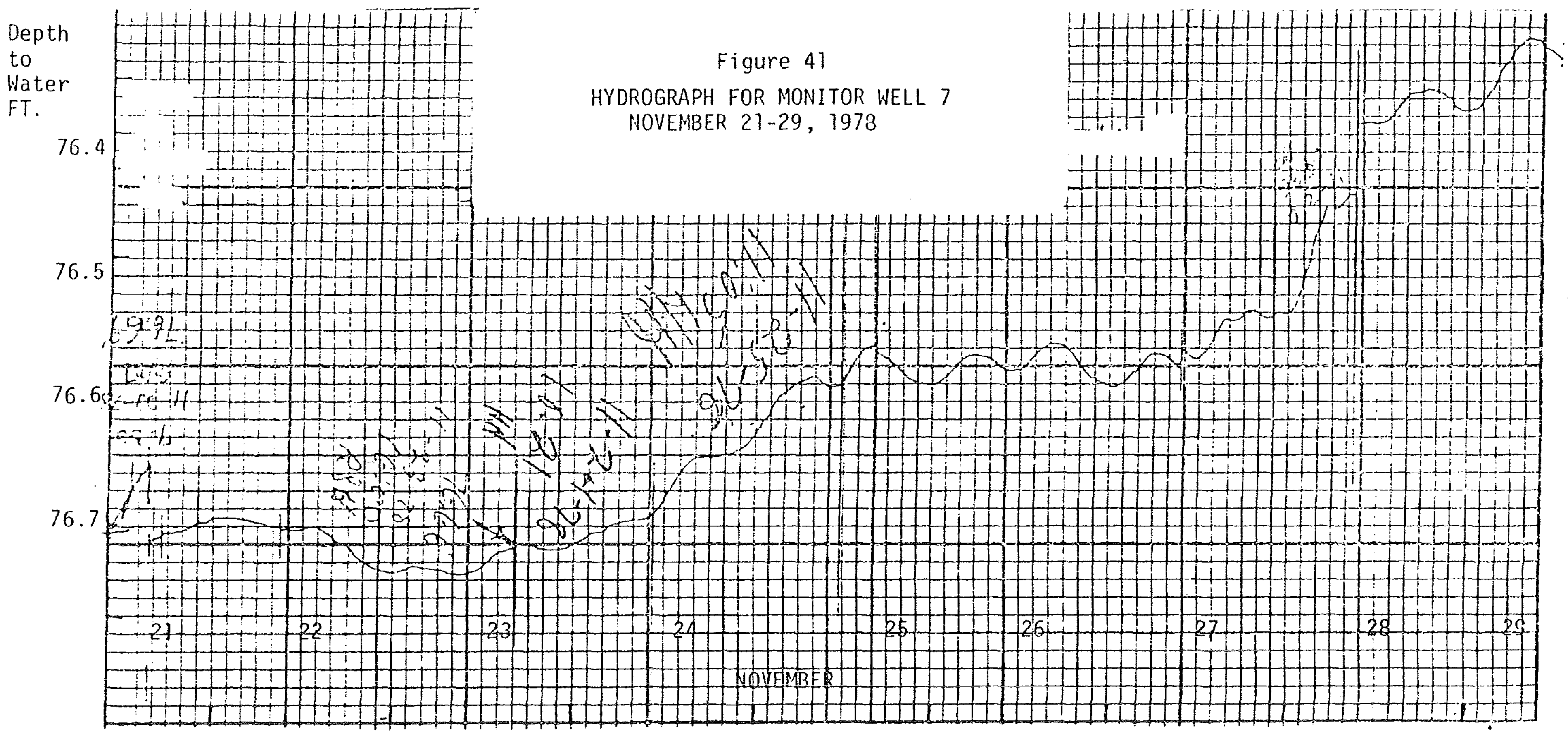
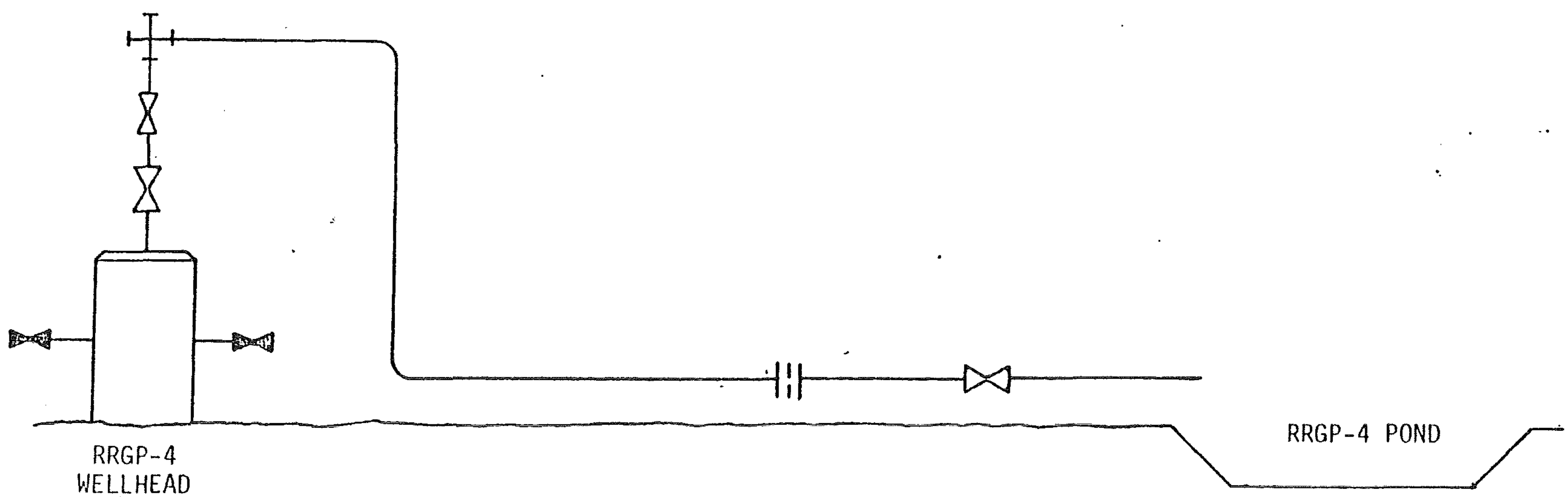


FIGURE 42 RRGP-4AB FREE FLOW DIAGRAM



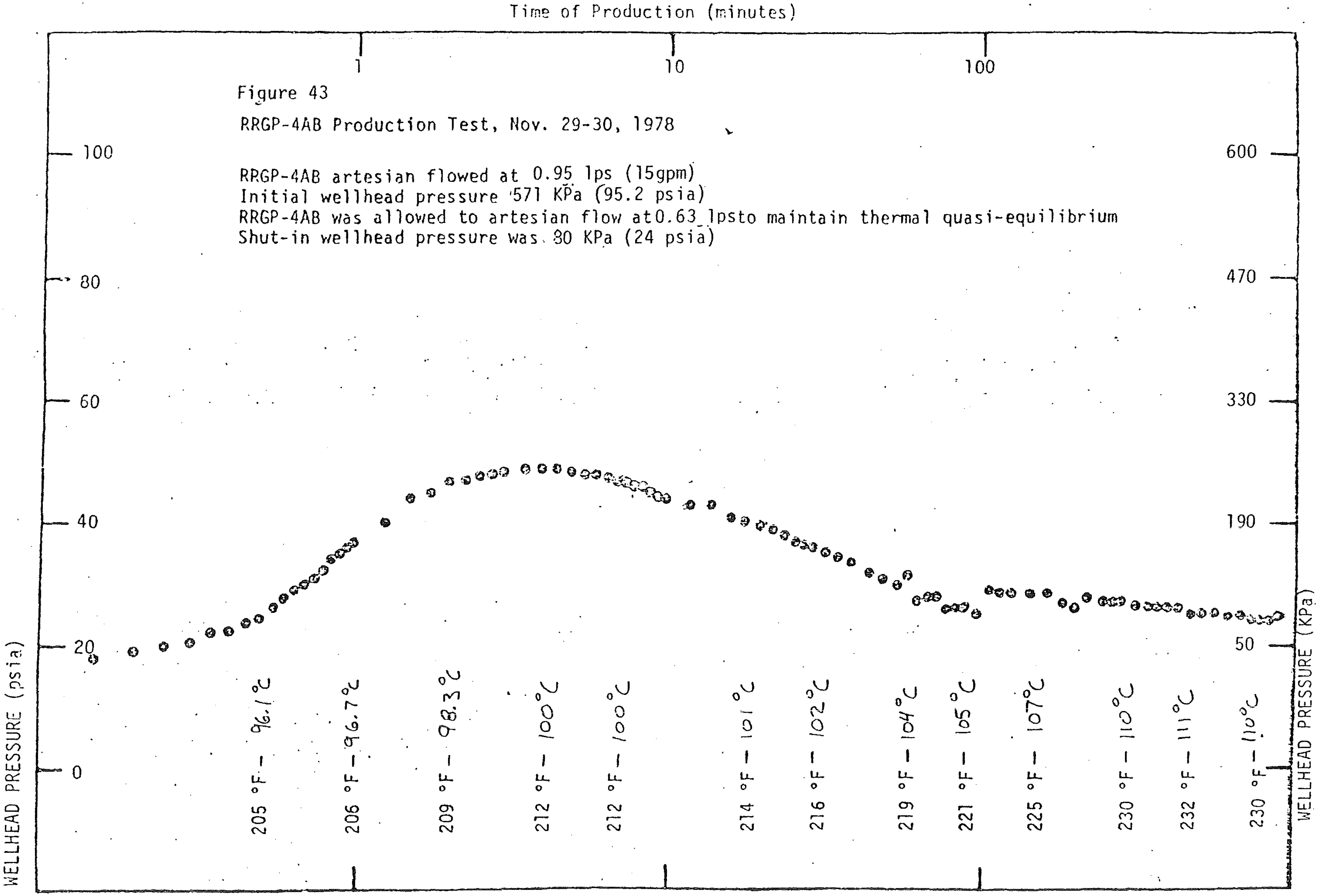


Figure 43

RRGP-4AB Production Test, Nov. 29-30, 1978

RRGP-4AB artesian flowed at 0.95 lps (15gpm)
Initial wellhead pressure 571 KPa (95.2 psia)
RRGP-4AB was allowed to artesian flow at 0.63 lps to maintain thermal quasi-equilibrium
Shut-in wellhead pressure was 80 KPa (24 psia)

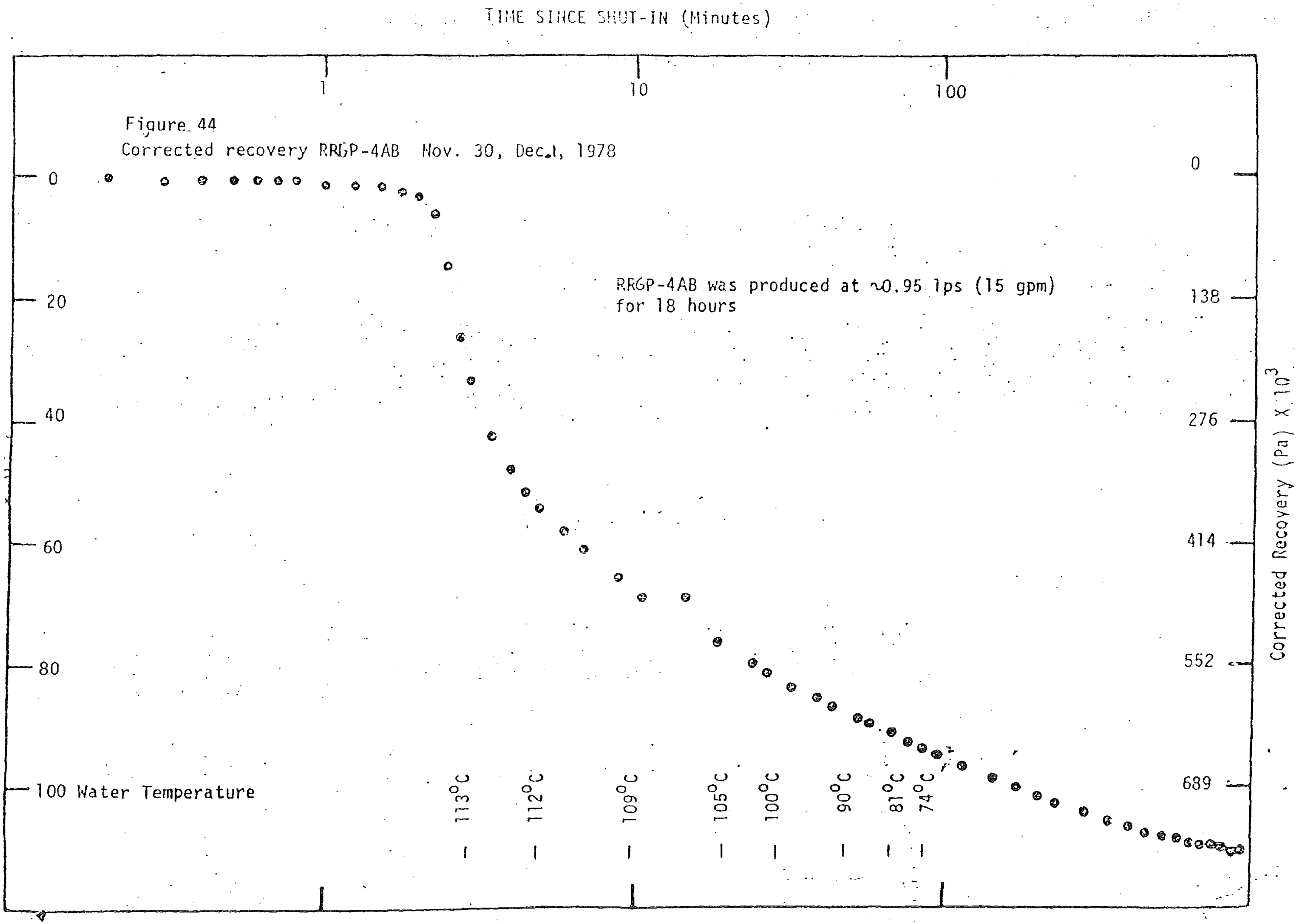


Figure 44
Corrected recovery RRGP-4AB Nov. 30, Dec.1, 1978

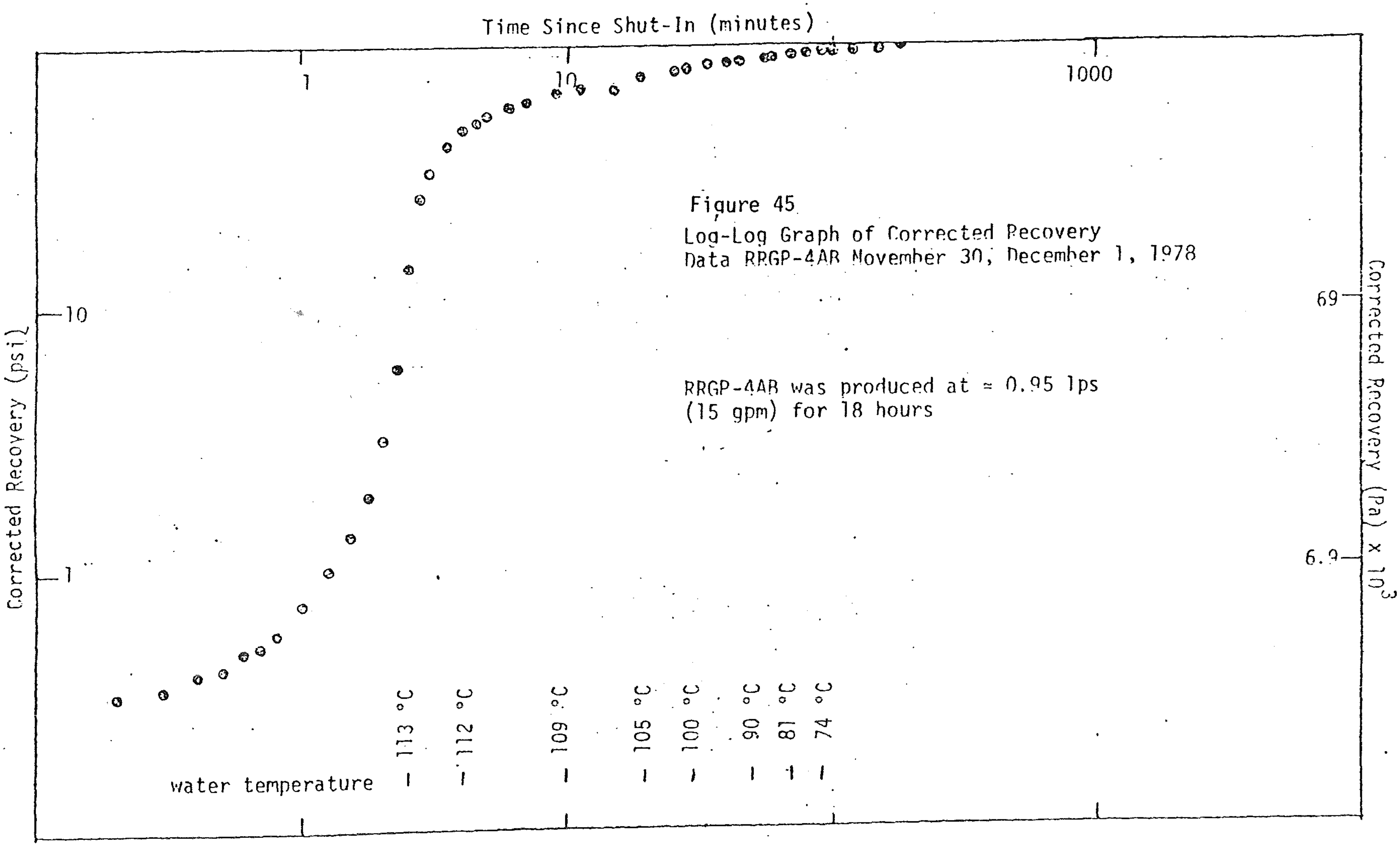


Figure 45

Log-Log Graph of Corrected Recovery Data RRGP-4AB November 30, December 1, 1978

Figure 46

RRGE-1 and RRGP-5B
WELLHEAD PRESSURE NOV. 27 - DEC. 1, 1978

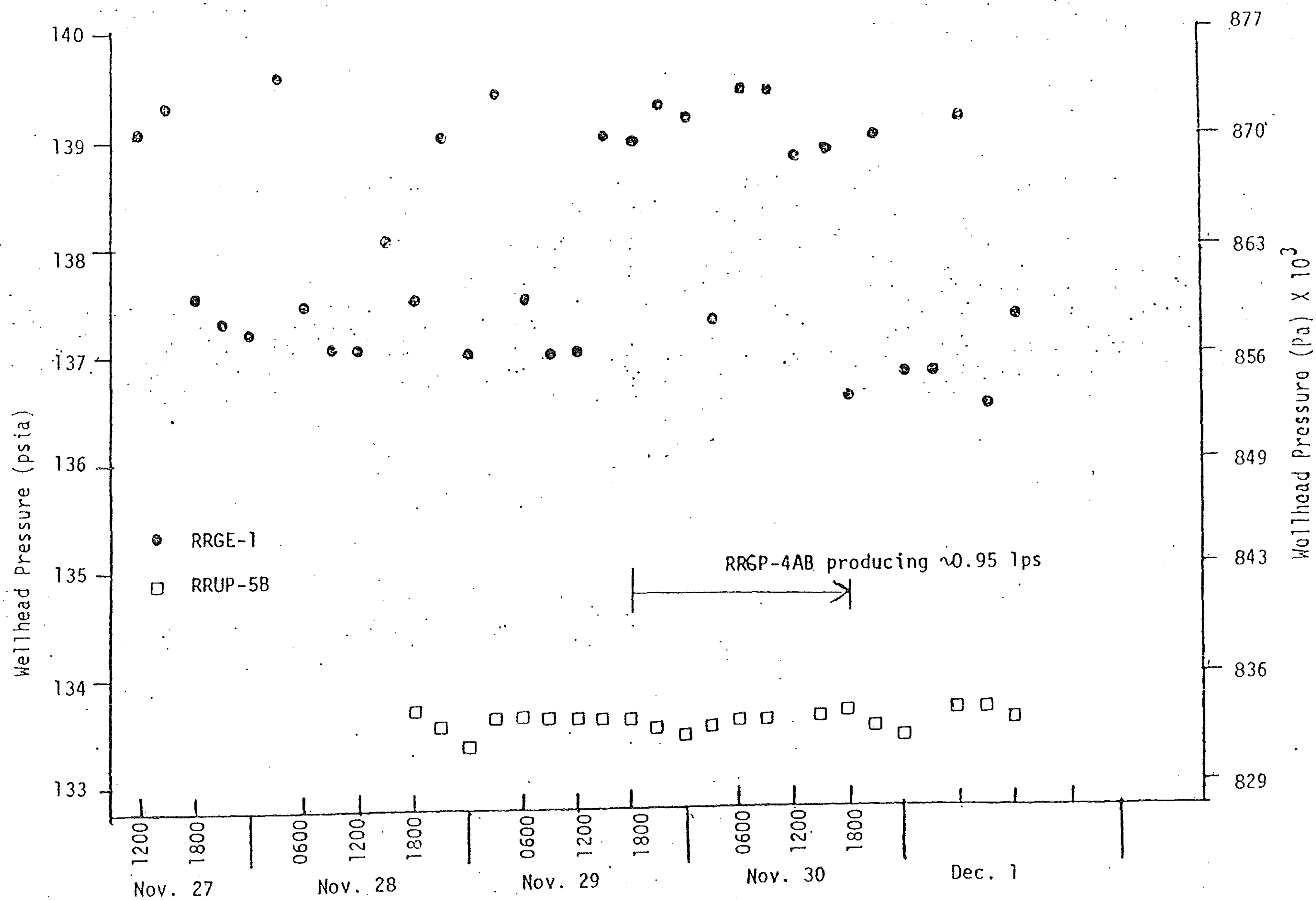
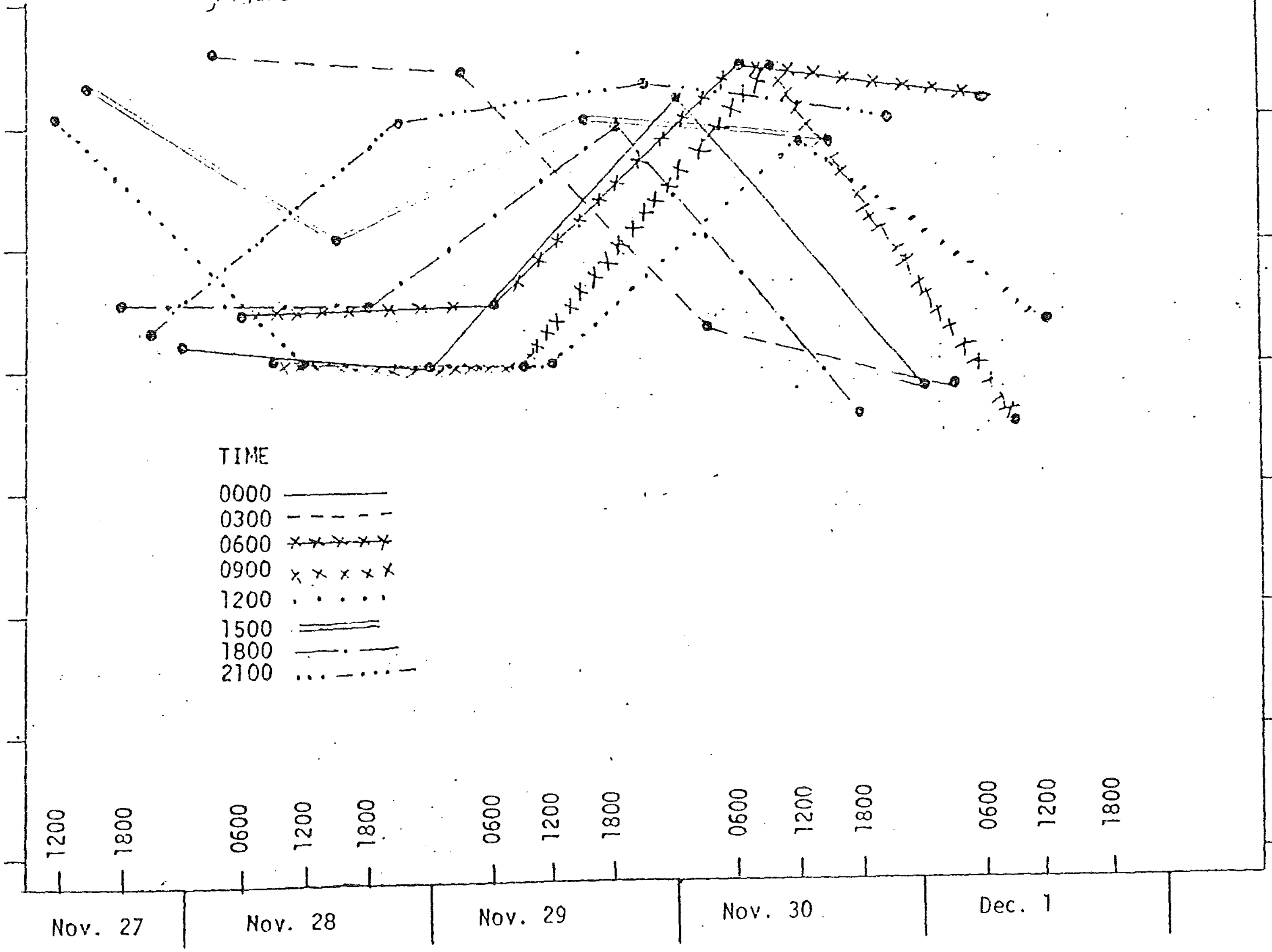


Figure 47 - WELLHEAD PRESSURE RRGE-1 NOVEMBER 27 - DECEMBER 1, 1978



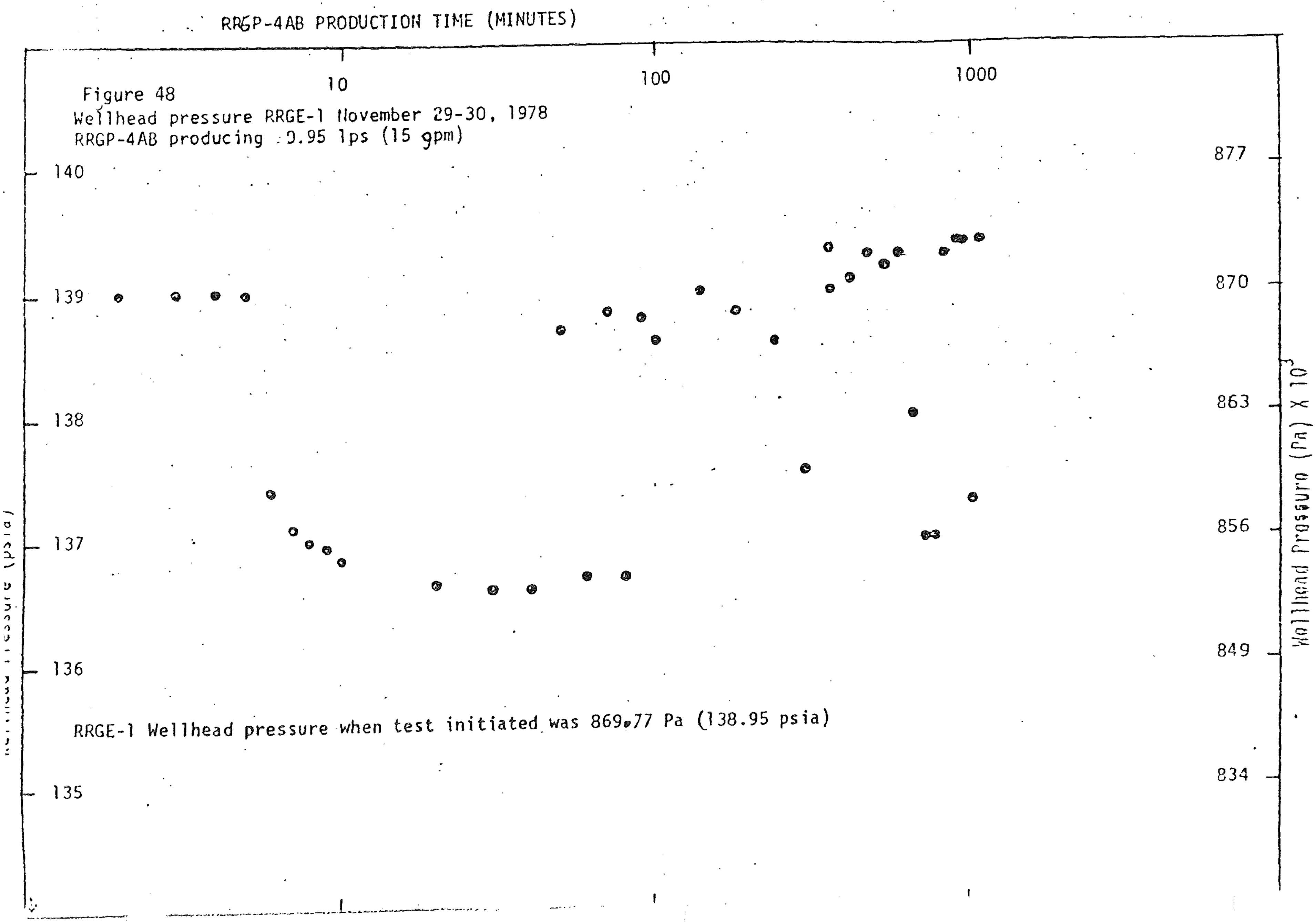
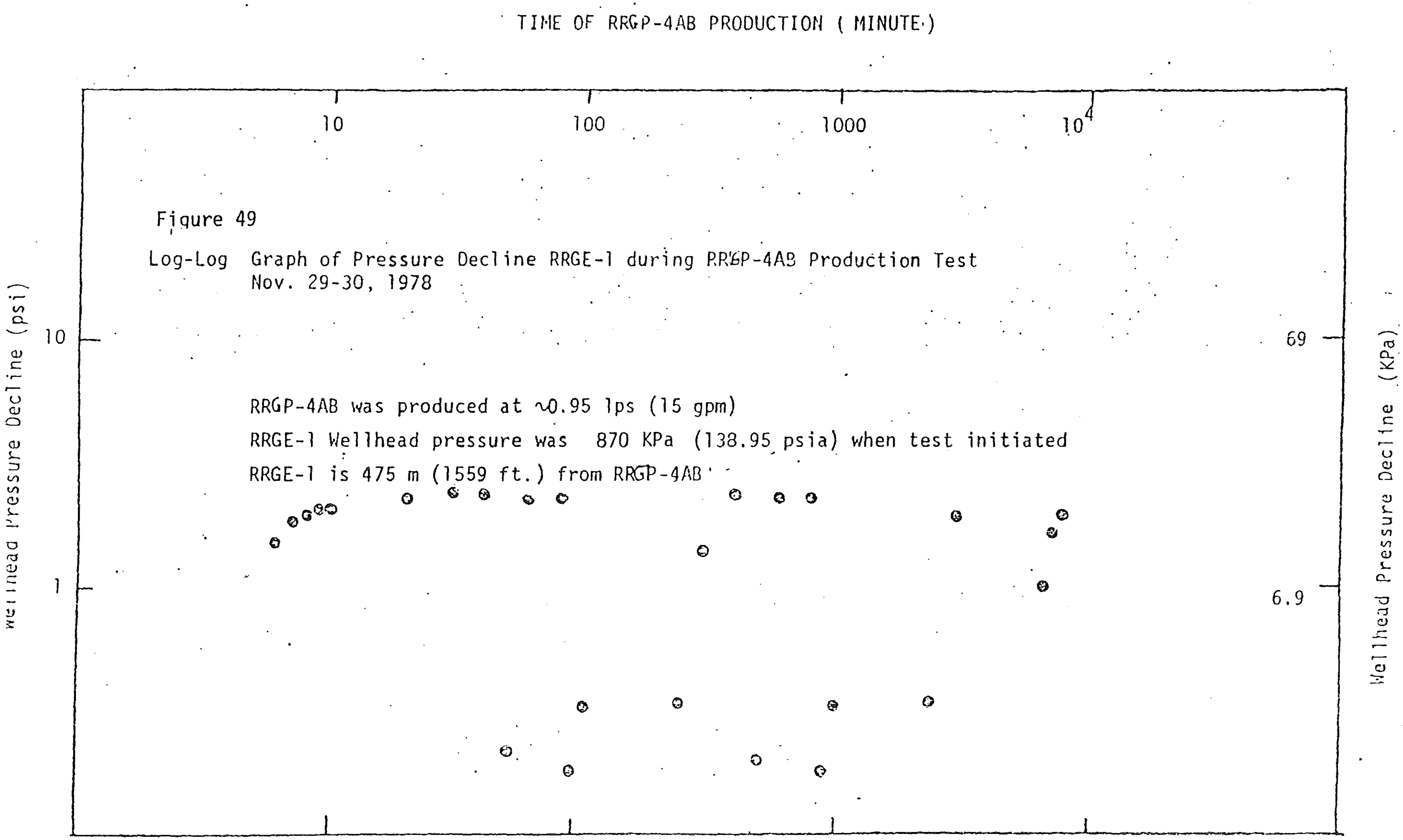


Figure 48
Wellhead pressure RRGE-1 November 29-30, 1978
RRGP-4AB producing 0.95 lps (15 gpm)



TIME OF RRGP-4AB PRODUCTION (MINUTE)
10
100
1000
10^4
Figure 49
Log-Log Graph of Pressure Decline RRGE-1 during RRGP-4AB Production Test
Nov. 29-30, 1978
RRGP-4AB was produced at ~0.95 lps (15 gpm)
RRGE-1 Wellhead pressure was 870 KPa (138.95 psia) when test initiated
RRGE-1 is 475 m (1559 ft.) from RRGP-4AB
Wellhead Pressure Decline (psi)
10
1
69
6.9
Wellhead Pressure Decline (KPa)

Figure 50,
USGS-3 & MW-1 WELLHEAD PRESSURE NOV. 27 THRU DEC 1, 1978

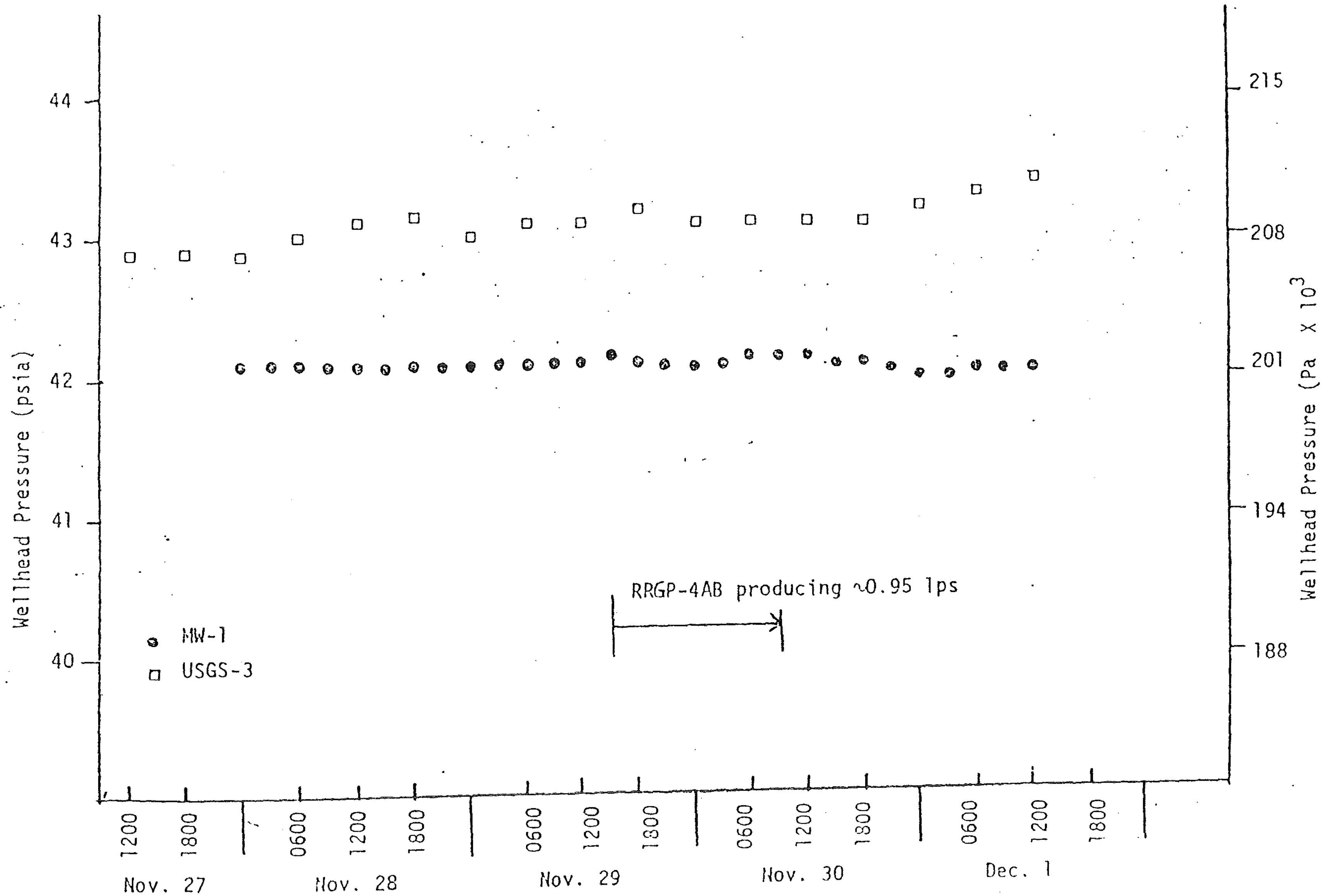


Figure 51

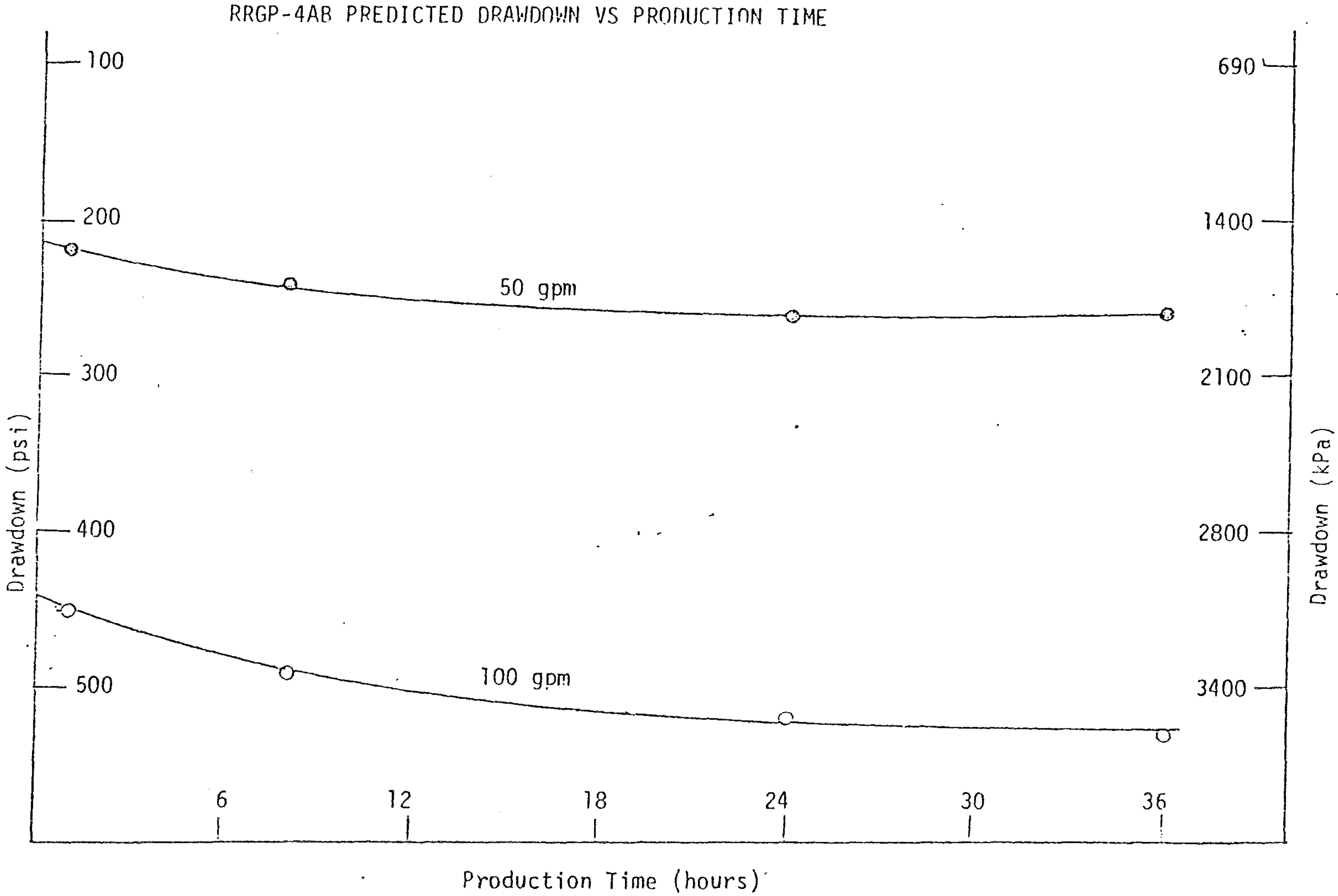
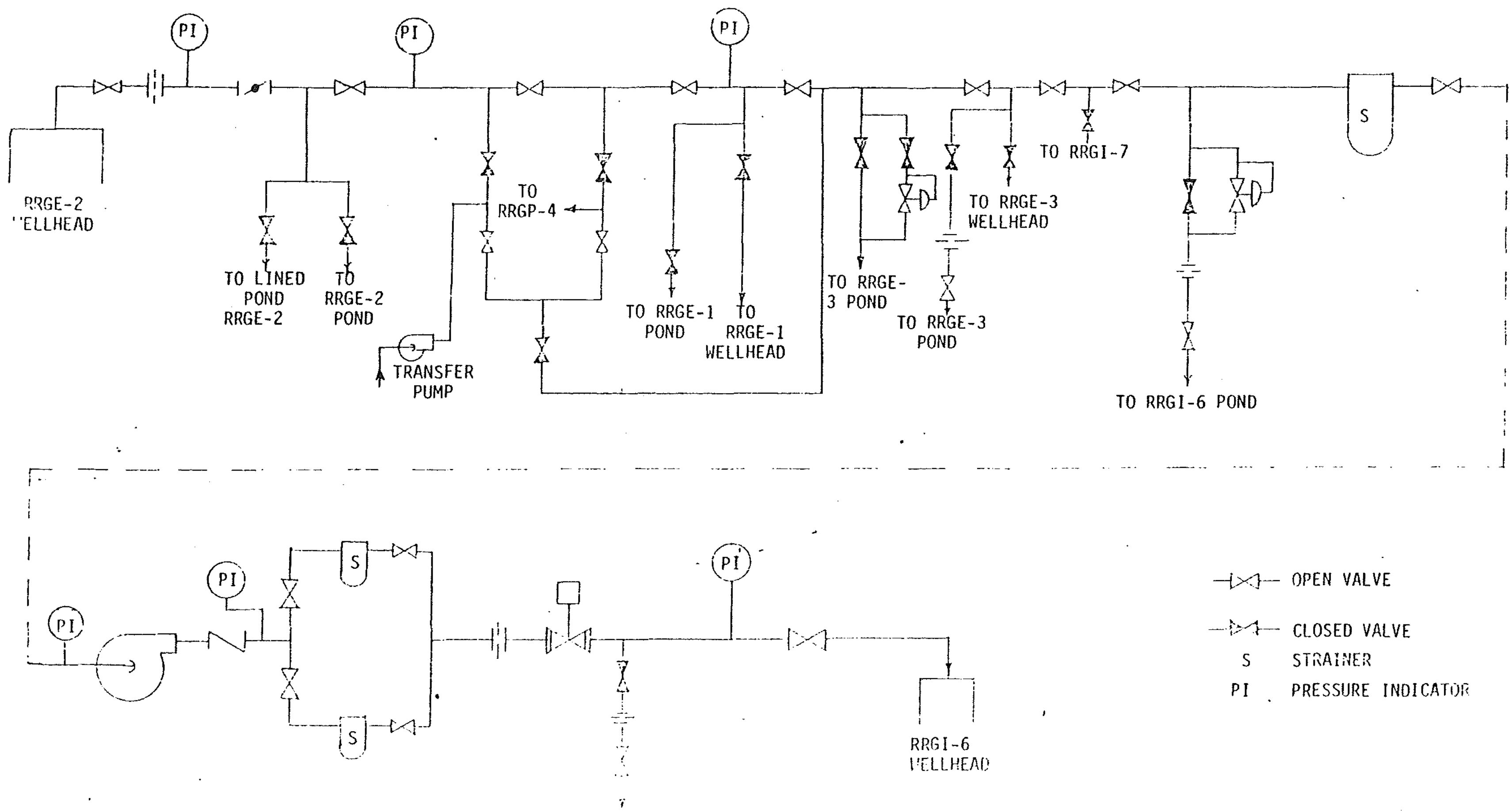

RRGP-4AB PREDICTED DRAWDOWN VS PRODUCTION TIME
100
200
300
400
500
Drawdown (psi)
690
1400
2100
2800
3400
Drawdown (kPa)
50 gpm
100 gpm
6
12
18
24
30
36
Production Time (hours)

FIGURE 52 FLOW DIAGRAM FROM RRGE-2 TO RRGI-6



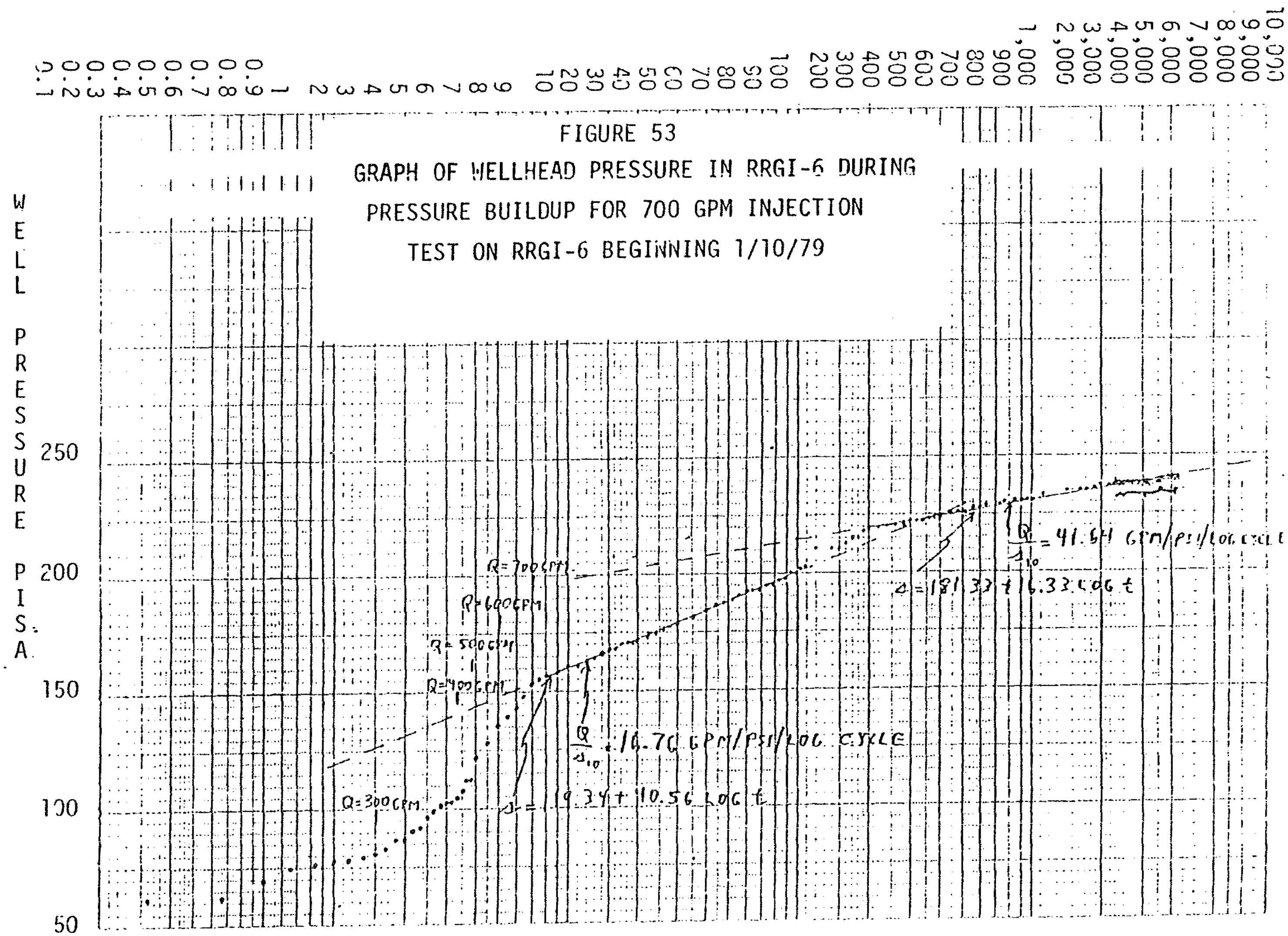


FIGURE 53

GRAPH OF WELLHEAD PRESSURE IN RRGI-6 DURING PRESSURE BUILDUP FOR 700 GPM INJECTION TEST ON RRGI-6 BEGINNING 1/10/79

APPENDIX B

TEST PLAN, FET-14A-78

EG&G Idaho

INTEROFFICE CORRESPONDENCE

date October 26, 1978

to RRFO Manager

from Fluids Experiments and Testing

subject R.R. PRODUCTION TEST PLAN RRGI-5 - FET-14A-78

64A1124-16

Approved by:

Reservoir Eng. [signature] Date 10-31-78

Drilling Eng. [signature] Date 10/30/78

Design Eng. [signature] Date 10/30/78

Environmental Eng. [signature] Date 10/30/78

RRFO Eng. Original Signed By [signature] Date 11/2/78

Safety Eng. Original Signed By [signature] Date 11/2/78

Chemistry Eng. Original Signed By [signature] Date 11/29/78

Authorized for Release

[signature] Date 10-31-78

F.G. #1 9.4.2

#2 9.1.6

#3 9.4.3 & 9.4.7

#4 9.4.4

#5 9.4.6

REV.	RELEASE DATE
A	10-31-78

EXECUTION COPY

R.R. PRODUCTION TEST PLAN FOR
NO. 5

1.0 PURPOSE OF TEST

The primary purpose for testing the well for a 72-hour test is checkout of test hardware and instrumentation and to define pump requirements.

2.0 OBJECTIVE(S) OF THE TEST

The test will check-out test hardware and instrumentation and familiarize RRFO with operation of Well #5. In addition this test will provide borehole flow characteristics, local Kh and local boundaries. Also add data to size pumps for 5MW Plant.

3.0 WELL BACKGROUND

Well #5 at Raft River was drilled as a production well to a depth of 4936 feet. The well is cased to a depth of 3417 feet.

4.0 RESPONSIBILITIES

4.1 Engineering will design and procure the permanent pipeline required for the flow tests. Raft River Operations will install the line.

4.2 Overall responsibility for conducting the tests is the responsibility of Raft River Operations.

Raft River Operations is responsible for safety, for installation of all hardware and for the operation of all systems.

4.3 Reservoir Engineering will have prime responsibility for taking reservoir engineering data during the first eight hours of testing, then Raft River operations will have responsibility for this data until the end of the test.

4.4 Raft River Operations will have responsibility for competent data collection during the recovery portion of a production test, in the absence of Reservoir Engineering hydrogeologists. Data will be collected in accordance with Table 1, with "time from - to" referring to time since shut-in.

4.5 Close cooperation and coordination will be required. Raft River Operations will be responsible for all operational data required for conducting the test.

4.6 Reservoir Engineering will provide the forms required for recording reservoir engineering data; the copy forms will remain in a data file at Raft River. Original will be sent to Reservoir Engineering at UPB.

4.7 Reservoir Engineering will have the prime responsibility for data analysis and reporting.

4.8 Reservoir Engineering is responsible for providing certain test condition parameters, based on previous tests as specified in the detailed test plan.

4.9 Test scheduling is the responsibility of the S&I Testing Work Package Manager by negotiation with Raft River Operations and Reservoir Engineering.

4.10 The Cognizant Reservoir Engineering Manager is D. Allman or alternate. The Cognizant Raft River Operations Test Engineer is L. Pean or alternate. The Cognizant S&I Testing Work Package Manager is D. Erickson or alternate.

4.11 In the event of a test interruption Reservoir Engineering will make the decision whether to continue with the test or whether to restart the test from the beginning, after appropriate recovery period.

4.12 Reservoir Engineering will provide training for RRFO Eng. and technician to monitor test.

4.13 RRFO to supply trailerhouse or some other personnel weather protection facility at test site. Provided with table or desk and sleeping capabilities.

4.14 Raft River Field Operations will ensure that conductivity will not exceed 3500 umhos. If conductivity exceeds 3500 umhos, Raft River Field Operations will transfer geothermal fluid to a lined pond.

5.0 SAFETY

5.1 All personnel operating experiments at Raft River will be under the cognizance of the Raft River Operations Manager and subject to site operating rules.

5.2 Any experiment or experimental procedure deemed unsafe will be shut down by the Raft River Operations Manager, the Raft River Experiment Coordinator or the Safety Division representative.

5.3 Raft River Operations is responsible for all site safety. Any unsafe condition developing through the operation of an experiment shall be reported immediately to the Manager of Raft River Operations.

5.4 Safety Manual uses required:

5.4.1 Hazardous Material Safety No. 6020
5.4.2 Material Handling Safety No. 6030
5.4.3 Electrical Safety No. 6040
5.4.4 High Pressure/Temperature Systems Safety No. 6060
5.4.5 Fire Protection System No. 7030

6.0 EQUIPMENT REQUIREMENTS

6.1 A permanent pipeline has been designed and installed with flow control valve and orifice flanges from wellhead #5 to the storage pond 5.1 with a minimized overall pressure drop and capable of manual flow control ± 3% of the low end of the desired flow rate from 25 to 250 gpm. Expected flow temperature approximately 265°F.

6.2 The following instrumentation will be installed at well #5 for flow tests.

6.2.1 Parascientific digiquartz pressure transducer to measure wellhead pressure (supplied by Reservoir Engineering and installed by Raft River Operations). (Sketch RS82473 Rev. A.)

6.2.2 A dial type (Heise) pressure gauge capable of measuring wellhead pressure from 0 psi to 125 + psi readable to the nearest 0.5 psi, supplied and installed by Raft River Operations.

6.2.3 A temperature transducer capable of measuring wellhead fluid temperature to ± 1°F, supplied and installed by Raft River Operations.

6.2.4 A pH meter will be supplied by Res. Eng. The pH meter requires a 1-1/2 inch threaded pipe port on a side piping loop for installing the probe. The probe will

6.2.5 A conductivity meter will be supplied by Res. Eng. The probe requires a 3/4 inch threaded pipe port on a side piping loop for installation. The probe will be installed by Raft River Operations.

NOTE: These meters, pH and conductivity, may be provided with a continuous strip chart record. Otherwise the data will be hand recorded as the flow and injection tests proceed. Chart speed is not critical but should be at least 1-inch per hour. (Prevent all instrumentation from freezing.)

6.2.6 A Parascientific Digiquartz pressure transducer or Stevens water level recorders supplied by Reservoir Engineering will be installed by Raft River Operations on wellheads RRGE-1, RRGE-2. Environmental Eng. will supply transducers for MW-1, USGS-3, and a weir for the BLM well. USGS water level recorder will be used on BLM offset.

6.2.7 The geophysical measurement laboratory will be used for producing temperature logging in well #5. Raft River Operations will install the required stripper/lubricator on the wellhead. Geophysical measurements will be done by Drilling Engineering assisted by Raft River Operations. The geophysical measurement laboratory will also be required when using the H-P downhole pressure/temperature tool.

7.0 DETAILED TEST PLAN

7.1 Borehole Geophysical Logs

7.1.1 Temperature log Well #5 in the shut-in condition. The temperature log must be made before the well is disturbed by any other activities.

7.1.2 Fluid temperature log to total depth, recorded at the end of "long" term artesian flow test. (Using single conductor cable.)

7.1.3 H-P downhole temperature pressure probe will be used to check calibration during flow testing, to measure transient pressure changes and used after flow testing to check recovery conditions.

A | 7.1.4 If Geophysical Measurement Laboratory is unable to achieve temp. logging data a wellhead temp. device will be used during testing.

7.2 Background and Baseline Data

7.2.1 Install the pressure transducers at Well #1 and begin taking daily readings to correlate the pressure gauge and the digiquartz readings at Well #5. Set the digiquartz data printers to print hourly at both wells. Begin heating up the borehole by flowing the well at a low flow rate - 10 to 15 gpm.

7.2.2 Control artesian production of RRGE-1 (225 gpm ± 5.) to begin as soon as possible and continue for duration. The discharge from RRGE-1 shall be set at 225 gpm and should not be changed without permission of Reservoir Engineering and RRFO. Hand throttling of Well #1 is permissible when this is performed, record on data sheets.

8.0 GEOCHEMICAL TESTING

8.1 Required samples of flow water to be collected every 1/2 hour or at any change in conditions (like temp. change, etc.).

A | 8.1.1 Samples are required from RRGP-5

8.1.2 Flow samples will be collected in 1 liter container premarked by RRFO with time and sample no. or condition change. Uses of a cooling coil is necessary for flashing samples.

8.1.3 Container will be placed in a predetermined spot next to collection area.

8.1.4 The sample will be analyzed as follows:

A | A) All samples will be analyzed for pH and conductivity. Let samples cool to approximately 30°C before taking conductivity readings.

Execution Copy

F.E.T. TEST PLAN
Field Change Sheet

Title *RRFO SUMMIT REEF-5 FLOW TEST* WBS No. ______ FET No. *160* F.C. No. *2*

Requester *R E Martin* Time *12:* Date *11-2-78*

- [x] Cancellation — Basis ______
- [ ] Hold — Basis ______
- [ ] Hours Update Only (Budget Manager's concurrence required for all hours in excess of estimated hours) — Hours ______ Hours ______ Hours ______
- [ ] Due Date Change — Basis ______

Change Description

1. CHANGE SAMPLING SCHEDULE FOR [illegible] AND [illegible]. TAKE SAMPLE EVERY 8 HRS IF INLINE CONDUCTIVITY PROBE IS [illegible] PROPERLY AND READINGS PARALLEL THE CONDUCTIVITY OF ANALYSES ALREADY PERFORMED.

2. IF IN LINE CONDUCTIVITY PROBE IS NOT FUNCTIONING PROPERLY SAMPLE RATE EVERY HR.

Justification

NOT NECESSARY TO SAMPLE THAT OFTEN SINCE CHANGES [illegible] TAKE PLACE MORE SLOWLY

Concurrence

R. E. Martin	*12:15*	*11-2-78*
Requesting Manager	Time	Date
[illegible signature]	*12:15*	*11-2-78*
Budget Manager	Time	Date

Approval

R. W. [illegible]	*12:15*	*11-2-78*
Facility/Area Manager	Time	Date

Distribution

Facility/Area Supervisor
Budget Manager
Requester
Job Supervisor
FET Coordinator
Res. Engineer

EXECUTION COPY

A | B) Samples taken at: 0800, 1330, and 2400. Will be analyzed for Na^+, HCO_3^-, CA^{++}, Cl^-, pH and conductivity.

Chemist on day shift should analyze samples from previous 16-hour period in the order they were sampled. Chemist will analyze sample from previous 16-hour immediately upon start of day shift. Chemist should complete samples 0800 and 1330 by end of day shift.

C) If conditions change by more than 10% conductivity in any 1/2-hour period mark the sample with the time and mark for complete analysis and deliver to chemistry lab by 0800 each day.

F.E.T. TEST PLAN
Field Change Sheet

Title R.P. Production test Plan RRGP-5 WBS No. 64A112416
FET No. 14A-78
F.C. No. 2

Requester Nicm Time 0910 Date 1 Nov 78

- [ ] Cancellation Basis ______
- [ ] Hold Basis ______
- [x] Hours Update Only (Budget Manager's concurrence required for all hours in excess of estimated hours) Hours No Change in Hours Budget Hours ______
- [ ] Due Date Change Basis ______

Add 9.1.c

Change Description INSTALL ΔP GAUGE (FOR DISCHARGE MEASUREMENTS) AT RRGP-5. GAUGE TO BE USED DURING RECOVERY PERIOD FROM THE PRODUCTION TANK [illegible] OF [illegible], OR DURING RECOVERY FROM TEST TANK #1 (100 GPM) OR #2 (250 GPM)

Justification

Change in production rate
Need to Gage Higher Rate's

Concurrence

D. P. Erickson 08:00 11-1-78
Requesting Manager Time Date

D. P. Erickson 09:00 11-1-78
Budget Manager Time Date

Approval

R. W. Gould 0900 11-1-78
Facility/Area Manager Time Date

Distribution

Facility/Area Supervisor
Budget Manager
Requester
Job Supervisor
FET Coordinator
Res. Engineer

9.0 TEST SEQUENCE - CONTROLLED ARTESIAN FLOW

NOTE: Appendix A includes all data sheet information.

9.1 Raft River field personnel are to install permanent pipeline designed from 6.1 requirement above and instrumentation at RRGP-5

RRFO Eng. C. H. Cooper Date 10-30-78

9.1.1 Install parascientific digiquartz pressure transducer. Insure calibration current when applicable. Protect from freezing.

RRFO R. W. Knoll Date 10-31-78

9.1.2 Install Heise pressure gauge for 0 psi to 125 psi readable to nearest 0.5 psi. Insure calibration current, when applicable. Protect from freezing.

RRFO R. W. Knoll Date 10-31-78

9.1.3 Install temperature transducer capable of measuring wellhead fluid temperature to ± 0.5°F. Insure calibration current, when applicable. Protect from freezing.

RRFO R. W. Knoll Date 10-31-78

9.1.4 Install pH meter. Insure calibration current, when applicable. Protect from freezing.

RRFO R. W. Knoll Date 10-31-78

9.1.5 Install conductivity meter. Insure calibration current, when applicable. Protect from freezing.

RRFO R. W. Knoll Date 10-31-78

9.2 Two hours prior to flow testing install Hewlett-Packard downhole pressure temperature tool at 1500 feet. Insure that H.P. probe in current calibration.

VOID

Logger_______________ Date__________

9.3 Observation Well Set-Up

9.3.1 RRGE-1, RRGE-2, MW-1, and USGS-3 will be monitored with Parascientific digiquartz pressure transducers if they have positive wellhead pressure.

Insure that parascientific digiquartz pressure transducers are installed if not install them. Insure they are current on calibration.

RRFO Eng [signature] Date 10-31-78

F.E.T. TEST PLAN
Field Change Sheet

Title R.R. Production test Plan RRGI-5 | WBS No. 64A112416
FET No. 14A-78
F.C. No. 1

L.B.W.
Requester D. P. Erickson Time 8:45 Date 11-1-78

- [ ] Cancellation — Basis
- [ ] Hold — Basis
- [x] Hours Update Only (Budget Manager's concurrence required for all hours in excess of estimated hours) — Hours no change in / Hours Budget / Hours
- [ ] Due Date Change — Basis

Change Description

Change 9.4.2 to Flow well 5# to pond 5# at a rate of 100 GPM ± 3gm for 1 hour. Record data on data sheet per table 1

Justification

well condition and/or production cabibility better than antisapated.

Concurrence

D. P. Erickson	8:45	11-1-78
Requesting Manager	Time	Date
D. P. Erickson	8:45	11-1-78
Budget Manager	Time	Date

Approval

R. W. Gould	8.45	11-1-78
Facility/Area Manager	Time	Date

Distribution

Facility/Area Supervisor
Budget Manager
Requester
Job Supervisor
FET Coordinator
Res. Engineer

F.E.T. TEST PLAN
Field Change Sheet

Title R.R. Production test PLAN RRGI-5 WBS No. 64A112416
FET No. 14A-78
F.C. No. 3

Requester Niemi Time 09:17 Date 11-1-78

☐ Cancellation Basis
☐ Hold Basis
☒ Hours Update Only (Budget Manager's concurrence required for all hours in excess of estimated hours) Hours No. Change in
Hours Budget
Hours
☐ Due Date Change Basis

Change 9.43 & 9.47

Change Description CHANGE DISCHARGE RATE (Q) FOR MAINTAINANCE OF THERMAL QUASIEQUILIBRIUM BETWEEN WELLBORE AND AQUIFER FROM Q = 10 GPM TO Q = 20 DURING RECOVERY PERIODS FROM PRE PRODUCTION TEST WELL HEATING AND PULSE TESTING
RRGP-5B Q = 20 GPM = MINIMUM FOR ΔP = [illegible]

Justification
This rate of 20GPM keep well warm more efficiently than 10 GPM

Concurrence

Requesting Manager	Time	Date
[signature]	09:17	11-1-78

Budget Manager	Time	Date
D. P. Eickson	09:18	11-1-78

Approval

Facility/Area Manager	Time	Date
R. W. [signature]	0918	11-1-78

Distribution

Facility/Area Supervisor
Budget Manager
Requester
Job Supervisor
FET Coordinator
Res. Engineer

F.E.T. TEST PLAN
Field Change Sheet

Title *RR Production test Plan RR61-5* WBS No. *64 HU 3418*
FET No. *148-78*
F.C. No. *4*

Requester *L Nelson* Time *12:30* Date *11-1-78*

☐ Cancellation Basis ______
☐ Hold Basis ______
☒ Hours Update Only (Budget Manager's concurrence required for all hours in excess of estimated hours) Hours *NO Budget* Hours *Change* Hours ______
☐ Due Date Change Basis ______

Change Description

Change 9.4.4 to Flow well 5H to pond 5 At a rate of 250 gpm ± 3 gpm for 1 hour. Record required data on data sheet per Table 1.

Justification

Based on increased production capabity of well 5H

Concurrence

L Nelson	*12:30*	*11-1-78*
Requesting Manager	Time	Date
D. P. Erickson	*12:30*	*11-1-78*
Budget Manager	Time	Date

Approval

E. W. Gould	*12:55*	*11-1-78*
Facility/Area Manager	Time	Date

Distribution

Facility/Area Supervisor
Budget Manager
Requester

Job Supervisor
FET Coordinator
Res. Engineer

F.E.T. TEST PLAN
· Field Change Sheet

Title *R.R. Production test Plan RRG1-5* WBS No. *6490112416*
FET No. *14A-78*
F.C. No. *5*

Requester *Niemi* Time *15:00* Date *11-1-78*

- [ ] Cancellation — Basis
- [ ] Hold — Basis
- [x] Hours Update Only (Budget Manager's concurrence required for all hours in excess of estimated hours) — Hours *No Change in* / Hours *Buget* / Hours
- [ ] Due Date Change — Basis

Change Description

Change 9.4.6 Flow well 5# to pond 5# at rate of 300 gpm ± 3 gpm for 1 hour or until back pressure will no longer prevent well bore flashing. Record required data on data sheet per table 1#

Justification

Production of well max. ~~*[illegible]*~~

Concurrence

Requesting Manager	Time	Date
[signature]	*15:00*	*11-1-78*

Budget Manager	Time	Date
D. P. Erickson	*15:00*	*11-1-78*

Approval

Facility/Area Manager	Time	Date
R. W. [signature]	*16:10*	*11-1-78*

Distribution

Facility/Area Supervisor
Budget Manager
Requester
Job Supervisor
FET Coordinator
Res. Engineer

9.4 Flow Testing

A | 9.4.1 As soon as observation wells are set up and recording, start taking data on a 4-hour basis prior to test, weekly during test by recording on data sheet in Appendix A.

NOTE: Start collection of fluid. Sample at start of test. Start collection of well #1 data on data sheet.

9.4.2 Flow well #5 to pond #5 at a rate of ~~50~~ gpm ± 3 gpm for 1 hour. Record required data on data sheet per Table 1

9.4.3 Flow well #5 to pond #5 at a rate of 10 gpm ± 3 gpm for 1 hour. Record required data on data sheet per Table 1.

Time 12:30 RRFO Eng. [illegible] Date 11-1-78
Time [illegible] ~~RRFO~~ Res. Eng LBN Date 11-1-78

9.4.4 Flow well #5 to pond #5 at a rate of 100 gpm ± 3 gpm for 1 hour. Record required data on data sheet per Table 1.

Time 14:15 RRFO Eng. RWS Date 11-1-78
Time 14:15 Res. Eng. LB Date 11-1-78

D 200 GPM

9.4.5 Flow well #5 to pond #5 at a rate determined by Res. Eng. for 1 hour. Record required data on data sheet per Table 1.

Time 15:15 RRFO Eng. RWS Date 11-1-78
Time 15:15 Res. Eng. LB Date 11-1-78

9.4.6 Flow well #5 to pond #5 at a rate of ~~200~~ 300 DF gpm ± 3 gpm for 1 hour. Record required data on data sheet per Table 1.

completed
Time 16:00 RRFO Eng. [illegible] Date 11-1-78
Time 16:00 Res. Eng. LB Date 11-1-78

9.4.7 Flow well #5 to pond #5 at a rate of 10 gpm ± 3 gpm for 1 hour. Record required data on data sheet per Table 1.

F.E.T. TEST PLAN
Field Change Sheet

Title RR PRODUCTION TEST PLAN RRG-5 WBS No.
FET No.
F.C. No.

Requester D. P. Erickson Time 0810 Date 11-7-78

- [X] Cancellation — Basis
- [ ] Hold — Basis
- [ ] Hours Update Only (Budget Manager's concurrence required for all hours in excess of estimated hours) — Hours / Hours / Hours
- [ ] Due Date Change — Basis

Change Description

SHUT DOWN RECOVERY DATA COLLECTION FROM RRGP-5 FROM TEST FET 14

Justification

Telecon 11-7-78
SHUTDOWN RECOVERY TEST TO MOVE INSTRUMENTS FOR FET 12 TEST

Concurrence

D.P. Erickson by [illegible]	0815	11-7-78
Requesting Manager	Time	Date
D.P. Erickson by [illegible]	0815	11-7-78
Budget Manager	Time	Date

Approval

[signature]	0815	11-7-78
Facility/Area Manager	Time	Date

Distribution

Facility/Area Supervisor
Budget Manager
Requester
Job Supervisor
FET Coordinator
Res. Engineer

Time 17:20 .... RRFO Eng. [illegible] Date 11-1-78
Time 17:20 .... RRFO Eng. [illegible] Date 11-1-78

9.4.8 Flow well #5 to pond #5 at a rate determined by Res. Eng. for 72 hours. Record data required on data sheet per Table 1. 200 GPM
SHUT IN

Time 1720 RRFO Eng. [illegible] Date 11-4-78
Time ________ Res. Eng. ________ Date ________

VOID When thermal quasi-equilibrium is established remove H-P probe

9.4.8.2 Record fluid temp. log while RRGP-5 is flowing.

PER 7.1.4

VOID Reinsert H-P probe into RRGP-5 and assure calibration, approximately 2 hours before test termination.

9.4.8.4 Recovery period with data collection according to Table 1, for approximately same duration as RRGP-5 was allowed to flow, or until wellhead pressures become thermally effected, as shown by wellhead temperature and pressure responses.

9.4.9 Flow well #5 to pond #5 at a rate of 10 gpm until Res. Eng. has satisfactory test data.

Time 08:00 RRFO Eng C.Y. Cooper Date 11-7-78
Time ________ Res. Eng. ________ Date ________

NOTE: Fluid temperature log recorded as near to the end of the flow test as practical.

9.4.10 Shut Down Flow

Time 09:00 RRFO Eng. C.Y. Cooper Date 11-7-78
Time ________ Res. Eng. ________ Date ________

9.4.11 Chemist receives all samples not tested and tests.

Chemist has received all samples required by test and performed testing per 8.0.

Time 1700 Chemist [signature] Date 11-4-78

9.4.12 All data required on data sheet for flow rate of Well #1 collected.

Time 1500 RRFO Eng. [signature] Date 11-4-78
Time ______ Res. Eng. ______ Date ______

A | 9.4.13 Remove, store, preserve, and protect all piping and instrumentation per 9.1. Perform general clean-up of well area.

NOTE: Do not remove any permanent piping or instrumentation.

RRFO [signature] Date 11-5-78

10.0 DATA REDUCTION SURVEY

Reservoir Engineer will perform a data reduction survey on data collect with objectives of test in mind and report result not more than 14 working days after completion of test. Flow test data required to size 5MW plant pumps will be evaluated by Design Engineering and will not be part of the 14 day reported results.

On completion of test at RRFO one copy of completed test plan with sign-offs, to be delivered to RRFO at Site #1.

RRFO [signature] Date 11-15-78

APPENDIX A

DATA SHEET INFORMATION
AND EXAMPLES

Data Sheet for Well #1.

Data will be collected and recorded on data sheet as follows:

A) Prior to start of flow test on Well #5, record data every 4 hours.

B) During flow test of Well #5, record data at start and every hour thereafter.

C) If any change occurs in flow rate at Well #1, hand throttle as follows:

1) Record rate and time

2) Throttle back to 225 GPM

3) Record rate and time

4. IF ANY CHANGE DEVELOP'S CHECK TO SEE IF ANYONE HAS CHANGED FLOW RATE'S ON WELL #1

1.	Time	Hr-Min	2400 clock
2.	Δt	Minutes	From start of test pump flow or injection
3.	Flow Δp	psi	From orifice plate gauge (tenth of pds)
4.	GPM	GPM	From orifice curve
5.		Adjustment to flow	Open or close valve
6.	Pump Discharge	psi	
7.	Wellhead or vapor pressure	psi	Pressure on flow & inject vapor pressure on pump after start of test
8.	Δp	Δp	Change from start & test
9.	Water level	Δp	See elec. tube pressure
10.	Water level	ft	convert Δp to ft of water
11.	Nitrogen pressure	psi	Record gauge pressure on tank
12.	Back pressure	psi	Down stream orifice pres
13.	Temp. water	^{o}F	T/C J type 1/2[illegible]
14.	HP Probe	psi	As instructed
15.	HP Probe	Δp	From start up test
16.	Comments.		

a) Any column not being used can be converted to other use.

b) Comment column should be used as necessary but use a complete line when needed to expalin and change or condition.

TABLE 1 DATA RECORDING INTERVALS

DIGIQUARTZ RECORDER INTERVALS

Time From To	TESTED WELL	OBSERVATION WELL(S)
0-1 min.	1 sec.	1 min.
1-5 min.	10 sec.	1 min.
5-10 min.	1 min.	1 min.
10-60 min.	1 min.	1 min.
1-5 hrs.	10 min.	10 min.
5 hrs.	1 hr.	1 hr.

DOWNHOLE H.P. PRESSURE/TEMP. RECORDER INTERVALS

Same as Digiquartz Intervals at RRGI-5.

TEMPERATURE, RRGI-5

0-60 min.	5-10 min.
1-5 hrs.	20 min.
5-24 hrs.	1 hr.

RAGE WELL TEST

DATE

Page______of ____

Well #________

Flow-Pump-Injection Test

Instruments Type | Range | Serial No.

Pretest Well Head Pressure________

Pretest Well Activity

Other Well Conditions Associated with this test

Function	Identification	Instruments	Flow Rates	Pipelines	Comments & Pretest Activities

COMMENTS 11-1-78

POND LEVEL START 3'8"

1130 STEP TEST COMPLETE - CLOSED 8" BALL VALVE TO INSTALL ΔP ~15 MIN TO COMPLETE, REOPENED 8" BALL VALVE, CLOSED 8" GATE, FLOWING THRU 3/4" LINE ≈ 20 GPM. DF REQUIRE 200 REGULATOR ON NITROGEN TO ELIMINATE POSSIBLE WATER FLOW TO INSTRUMENTS.

12:45 Flow rate not set at 250 gpm due to meter Reading menometer. Shutting in purge on at 1115 will start over. (Reading not valid on time period 12:30 to 1115)

16:00 Shut in on Step 9.4.6 DUE TO LOW WELLHEAD PRESSU

1700 PH Probe blew out of line Dave Erikson Warren Niemi were hit with hot water and steam. Erikson received minor burns [illegible] Safety discussions will be required for all future FET tests before approval. [illegible]

1630 USGS # 3

SHUT IN BETWEEN 1510 - 1520 [illegible] DUE TO PRESSURE COMPUTER PROBLEM NO ACCURATE PRESSURE DATA RECORDED BETWEEN 1500 - 1700 [illegible]

POND LEVEL AT END OF 72 HR FLOW TEST 9'10"

F.E.T. TEST PLAN
Field Change Sheet

Title [illegible] WBS No. [illegible]
FET No. 14A-[illegible]
F.C. No. 6

Requester NIEMI Time ______ Date ______

- [ ] Cancellation — Basis ______
- [ ] Hold — Basis ______
- [x] Hours Update Only (Budget Manager's concurrence required for all hours in excess of estimated hours) — Hours No Budget Change
  - Hours ______
  - Hours ______
- [ ] Due Date Change — Basis ______

Change Description

CHANGE 10-60 MIN TO 10-[illegible] MIN TO [illegible]
CHANGE [illegible]-5 HRS TO 2-5 HRS

Justification

better well [illegible]

Concurrence

[signature]	1300	1[illegible]
Requesting Manager	Time	Date
[signature]	12:00	11-1-78
Budget Manager	Time	Date

Approval

[signature]	13:00	11-1-79
Facility/Area Manager	Time	Date

Distribution

Facility/Area Supervisor
Budget Manager
Requester
Job Supervisor
FET Coordinator
Res. Engineer

APPENDIX C

TEST PLAN, FET-12A-78

EG&G Idaho

INTEROFFICE CORRESPONDENCE

date October 26, 1978

to RRFO Manager

from Fluids Experiments and Testing

subject R.R. PRODUCTION TEST PLAN RRGI-6 - FET-12A-78

Approved by:

Reservoir Eng. [signature] Date 11-7-78

Drilling Eng. Jim Bowman Per note [illegible] Date 11/7/78

Design Eng. Ray Sanders Date 11/7/78

Environmental Eng. S G Spencer Date 11/7/78

RRFO Eng. Original Signed By J M Millar Date 11/17/78

Safety Eng. Original Signed By C R Shaber Date 11-7-78

Chemistry Eng. C A Allen Date 11-7-78

Authorized for Release

J E Driscoll Date [illegible]

REV.	RELEASE DATE
A	11-7-78

[illegible] 18:00 [illegible] 11 78

22:00

2:00

6:00

10:00

14:00

18:00 [illegible]

A

1.0 PURPOSE OF TEST

The primary purpose for testing the well for a 3½-hour test is checkout of test hardware and instrumentation and to define pump requirements.

2.0 OBJECTIVE(S) OF THE TEST

The test will check-out test hardware and instrumentation and familiarize RRFO with operation of Well #6. In addition this test will provide borehole flow characteristics, local Kh and local boundaries. Also add data to size pumps for 5MW Plant.

3.0 WELL BACKGROUND

Well #6 at Raft River was drilled as an injection well to a depth of 3844 feet. The well is cased to a depth of 1698 feet. The well is capable of free flowing 100 to 200 gpm at a nominal temperature of 253°F.

4.0 RESPONSIBILITIES

4.1 Engineering will design and procure the temporary pipeline required for the flow tests. Raft River Operations will install the line.

4.2 Overall responsibility for conducting the tests is the responsibility of Raft River Operations.

Raft River Operations is responsible for safety, for installation of all hardware and for the operation of all systems.

4.3 Reservoir Engineering will have prime initial responsibility for taking reservoir engineering data during the ten hours of testing, then Raft River operations will have responsibility for this data until the end of the test. Close cooperation and coordination will be required. Raft River Operations will be responsible for all operational data required for conducting the test.

A 4.4 Raft River Operations will have the responsibility for competent data collection during the recovery portion of a production test, in the absence of Reservoir Engineering hydrogeologists. Data will be collected in accordance with Table 1, with "time from-to" referring to time since shut-in.

4.5 Close cooperation and coordination will be required. Raft River Operations will be responsible for all operational data required for conducting the test.

4.6 FET Branch will provide the forms required for recording Reservoir Engineering data, the copy forms will remain in a data file at Raft River. Original will be sent to FET Branch at IPO.

4.7 Reservoir Engineering will have the prime responsibility for data analysis and reporting.

4.8 Reservoir Engineering is responsible for providing certain test condition parameters, based on previous tests as specified in the detailed test plan.

4.9 Test scheduling is the responsibility of the [illegible] Testing Work Package Manager by negotiation with Raft River Operations and Reservoir Engineering.

4.10 The cognizant Reservoir Engineering Manager is D. Allman. The Cognizant Raft River Operation Test Engineer is L. B. Dean. The Cognizant SRI Testing Work Package Manager is D. Erickson.

4.11 In the event of a test interruption Reservoir Engineering will make the decision whether to continue with the test or whether to restart the test from the beginning.

4.12 Reservoir Engineering will provide training for RRFO Eng. and technicians to monitor test.

4.13 RRFO to supply trailerhouse or some other personnel weather protection facility to test site. Provided with table or desk and sleeping accommodations.

A 4.14 RRFO will ensure that the seepage of geothermal fluid in RRGI-6 reserve pit will not exceed 6000 gal/day if this is exceeded, water will be transferred to a lined pond until the seepage rate decreases.

5.0 SAFETY

5.1 All personnel operating experiments at Raft River will be under the cognizance of the Raft River Operations Manager and subject to site operating rules.

5.2 Any experiment or experimental procedure deemed unsafe will be shut down by the Raft River Operations Manager, the Raft River Experiment Coordinator or the Safety Division representative.

5.3 Raft River Operations is responsible for all site safety. Any unsafe condition developing through the operation of an experiment shall be reported immediately to the Manager of Raft River Operations.

5.4 Safety Manual uses required:

5.4.1 Hazardous Material Safety No. 6020
5.4.2 Material Handling Safety No. 6030
5.4.3 Electrical Safety No. 6040
5.4.4 High Pressure/Temperature Systems Safety No. 6050
5.4.5 Fire Protection System No. 7030

6.0 EQUIPMENT REQUIREMENTS

6.1 A temporary pipeline, flow control valve and flow measuring instrument from Wellhead #6 to the storage pond with less than 2 psi overall pressure drop and capable of manual flow control ± 3% of the desired flow rate from 25 to 250 gpm. Expected flow temp. approximately 250°F. Design engineering will design system and purchase the components as necessary. RRFO will install system.

6.2 The following instrumentation will be installed at well #6 for flow tests. Ref. SK 82373.

6.2.1 Parascientific digiquartz pressure transducer to measure wellhead pressure (supplied by Reservoir Engineering and installed by Raft River Operations).

6.2.2 A dial type (Heise) pressure gauge capable of measuring wellhead pressure from 0 psi to 30 psi readable to the nearest 0.1 psi, supplied and installed by Raft River Operations.

6.2.3 A temperature transducer capable of measuring wellhead fluid temperature to ± 0.5°F, supplied and installed by Raft River Operations.

6.2.4 A pH meter supplied by Res. Eng. The pH meter requires a 1-1/2 inch threaded pipe port for installing the probe. The probe will be installed by Raft River Operations.

6.2.5 A conductivity meter supplied by Res. Eng. The probe requires a 3/4 inch threaded pipe port for installation. The probe will be installed by Raft River Operations.

NOTE: These meters may be provided with a continuous strip chart record. Otherwise the data will be hand recorded as the flow and injection tests proceed. Chart speed is not critical but should be at least 1-inch per hour.

6.2.6 A Parascientific Digiquartz pressure transducer supplied or Stevens water level recorders by Reservoir Engineering will be installed by Raft River Operations of wellhead #3, and 7. (RRGE-3 and 7 will be used as a monitor well during testing of RRGI-6.)

6.2.7 The geophysical measurement laboratory will be used for producing temperature logging in well #6. Raft River Operations will install the required stripper/lubricator on the wellhead. Geophysical measurements will be done by Drilling Engineering assisted by Raft River Operations or Reservoir Engineering personnel. The geophysical measurement laboratory will also be required when using the H-[illegible] downhole pressure/temperature tool.

A | 6.2.8 A Stevens level detector will be installed in pond #6 measure 300,000 gallons of water per 4.1[illegible]

6.2.9 Orifice plate size is determined by Reservoir Engineering.

7.0 DETAILED TEST PLAN

7.1 Borehole Geophysical Logs

7.1.1 Temperature log well #6 in the shut-in condition. The temperature log must be made before the well is disturbed by any other activities.

7.1.2 Fluid temperature log to total depth, recorded at the end of "long" term artesian flow test.

7.1.3 H-P downhole temperature-pressure probe to be installed in wellbore before, during, and after flow testing.

A 7.1.4 If Geophysical Measurement Laboratory is unable to achieve temperature logging data, a wellhead temperature device will be used during testing.

7.2 Background and Baseline Data

7.2.1 Install the pressure transducers at Well #6 and Well #3 and #7 wellheads as soon as possible and begin taking daily readings to correlate the pressure gauge and the digiquartz readings at well #6. Set the digiquartz data printers to print hourly at both wells. Begin heating up the borehole by flowing the well #6 at a low flow rate - 10 to 15 gpm. 4 days prior to beginning test if old logging cable used. If new cable used no preheating necessary.

8.0 GEOCHEMICAL TESTING

4 HR's

8.1 Required samples of flow water to be collected every 1/2 hour or at any change in conditions (like temp. change, etc.).

8.1.1 Samples are required from RRGI-6 and ~~3~~ and from Monitor Wells MW-5, 6, 7, 4, 3, and USGS-2, if possible.

8.1.2 Flow samples will be collected in 1 liter container premarked by RRFO with time and sample no. or condition change.

8.1.3 Container will be placed in a predetermined spot next to collection area.

A | 8.1.4 The sample will be analyzed as follows:

A) All samples will be analyzed for PH and conductivity (by sampling on meters and strip recorders).

NOTE: Let samples cool at approximately 30°C before taking conductivity readings.

B) Samples taken at: 0800, 1330, and 2400. Will be analyzed for Na^+, HCO_3^-, CA^{++}, Cl^-, pH and conductivity.

Chemist on day shift should analyze samples from previous 16-hour period in the order they were sampled. Chemist will analyze sample from previous 16-hour immediately upon start of day shift. Chemist should complete samples 0800 and 1330 by end of day shift.

C) If conditions change by more than 10% conductivity in any 1/2 hour period mark the sample with the time and mark for complete analysis and deliver to chemistry lab by 0800 each day.

9.0 TEST SEQUENCE- CONTROLLED ARTESIAN FLOW

9.1 Raft River field personnel are to install temporary pipeline designed from 6.1 requirement above and instrumentation for well #6.

RRFO Eng. ______ Date ______

9.1.1 Install parascientific digiquartz pressure transducer. Ensure current calibration, when applicable. Protect from freezing.

RRFO ______ Date ______

9.1.2 Install Heise pressure gauge for 0 psi to 30 psi readable to the nearest 0.1 psi. Ensure current calibration, when applicable. Protect from freezing.

RRFO ______ Date ______

9.1.3 Install temperature transducer capable of measuring wellhead fluid temperature to ± 0.5°F. Ensure current calibration, when applicable. Protect from freezing.

RRFO ______ Date ______

9.1.4 Install pH meter. Ensure current calibration, when applicable. Protect from freezing.

RRFO ______ Date ______

9.1.5 Install conductivity meter. Ensure current calibration, when applicable. Protect from freezing.

RRFO ______ Date ______

A 9.1.6 Install Stevens level detector in pond #6. Ensure current calibration when applicable. Protect from freezing.

RRFO ______ Date 11-__-__

9.1.7 Install orifice plate.

RRFO ______ Date 11-__-__

9.2 Install 2 hours prior to flow testing Hewlett Packard downhole pressure temperature tool to 1500 feet. Ensure that H.P. probe in current calibration.

N/A.
Logger ______ Date ______

9.3 Observation Well Set-Up

9.3.1 RRGE-3, RRGI-7, MW-3, MW-4, MW-5, MW-6, and MW-7 will be monitored with parascientific digiquartz pressure transducers if they have positive wellhead pressure.

Ensure that parascientific digiquartz pressure transducers are installed, if not install them. Insure they are current on calibration.

RRFO Eng ______ Date 11-__-__

9.3.2 Wells having a static, water level below ground surface will be monitored with Stevens water level recorders.

Insure that Stevens water level recorders are installed. If not install them. For background data use weekly clock drive gears and either 1:1 or 1:2 drum drive gears. During the test use weekly clock drive gears and 1:1 or 1:2 drum drive gears.

Insure that the Stevens water level recorders are in current calibration.

RRFO Eng ______ Date 11-__-__

9.4 Flow Testing

9.4.1 As soon as observation wells are set up and recording, start taking data.

Time ______ RRFO Eng. ______ Date 11-__-__

NOTE: Start collection of fluid. Sample at start of test.

9.4.2 Flow well #6 to pond #6 at a rate of 50 gpm ± 3 gpm for 1 hour. Record required data on data sheet per Table 1.

9.4.3 Flow well #6 to pond #6 at a rate of 10 gpm ± 3 gpm for an hour. Record required data on data sheet per Table 1.

Time ______ RRFO Eng. ______ Date ______

Time ______ Res. Eng. ______ Date ______

9.4.4 Flow well #6 to pond #6 at a rate of 75 gpm ± 3 gpm for 1 hour. Record required data on data sheet per Table I.

Time__________ RRFO Eng.__________ Date__________

Time__________ Res. Eng.__________ Date__________

9.4.5 Flow well #6 to pond #6 at a rate of 10 gpm ± 3 gpm for 1 hour. Record required data on data sheet per Table I.

Time__________ RRFO Eng.__________ Date__________

Time__________ Res. Eng.__________ Date__________

9.4.6 Flow well #6 to pond #6 at a rate of 100 gpm ± 3 gpm for 1 hour. Record required data on data sheet per Table I.

Time__________ RRFO Eng.__________ Date__________

Time__________ Res. Eng.__________ Date__________

Rec Field Change

9.4.7 Flow Well #6 to pond #6 at a rate of 10 gpm ± 3 gpm for 1 hour. Record required data on data sheet per Table I.

Time__________ RRFO Eng.__________ Date__________

Time__________ Res. Eng.__________ Date__________

9.4.8 Flow at Well #6 to pond #6 at rate determined by Res. Eng. for 24 hours. Record data required on data sheet per Table I.

Time 18:00 RRFO Eng. [signature] Cooper Date 11-9-78

~177 GPM Time 18:00 Res. Eng. Dave [signature] BY PHONE Date 11-9-78

9.4.9 Flow well #6 to pond at a rate of 10 gpm ± 3 gpm for 1 hr. Record required data on sheet per Table I.

DELETE Time__________ RRFO Eng.__________ Date__________

Time__________ Res. Eng.__________ Date__________

9.4.10 Flow well #6 to pond #6 at a rate determined by Res. Eng. for 24 hours. Record data required on sheet per Table I.

DELETE

9.4.11 Flow well #6 to pond #6 at a rate of 10 gpm until Res. Eng. is assured of sufficient test data.

Time ___/___ RRFO Eng. ___C.G. Cooper___ Date ______

Time ______ Res. Eng. ______ Date ______

NOTE: Fluid temperature log recorded as near to the end of the flow test as practical.

9.4.12 Shut Down Flow

Time ___18:00___ RRFO Eng. ___C.G. Cooper___ Date ___11-10-78___

Time ______ Res. Eng. ___NA___ Date ______

9.4.13 Chemist receives all samples not tested and test.

Chemist has received all samples required by test and performed testing per 8.0

Time ___15:00___ Chemist ___[illegible]___ Date ___[illegible]___

9.4.14 Remove, store, preserve, and protect all piping and instrumentation per 6.1. Perform general clean-up of well area.

NOTE: Do not remove any permanent piping or instrumentation.

RRFO ___C.G. Cooper___ Date ___[illegible]___

10.0 DATA REDUCTION SURVEY

Res. Eng. will perform a data reduction survey on data collect with objectives of test in mind and report result not more than 14 working days after completion of test.

On completion of test at RRFO one copy of completed test plan with sign-offs to be delivered to RRFO at Site #1.

RRFO Mgr. ___C.G. Cooper___ Date ___[illegible]___

APPENDIX A

DATA SHEET INFORMATION
AND EXAMPLES

1.	Time	Hr-Min	2400 clock
2.	Δt	Minutes	From start of test pr flow or injection
3.	Flow Δp	psi	From orifice plate gau (tenth of psi)
4.	GPM	GPM	From orifice curve
5.		Adjustment to flow	Open or close valve
6.	Pump Discharge	psi	
7.	Wellhead or vapor pressure	psi	Pressure on flow & inj vapor pressure on psi after start of test
8.	Δp	Δp	Change from start & be
9.	Water level	Δp	See elec. tube pressure
10.	Water level	ft	convert Δp to ft of wat
11.	Nitrogen pressure	psi	Record gauge pressure on tank
12.	Back pressure	psi	Down stream orifice pre
13.	Temp. water	$^{\circ}F$	T/C J type 1/2°F
14.	HP Probe	psi	As instructed
15.	HP Probe	Δp	From start up test
16.	Comments		

a) Any column not being used can be converted to other use.

b) Comment column should be used as necessary but use a complete line when needed to expalin and change or condition.

A c) Record orifice and pipe size and pertinent set up information.

Page ____ of ____

Instruments Type   Range   Serial No.

[illegible]

[illegible] Well [illegible] ____

[illegible] Well Acti[illegible]

[illegible] Conditions/[illegible] with this test

Location	Identification	Instruments	Flow Rates	Pipelines	Comments & Prese Activities

TABLE I DATA RECORDING INTERVALS

DIGIQUARTZ RECORDER INTERVALS

Time From To	TESTED WELL	OBSERVATION WELL(S)
0-1 min.	A 10 sec.	1 min.
1-5 min.	10 sec.	1 min.
5-10 min.	1 min.	1 min.
10-60 min.	1 min.	1 min.
1-5 hrs.	10 min.	10 min.
5 hrs.	1 hr.	1 hr.

DOWNHOLE H.P. PRESSURE/TEMP. RECORDER INTERVALS

Same as Digiquartz Intervals at RRGI-5.

TEMPERATURE, RRGI-5

0-60 min.	5-10 min.
1-5 hrs.	20 min.
5-24 hrs.	1 hr.

F.E.T. TEST PLAN
Field Change Sheet

Title R.R. PRODUCTION TEST PLAN RRGT 6 WBS No. ______
FET No. 12 A-78
F.C. No. ______

Requester C. G. COOPER Time 18:00 Date 11-9-78

☐ Cancellation — Basis ______

☐ Hold — Basis ______

☐ Hours Update Only (Budget Manager's concurrence required for all hours in excess of estimated hours) — Hours ______ Hours ______ Hours ______

☐ Due Date Change — Basis ______

Change Description DELETE STEPS 9.4.2 TO 9.4.8 AND STEPS 9.4.9 AND 9.4.10.

Justification POOR WELL FLOW PREFORMANCE

Concurrence

Dave Erickson / C G Cooper BY RADIO — 18:00 — 11-9-78
Requesting Manager — Time — Date

Justin Arnold BY RADIO — 18:00 — 11-9-78
Budget Manager — Time — Date

Approval

C G Cooper — 18:00 — 11-9-78
Facility/Area Manager — Time — Date

Distribution

Facility/Area Supervisor
Budget Manager
Requester
Job Supervisor
FET Coordinator
Res. Engineer

APPENDIX D

Test Plan, FET-27-78

EG&G Idaho

INTEROFFICE CORRESPONDENCE

date October 26, 1978

to RRFO Manager

from Fluids Experiments and Testing

subject R.R. INJECTION TEST PLAN RRGI-7 - FET-27-78

Approved by:

Reservoir Eng. [signature] Date 11/9/78

Drilling Eng. J. A. Bowman Date 11/13/78

Design Eng. [signature] Date 11/9/78

Environmental Eng. [signature] Date Nov 13, 78

RRFO Eng. Original Signed By [signature] Date 11/17/79

Safety Eng. [signature] Date 11/9/78

Chemistry Eng. [signature] Date 11/9/78

Authorized for Release

[signature] Date [illegible]

REV.	RELEASE DATE

R.R INJECTION TEST PLAN FOR RRGI-7

1.0 PURPOSE OF TEST

The primary purpose for the 72-hour test is to obtain preliminary assessment of well to aquifer characteristics, collect data for definition of a long-term test, test hardware, and an instrumentation checkout.

2.0 OBJECTIVES OF TEST

In addition, this test will check-out test hardware and instrumentation and familiarize RREO with RRGI-7 injection operation.
This test will provide borehole flow characteristics, local Kh and local boundaries

3.0 WELL BACKGROUND

RRGI-7 was drilled as an injection well to a depth of 3844 feet (referenced from ground level) and is cased to 2030 feet.

4.0 RESPONSIBILITIES

4.1 Engineering will design and procure instrumentation and piping requirements. Raft River Operations will install them.

4.2 Overall responsibility for conducting the tests is the responsibility of Raft River Operations.

Raft River Operations is responsible for safety, for installation of all hardware and for the operation of all systems.

4.3 Reservoir Engineering will have prime responsibility for taking reservoir engineering data during the first eight hours of testing, then Raft River Operations will have responsibility for this data until the end of the test.

4.4 Raft River Operations will have responsibility for competent data collection during the recovery portion of the injection test.

Data will be collected in accordance with Table 1, with "time from-to" referring to time from the beginning of the 72-hour injection to the end of injection and from the beginning of shut-in to the end of shut-in.

4.5 Close cooperation and coordination will be required. Raft River Operations will be responsible for all operational data required for conducting the test.

4.6 FET will provide the forms required for recording reservoir engineering data; a copy of the forms will remain in a data file at Raft River. Data originals will be sent to FET at UPD and a copy transmitted to Reservoir Engineering. Injection data will be after the injection completion with the remaining data transmitted at the end of the test.

4.7 Reservoir Engineering will have the prime responsibility for data analysis and reporting.

4.8 Reservoir Engineering is responsible for providing certain test condition parameters, based on previous tests as specified in the detailed test plan.

4.9 Test scheduling is the responsibility of the S&I Testing Work Package Manager by negotiation with Raft River Operations and Reservoir Engineering.

4.10 The Subcontractor will be responsible for supplying injection pumps and piping from the pit to the wellhead.

4.11 The Cognizant Reservoir Engineering Manager is D. Goldman or alternate. The Cognizant Raft River Operations Test Engineer is L. B. Dean or alternate. The Cognizant S&I Testing Work Package Manager is B. Meyer or alternate.

4.12 In the event of a test interruption, Reservoir Engineering will make the decision whether to continue with the test or whether to restart the test from the beginning, after appropriate recovery period.

4.13 Reservoir Engineering will provide training for RRFO Eng. and Technician to monitor test.

6.1.3 A temperature transducer capable of measuring injection fluid temperature to ± 1.0°F, supplied and installed by Raft River Operations.

6.1.4 A pH meter will be supplied by Res. Eng. The pH meter requires a 1-1/2 inch threaded pipe port on a side piping loop for installing the probe or suspension in the injection fluid. The probe will be installed by Raft River Operations.

6.1.5 A conductivity meter will be supplied by Reservoir Engineering. The probe requires a 3/4 inch threaded pipe port on a side piping loop for installation or suspension in the injection fluid. The probe will be installed by Raft River Operations.

~~6.1.6~~ A Hach Spectra-photometer will be supplied by Chemical Engineering and samples to be taken by Raft River Operations per Table 1.

NOTE: These meters, pH and conductivity, may be provided with a continuous strip chart record. Otherwise the data will be hand recorded as the injection tests proceed. Chart speed is not critical but should be at least 1-inch per hour. (Prevent all instrumentation from freezing.)

6.2 The Hewlett-Packard downhole pressure-temperature probe will be installed with the INEL geophysical measurement laboratory. If the HP probe is unavailable delete steps 7.4.2, 7.5.4.1 and the applicable portion of 7.5.4.3.

6.3 Parascientific Digiquartz pressure transducers (0-200 psi) or Stevens Water Level Recorders supplied by Reservoir Engineering and installed by Raft River Operations will be installed at the following observation well wellheads:

a. RRGE-3
b. RRGI-6
c. MW-5
d. MW-6
e. MW-7

6.4 A bubbler system, installed by Raft River Operations, will measure water depth in RRGI-7. RS. 11878

6.5 Permanent and temporary lines necessary to pump water from RRGE-1 and/or RRGE-2 to RRGI-7 reserve pit will be provided and installed by Raft River Operations.

6.6 Subcontractor will supply the following equipment.

6.6.1 Pump truck capable of supplying, a) 800 gpm for one hour, b) 600 gpm for one hour, and c) 200 gpm for one hour, and d) 400 gpm continuously for 72 hours.

6.6.2 Pipe and/or hoses to transfer water from RRGI-7 reserve pit and inject into RRGI-7.

6.6.3 Instrumentation to monitor injection rate.

6.7 The geophysical measurement laboratory will be used for flowmeter logging in Well #7. Raft River Operations will install the required stripper/lubricator on the wellhead and scaffolding Geophysical measurements will be done by Drilling Engineering assisted by Raft River Operations. The geophysical measurement laboratory will also be required when using the H-P downhole pressure/temperature tool and during logging operations.

If the lab or alternate is unavailable delete steps 7.4, 7.5.4.1, 7.5.4.2 7.5.4.3, and 7.5.6.3.

The downhole pressure probe will be manually inserted and taken out if the geophysical measurement laboratory is unavailable.

7.0 DETAILED TEST PLAN

7.1 Raft River Field personnel (or as noted) are to install the following instruments for RRGI-7 per sketch

7.1.1 Install parascientific digiquartz pressure transducer. Ensure current calibration when applicable. Protect from freezing. This instrument shall be used only under 200 psi.

7.1.2 Install Heise pressure gauge for 0 psi to 1000 psi. readable to nearest 1.0 psi. Ensure current calibration when applicable. Protect from freezing.

RRFO *RSH GT* Date *11-15-78*

7.1.3 Install temperature transducer capable of measuring injection fluid temperature to ± 1.0°F. Ensure current calibration when applicable.

RRFO *RSH DE* Date *11-15-78*

7.1.4 Install pH meter. Ensure current calibration when applicable. Protect from freezing.

RRFO__________ Date__________

7.1.5 Install conductivity meter. Ensure current calibration when applicable. Protect from freezing.

7.1.6 Install bubbler system and test for functionability. Protect from freezing. Record setting depth referenced to point of existing wellhead in remarks column on data sheet. *#1 21' 9" total, 11' 9" water*

RRFO *J.T. V.L. CGC* Date *11-14-78*

7.1.7 Collect turbidity samples from RRGI-7 reserve pit near subcontractor intake or from subcontract tanks per Table 1. 2 ea., 1 litre, sample 2 hrs. interval, entire injection test. Date, time and well No. *SEE FIELD CHANGE*

RRFO *[illegible]* Date *11-20-78*

7.2 Observation Well Set-Up

7.2.1 RRGE-3, RRGI-6, MW-5 and MW-7 will be monitored with parascientific digiquartz pressure transducers or Stevens Water level meters per Table 1. Hourly at least 24 hours prior to testing.

Ensure that instrumentation is installed and in current calibration as applicable. Protect from freezing.

RRFO RSH - G.T. Date 11-15-78

7.2.2 Measure monitor well levels with a steel tape every other day from test start until 1 week after test completion or as determined by the Environmental Engineer.

To check accuracy of Stevens recorders, measure to within 1/100 feet, record hold, cut, depth to water, time and date on chart (see Examp-e 1). At chart change measure level and record data prior and after change. Clearly mark well, date and time on chart and transport to FET - UPD.

NOTE: Steel tape and chalk are located in the Environmental Building. After use, dry tape and return to Environmental Building.

7.3 Prior to start of test, fill RRGI-7 reserve pit with water from RRGE-1 and/or RRGE-2.

RRFO *RSH* Date *11-15-78*

7.4 Borehole Geophysical Logs

7.4.1 H-P downhole temperature pressure probe will be used to check calibration during flow testing, to measure transient pressure changes and used after flow testing to check recovery conditions.

7.4.2 If Geophysical Measurement Laboratory or alternate is unable to achieve temperature logging data, a continuous reading injection fluid temperature device will be used during testing. Logger__________ Date__________

7.5 Injection Testing

NOTE: Pulse testing will start prior to 8:00 a.m. to allow all pulse and initial injection data to be taken in daylight hours. Injection pressure shall not exceed 700 psi.

The Subcontractor shall inject water pumped from the RRGI-7 reserve pit at the given rates and durations. Water shall be supplied from RRGE-1 and/or RRGE-2 and discharged into the RRGI-7 reserve pit for injection.

Selected 7.5.1 Inject at 200 gpm ± 5% for 1/2 to 1 hour (as determined by the Reservoir Engineer). Allow the well to recover for 1 hour or as determined by the Reservoir Engineer.

Deleted 7.5.2 Inject at 600 gpm ± 5% for 1/2 to 1 hour (as determined by Reservoir Engineer). Allow well to recover for 1 hour or as determined by Reservoir Engineer.

Deleted 1-5-3 inject at 800 gpm ± 5% for 1/2 to 1 hour (as determined be Reservoir Engineer). Allow well to recover for 1 hour or as determined by Reservoir Engineer.

7.5.4 Inject at a rate determined by Reservoir Engineers for 72 hours. Collect samples and record data required on data sheet per Table 1. 400 gpm RSH 11-16-78

Restart 11-17-78

7.5.4.1 Shut down injection and release subcontractor. Shut down 0145 11-20

Pumper Truck released ≈ 12:00 pm 11-20

7.5.4.2 Record recovery data per Table 1.

no pressure on well #7 Time 02:00 RRFO Eng. RSH. Date 11-20-78

Time________RRFO Eng.________Date________

7.6 Monitor recovery period with data collection according to Table 1, for approximately the same duration as RRGI-7 was injected into or until wellhead pressures become thermally effected, as shown by wellhead temperature and pressure responses. If Digiquartz fails collect data on Heise Gauge.

7.7 Chemist receives all samples not tested and tests. Chemist has received all samples required by test and performed testing (see 7.1.7).

Time 10:00 Chemist [illegible] Date 11-28-78

7.8 Remove, store, preserve, and protect all piping and instrumentation per 6.1. Perform general clean-up of well area.

NOTE: Do not remove any permanent piping and instrumentation.

RRFO [illegible signature] Date 11-28-78

8.0 DATA REDUCTION SURVEY

Reservoir Engineer will analyze a data reduction survey on data collected with objectives of test in mind and report result not more than 14 working days after receiving all data. Flow test data required to size 5MW plant pumps will be evaluated by Design Engineering and will not be part of the 14 day reported results.

On completion of test at RRFO one copy of completed test plan with sign-offs, to be delivered to RRFO at Site #1.

RRFO C G Cooper Date 11-28-78

TABLE 1 DATA RECORDING INTERVALS FOR INJECTION AND RECOVERY

DIGIQUARTZ RECORDER INTERVALS

Time From To	RRGI-7	OBSERVATION WELL(S)
0-5 min.	10 sec.	1-Hour
5-10 min.	1 min.	1-Hour
10-60 min.	1 min.	1-Hour
1-5 hrs.	10 min.	1-Hour
5 hrs.	1 hr.	1-Hour

DOWNHOLE H.P. PRESSURE/TEMP. RECORDER INTERVALS

Same as Digiquartz Intervals at RRGI-7

TEMPERATURE, pH, CONDUCTIVITY INTERVALS AT RRGI-7

0-60 min.	5-10 min.
1-5 hrs.	20 min.
5-72 hrs.	1 hr.

TURBIDITY SAMPLES (During Injection)

0-72 hrs.	2 hrs.

DATE

Page____ of ____

Well # ________

Flow-Pump-Injection Test

Instruments Type	Range	Serial No.

Pretest Well Head Pressure________

Pretest Well Activity

<u>Other Well Conditions Associated with this test</u>

Function	Identification	Instruments	Flow Rates	Pipelines	Comments & Pre Activities

1.	Time	Hr-Min	2400 clock
2.	Δt	Minutes	From start of test pump, flow or injection
3.			
4.	GPM	GPM	Subcontractor gauge
5.			
6.			
7.			
8.	Wellhead or vapor pressure	psi	Pressure on flow & inject vapor pressure on pump after start of test
9.	Δp	Δp	Change from start & test
10.	Water level	Δp	See elec. tube pressure
11.	Water level	ft	convert Δp to ft of water
12.			
13.			
14.	Temp. water	^{o}F	T/C J type $1^{o}F$
15.	HP Probe	psi	As instructed
16.	HP Probe	Δp	From start up test
17.	Comments		

a) Any column not being used can be converted to other use.

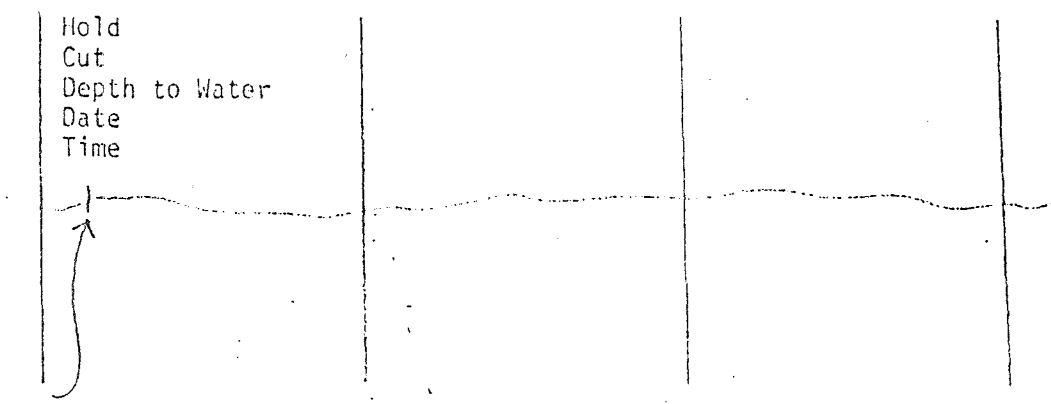
b) Comment column should be used as necessary but use a complete line when needed to expalin and change or condition.

EXAMPLE 1

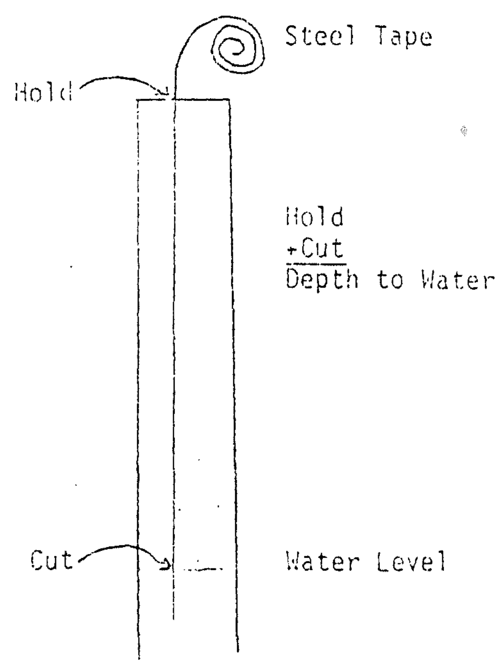
Data

Each chart shall have start tick, every other day tick, and end chart tick with data.

Chart



Roll drum with pen down to make "tick" mark.



NOTE: Only last 10 feet of tape is etched in hundredth of feet. Tape is marked in feet only: i.e. 5.79 feet.

F.E.T. TEST PLAN
Field Change Sheet

Title *RRG1-7 Injection Test* WBS No. ____
FET No. *FET-27-78*
F.C. No. ____

Requester *R E McAtee* Time *11:00* Date *11-16-78*

- [ ] Cancellation — Basis ____
- [ ] Hold — Basis ____
- [ ] Hours Update Only (Budget Manager's concurrence required for all hours in excess of estimated hours) — Hours ____ Hours ____ Hours ____
- [ ] Due Date Change — Basis ____

Change Description

Increase the sampling interval in section 7.1.7 to 2 samples every 6 hours

Justification *Changes in original plan resulted in samples being collected at the RRG1-7 pond. This will decrease the integrity of the samples so fewer samples are required*

Concurrence

R E McAtee	*11:00*	*11-16-78*
Requesting Manager	Time	Date
Budget Manager	Time	Date

Approval

R G Cooker	*11:00*	*11-16-78*
Facility/Area Manager	Time	Date

Distribution

Facility/Area Supervisor
Budget Manager
Requester

Job Supervisor
FET Coordinator
Res. Engineer

F.E.T. TEST PLAN
Field Change Sheet

Title RR Injection Test #7 | WBS No. ______
FET No. 27-78
F.C. No. ______

Requester D Goldman Time 15:50 Date 11-11-78

☐ Cancellation — Basis ______
☐ Hold — Basis ______
☐ Hours Update Only (Budget Manager's concurrence required for all hours in excess of estimated hours) — Hours ______ Hours ______ Hours ______
☐ Due Date Change — Basis ______

Change Description

7.9 7.9.1 Should the pumper truck fail in the 1st 4 hrs — Abort test — Run Recovery 4 hrs and start again.

7.9.2 should the pumper truck fail between 4-24 hrs for more than 15 min — abort test — Run

~~Justification~~ Recovery for time equivalent to flow period. Restart injection test

7.9.3 should the pumper truck fail between 24-72 hrs for more than 30 min — abort test — Run Recovery — contact Res Eng.

~~Concurrence~~

7.10 should pit water supply be exhausted — Terminate injection — Run Recovery — contact Res Eng.

Requesting Manager ______ Time ______ Date ______

[signature] Goldman 1600 11-16-78

Budget Manager ______ Time ______ Date ______

Approval

[signature] 16:00 11-16-78

Facility/Area Manager ______ Time ______ Date ______

Distribution

Facility/Area Supervisor
Budget Manager
Requester
Job Supervisor
FET Coordinator
Res. Engineer

F.E.T. TEST PLAN
Field Change Sheet

Title INJECTION TEST PLAN RRGI-7 WBS No. ______
FET No. 27-78
F.C. No. ______

Requester C G Cooper Time 15:00 Date 11-16-78

- [ ] Cancellation — Basis ______
- [ ] Hold — Basis ______
- [ ] Hours Update Only (Budget Manager's concurrence required for all hours in excess of estimated hours) — Hours ______ Hours ______ Hours ______
- [ ] Due Date Change — Basis ______

Change Description DELETE STEPS 4.13, 6.1.6, 7.5.1, 7.5.2 7.5.3

Justification 4.13 NOT SUFFICIENT TIME; 6.1.6 NO INSTRUMEN, WILL BE DONE BY CHEMICAL ANALYSIS; 7.5.1, 7.5.2, 7.5.3 PROBLEMS WITH HALIBURTON PUMPER TRUCK.

Concurrence

Dennis Goldman	16:00	11-16-78
Requesting Manager	Time	Date
Budget Manager	Time	Date

Approval

C G Cooper	15:20	11-16-78
Facility/Area Manager	Time	Date

Distribution

Facility/Area Supervisor
Budget Manager
Requester
Job Supervisor
FET Coordinator
Res. Engineer

F.E.T. TEST PLAN
Field Change Sheet

Title RRGI-7 Injection Test

WBS No. 64A112417
FET No. FET-27-78
F.C. No. ______

Requester Brenda Meyer Time 2 PM Date 11-16-78

[X] Cancellation — Basis Instrument Failure

[ ] Hold — Basis ______

[X] Hours Update Only (Budget Manager's concurrence required for all hours in excess of estimated hours) — Hours ______
Hours 6hrs less test time
Hours None

[X] Due Date Change — Basis Instrument Failure

Change Description

Cancel the three pulse tests at 200gpm, 600gpm and 800gpm and related data gathering.

Justification

Due to H.P. downhole probe failure, Res. Engineers Dennis Goldman and Tony Allen stated that pulse test data would be uninterpretable.

Concurrence

J. E. Driscoll		11/16/78
Requesting Manager	Time	Date
J. E. Driscoll		11/16/78
Budget Manager	Time	Date

Approval

G. M. Miller	1440	11/17/78
Facility/Area Manager	Time	Date

Distribution

Facility/Area Supervisor
Budget Manager
Requester
Job Supervisor
FET Coordinator
Res. Engineer

APPENDIX E

TEST PLAN, FET-10A-78

Execution Copy

EG&G Idaho

INTEROFFICE CORRESPONDENCE

date October 30, 1978

to RRFO Manager

from Fluids Experiments and Testing

subject TEST PLAN WELL #4 DURING DRILLING - FET-10A-78

Approved by:

Chemistry Engineer [signature] per telecon DPE. Date 10-30-78

Reservoir Engineer [signature] Date 10-30-78

RRFO Engineer [signature] Date 10-30-78

Safety Engineer Original Signed By C R Shaler Date 11-3-78

Environmental Engineer [signature] per telecon DPE Date 10-30-78

Drilling Program Mgr. N/A D.P.E. Date 10-30-78

Authorized for Release

[signature] Date 10-30-78

RRFO: C H Cooper

REV.	RELEASE DATE
N/C	10-16-78
A	10-30-78

EXECUTION COPY

FORM EG&G-954
(Rev 2-77)

RRGP-4A TEST PLAN FET-10-78 October 30, 1978

1.0 PURPOSE:

To estimate the Hydrogeologic and Temperature properties of Leg-4A, through controlled artesian flow testing of RRGP-4A.

2.0 PREREQUISITES:

2.1 Installation of discharge (flow) line with appropriate orifice plate: 2,500 dia/8" pipe.

2.2 Installation of monitering instruments

2.2.1 RRGP-4

Digiquartz transducer
Heise guage (or comparable) 0-100 psi (to 0.5 psi)

Temperature guage: Digi-mite

2.2.2 Digiquartz transducer at observation wells

MW-1
USGS-3
RRGE-1
RRGP-5

2.3 Installation of Manometer.

3.0 TEST PROCEDURES:

3.1 Data collection of observation wells (2.2.2) per table 1.

3.2 Colorado Well Service will remove drill pipe from RRGP-4B. (RRGP-4 discharge will be determined by L. B. Nelson, to maintain heated thermal quasiequilibrium between aquifer and well bore).

3.3 RRGP-4A will be allowed to artesian flow at approximately 25 gpm for 2 to 4 hours. Discharge will be maintained within ± 3%.

3.4 Water samples will be collected, for chemical analysis, when the test is initiated, and each hour thereafter. Cooling coil must be installed.

3.5 Reset data collection at the observation wells (2.2.2) for recovery, per table 1.

3.6 Recovery for approximately same duration as production.

4.0 DATA EVALUATION BY RESERVOIR ENGINEERING PERSONNEL

TABLE 1 DATA RECORDING INTERVALS

DIGIQUARTZ RECORDER INTERVALS

Time From To	TESTED WELL	OBSERVATION WELLS(S)
0-1 min.	1 sec.	1 min.
1-5 min.	10 sec.	1 min.
5-10 min.	1 min.	1 min.
10-60 min.	1 min.	1 min.
1-5 hrs.	10 min.	10 min.

APPENDIX F

TEST PLAN, FET-22C-78

EG&G Idaho

INTEROFFICE CORRESPONDENCE

date January 5, 1979

to RRFO Manager

from Fluids Experiments and Testing

subject R.R. PRODUCTION TEST PLAN TO FLOW WELL #2 INJECTING IN WELL #6 FOR 72 HOURS - FET-22C-79

Approved by:

Reservoir Eng. Denny Goldman Date 1-5-79

Drilling Eng. J. A. Bowman Date 1-5-9

Design Eng. [signature] Date 1-8-79

Environmental Eng. SG Spencer Date 1-5-79

RRFO Eng. Gary W. Miller Date 1-9-79

Safety Eng. Original Signed By C.R. Shaber Date 1-9-79

Chemistry Eng. Richard E McAtee Date 1-5-79

Authorized for Release

J. E. Driscoll 1/8/79

J. E. Driscoll Date

REV.	RELEASE DATE
A	12-20-78
B	1-3-79
C	1-8-79
FC-1	1-8-79
FC-2	1-9-79
FC-3	1-10-79
FC-4	1-10-79
FC-5	1-12-79
FC-6	1-16-79

[initials]

EXECUTION COPY
SHIFT SUPERVISORS DESK

FORM EG&G-954
(Rev. 2-77)

R.R. PRODUCTION TEST PLAN-TO FLOW WELL
INJECTION IN WELL #6 FOR 72-HOUR

1.0 PURPOSE OF TEST

The primary purpose for testing the well for a 72-hour test is checkout of test hardware and instrumentation and to define pump requirements for long term testing.

2.0 OBJECTIVE(S) OF THE TEST

The test will check out test hardware and instrumentation and familiarize RRO with operation of Well #2 flow to Well #6 and injection at #6. Will familiarize RRO with upcoming long term test plans which are similar to this one. In addition this test will provide data on RRGI-6 borehole flow characteristics, [illegible] and local boundaries. Also additional data to size pumps for [illegible] plant.

3.0 WELL BACKGROUND

Well #2 at Raft River was drilled as a production well to a depth of 6543 feet. The well is cased to a depth of 4227 feet.

Well RRGI-6 at Raft River was drilled to TD of 3888 feet. The well is cased to a depth of 1608 feet. Major lost circulation zone occurred at 2995 - 3025 feet.

4.0 RESPONSIBILITIES

4.1 Engineering will design and procure the permanent pipeline required for the flow tests.

4.2 Overall responsibility for conducting the tests is the responsibility of Raft River Operations.

4.3 Reservoir Engineering will have prime responsibility for taking reservoir engineering data during testing, while on site.

4.4 Raft River Operations will have responsibility for data collection as scheduled in Table I in the absence of Reservoir Engineering.

4.5 Close cooperation and coordination will be required. Raft River Operations will be responsible for all operational data required for conducting the test.

4.6 FCT Branch will provide the forms required for recording reservoir engineering data; the copy forms will remain in a data file at Raft River. Original will be sent to FCT Branch at UPD.

4.7 Reservoir Engineering will have the prime responsibility for data analysis and reporting.

4.8 Reservoir Engineering is responsible for providing certain test condition parameters, based on previous tests as specified in the detailed test plan.

4.9 Test scheduling is the responsibility of the S&I Testing Work Package Manager by negotiation with Raft River Operations and Reservoir Engineering.

4.10 The Cognizant Reservoir Engineering Manager is D. Goldman or alternate. The Cognizant Raft River Operations Test Engineer is L. Dean or alternate. The Cognizant S&I Testing Work Package Manager is B. [illegible] or alternate. Reservoir Engineer is on call 24 hours a day at 523-4526 (page Dennis Goldman).

4.11 In the event of a test interruption see Schedule [illegible] and contact Reservoir Engineer.

4.12 Reservoir Engineering will provide training for RRFO Eng. and technician to monitor test upon request.

4.13 RRFO to supply trailerhouse or some other personnel weather protection facility at test site. Provide it with a table or desk and sleeping accommodations. Also provide yard lights and safety equipment.

4.14 The Geothermal Project Field Operations Manager shall be responsible for implementing the changing status of water temperature in transite line as follows:

A

4.14.1 Pipeline shall be maintained in a pressurized condition of at least 35 psig. or above flash point, while pipeline temperatures exceed 200°F.

B

4.14.2 Pipeline pressure shall not exceed 150 psi and valve movement must be slow enough to assure no water or steam hammer.

4.14.3 All valve changes will be made by or supervised by a qualified operator.

B 4.14.4 DEFINITIONS

1) Transite - Asbestos Cement Pipe
2) Hot Water - water above [illegible]°F
3) Cold Water - Water below [illegible]°F
4) Stabilized condition - Very small or no change in flow temperature or pressure.

A 4.15 RRFO will ensure that no water will be discharged to the unlined #6 pit except the 25,000 gallons flush of the RRGI-3 to RRGI-6 line, if approved and acceptable. [illegible] B will check pit prior to flushing. Freeze line flows are permissible.

C 4.16 Insure experimental water can be transferred without interfering with RRGI-6 injection.

5.0 SAFETY

5.1 All personnel operating experiments at Raft River will be under the cognizance of the Raft River Operations Manager and subject to written site operating rules.

5.2 Any experiment or experimental procedure deemed unsafe will be shut down by the Raft River Operations Manager, the Raft River Experiment Coordinator or the Safety Division representative.

5.3 Raft River Operations is responsible for all site safety. Any unsafe condition developing through the operation of an experiment shall be reported immediately to the Manager of Raft River Operations.

5.4 Safety Manual items required:

5.4.1 Hazardous Material Safety No. [illegible].
5.4.2 Material Handling Safety No. 6030.
5.4.3 Electrical Safety No. 6040
5:4.4 High Pressure/Temperature Systems Safety No. [illegible].
5.4.5. Fire Protection Systems No. 7030.
5.4.6 General Protective Clothing and Equipment No. [illegible].

6.0 EQUIPMENT REQUIREMENTS

NOTE: Equipment shall be installed at RRGI-6 per Dwgs. [illegible], 414404, 41T405 as applicable.

6.1 A permanent pipeline has been designed and installed with flow control valve and orifice flanges from wellhead #7 to the wellhead at #6 with a minimized overall pressure drop and capable of manual flow control ± 3% of the low end of the desired injection rate. Expected injection temperature is approximately 270°F.

6.2 The following instrumentation will be installed at Well #6 for injection tests per Dwgs. in above "NOTE".

6.2.1 Paroscientific digiquartz pressure transducer to measure wellhead pressure (supplied by Reservoir Engineering and installed by Raft River Operations), for use only below 700 psi.

6.2.2 A dial type (Heise) pressure gauge capable of measuring wellhead pressure from 0 psi to 1000 ± psi [illegible] the nearest 1.0 psi, supplied and installed by Raft River Operations.

6.2.3 A temperature transducer with continuous recorder capable of measuring wellhead fluid temperature to ± 1°F supplied and installed by Raft River Operations.

6.2.4 A pH meter will be supplied by Reservoir Engineering. The pH meter requires a 1-1/2 inch threaded pipe port on a piping loop for installation of the probe. The probe will be installed by Raft River Operations.

6.2.5 A conductivity meter will be supplied by Reservoir Engineering. The probe requires a 3/4 inch threaded pipe port on a side piping loop for installation. The probe will be installed by Raft River Operations.

6.2.6 An oxidation reduction meter will be supplied by Reservoir Engineering. The probe will be installed by Raft River Operations.

6.2.7 A continuous flow recorder, readable to 8 gpm, supplied and installed by RRO.

NOTE: pH, conductivity, and oxidation reduction data will be [illegible]

6.2.8 A Parascientific digiquartz pressure transducer or Stevens water level recorders supplied by Reservoir Engineering will be installed by Raft River Operations. They shall be installed on RRGE-3, RRGE-1, and RRGE-2. MW-4 shall also have pressure transducer if positive wellhead pressure exists. If an extra one is available install on RRGP-5. The Stevens water level recorders shall be installed on MW-3, MW-5, MW-6, MW-7, RRGI-7 and, if negative wellhead pressure, on MW-4.

6.2.9 The Geophysical Measurement Laboratory will be used for producing temperature logs in Well -6. Raft River Operations will install the required stripper/lubricator and staging on the wellhead. Geophysical measurements will be done by Drilling Engineering assisted by

Raft River Operations. The geophysical measurement laboratory will also be required when using the H-P downhole pressure/temperature tool.

6.3 A bubbler system shall be installed on RRGE-2 per Dwgs. 410181 and 410291.

C 6.4 Immediately before digiquartz pressure at RRGE-2 reads vacuum during pumping on pulse and 72 hr. tests; valve out digiquartz, attach to (or valve into) bubbler, and record data per test requirements. Reattach digiquartz to annulus for pumping periods. Use digiquartz only below 200 psi. Hand record bubbler data from gauge when above 200 psi. (A tee arrangement which would allow the digiquartz to be valved to both the bubbler and wellhead would be easiest.)

7.0 DETAILED TEST PLAN

7.1 Borehole Geophysical Logs (Well No. 6)

C A 7.1.1 Temperature log Well #6 in the shut-in condition. The temperature log must be made within the 72 hour or acceptable period prior to the start of line flush and warm-up, and one between warm-up and pulse testing.

7.1.2 Fluid temperature log to total depth, at the end of 72-hour injection test.

7.1.3 H-P downhole temperature-pressure probe, will be used during pulse testing and 72-hour injection testing to measure transient pressure change and used after flow testing to check transient recovery condition.

7.1.4 A recording wellhead temperature device will be used during testing.

7.2 Background and Baseline Data

7.2.1 Install the pressure transducers at Well #1 and ~~72~~ 60 hours prior to injection into #6 begin taking hourly readings to correlate the pressure at Well #1 with the digiquartz readings at Well #6 and Well #2.

7.2.2 Controlled artesian production of RRGE-1 (constant gpm ± 3%) will begin 72 hours prior to beginning injection and continue for test duration. The discharge from RRGE-1 shall be set at constant gpm and should not be changed without permission of Reservoir Engineering and RRFO. Manual control of Well #1 is permissible to maintain "set constant rates". When it is performed, record on data sheet for well No. 1.

7.2.3 Sample MW-3 through MW-7 (if pumps are hooked up) in bottles provided by environmental group. Wells should be sampled at least two days prior to beginning injection to allow them to stabilize.

8.0 GEOCHEMICAL TESTING

8.1 Collect 1 liter samples from the RRGI-6 flow line at 0800, 1500 and 2400 or if conductivity changes 10%. Use premarked sample bottles.

8.1.1 All samples will be analyzed for pH and conductivity. Let samples cool to approximately 30°C before taking conductivity readings.

Samples will also be analyzed for Na[+], [illegible], [illegible], Cl[−], pH and F[−].

Chemist on day shift should analyze samples from previous 16-hour period in the order they were sampled. Chemist will analyze sample from previous 16-hour immediately upon start of day shift. Chemist should complete samples 0800 and 1500 by end of day shift on which samples were taken.

8.1.2 If water sample conductivity changes by more than 10 mark the sample with the date, time and notation "for complete analysis" and deliver to Chemistry lab by 0800 hours each day.

F.C. 2 [illegible]

8.2 Sample [illegible] Add Step 8.1.3 During testing collect 3 filtered samples- 1 liter. Collect one at start-up, one during, and one at the end of the 72 hour injection testing. Collect at the RRGI-6 sample tap. Collect and analyse per Chemistry Engr. requirements. Collect filtered 1 liter samples every 24 hours of injection testing.

NOTE: [illegible]

Take three(3) one liter samples within 2 hours of the end of injection. Mark the bottles with the date, time, "FET-22C", initials, and "for complete analysis." Transport to Idaho Falls with the next available carrier.

F.C. 5 BJM

[illegible] samples. Connect filters to condenser coils and run a 20 liter sample through the filter. If filter plugs before 20 liters are collected, remove and record quantity and time of flow. Connect another filter and start again. Record flow and residue weight on Data Sheet 3.

8.2.2 Collect bagged residue from strainer cleaning. Weigh and record on Data Sheet 4.

8.2.3 During line/well warm-up, collect a filtered 20-liter sample as in 8.2.1 from downstream condenser coil only. Collect 1 sample at start of warm-up, and one each day during proceeding line/wellbore warm-up period. Record data on Data Sheet 3.

9.0 TEST SEQUENCE

NOTE: Appendix A includes all data sheet information.

9.1 Raft River Field Operations personnel are to ensure instrumentation installation from 6.1 requirements and instrumentation from RRGP-4 to RRGI-6 as follows:

RRGO Eng. Date

C | 9.1.1 Install Parascientific digiquartz pressure transducer at ~~[illegible]~~ RRGI-6. Record line voltages. Protect from freezing. FC-2 GMM

RRFO *G M Miller* Date 1-9-79

C | 9.1.2 Install Heise pressure gauge for 0 psi to 1000 psi readable to nearest 1.0 psi at RRGI-2 and RRGI-6. Ensure current calibration. Protect from freezing.

RRFO *G. M. Miller* Date 1-5-79

C | 9.1.3 Install thermocouple and continuous recorder (TE 6-4 and TR 6-5) capable of measuring wellhead fluid temperature to ± 1.0°F. Protect from freezing.

RRFO *G. M. Miller* Date 1-5-79

9.1.4 Install pH meter per drawing 411403. Protect from freezing.

RRFO *G. M. Miller* Date 1-5-79

9.1.5 Install conductivity meter per drawing 411403. Protect from freezing.

RRFO *G. M. Miller* Date 1-5-79

9.1.6 Install oxidation reduction meter per drawing 411403. Protect from freezing.

RRFO *G. M. Miller* Date 1-5-79

C | 9.1.7 Install orifice plate FE 6-23 (3.370" bore 8") Reference: Drawing 411403.

RRFO *G. M. Miller* Date 1-5-79

C | 9.1.8 Install flow instrumentation FI 6-10, FT 6-9, FR 6-8, and FC 6.6. Reference Drawing 411403.

RRFO *G. M. Miller* Date 1-5-79

9.1.9 Install PdI 6-11, 6-12, and 6-19 per Dwg. 411403. Ensure calibrations are current. Protect from freezing.

RRFO *G. M. Miller* Date 1-5-79

9.1.10 Install pressure instrumentation ~~[illegible]~~, PI 1.1, PI 2.1, PI 2-2, PI 6.15, PI 5-1, PI 6-18, PS 7-1, PS 6-17, PS 6-16, PI 6-2 and PR 6-3 per Drawing 411403. Ensure calibration are correct. Protect from freezing. FC-2 GMM

RRFO *G M. Miller* Date 1-9-73

9.2 Install Bubbler system at RRGI 2 ~~per drawing [illegible] and [illegible]~~. FC-2 GMM
Collect drawdown and recovery data per Table 1 and Table 2 by

comparing corrected bubbler pressure to wellhead pressure.

RRGO *H. M. Millar* Date *1-9-79*

Install instrumentation per Ray Sander's sketch of 1/11/79. Take pressure and temperature readings at four(4) hour intervals on Data Sheet 7. *F.C. 5 DJM*

[illegible] with Parascientific digiquartz pressure transducers if they have positive wellhead pressure. *RRGE-2 DATA WILL BE HAND RECORDED.* *FC-1 [illegible]*

C Ensure that Parascientific digiquartz pressure transducers are installed. If not, install them and record line voltages. *AT SITE # 6.* *FC-2 [illegible]*

RRGO Eng. *H. M. Millar* Date *1-9-79*

9.3.2 Wells having a static water level below ground surface, MW-2, MW-5, MW-6, MW-7, RRGI-7 and RRGE-4 (if negative wellhead pressure) will be monitored with Stevens water level recorders. *~~CHECK RECORDER AT BGM OFFSET WELL TO~~ ENSURE CLOCK IS WOUND AND ON ~~TIME~~, AND PEN IS INKING ~~BEFORE START OF TEST.~~* *FC-1 [illegible]*

Ensure that Stevens water level recorders are installed; if not install them. Must be at least one week (7 days) prior to start of injection. *FC-2 [illegible]*

Ensure that the Stevens water level recorders are operating properly. See NOTE below.

NOTE: Monitor wells equipped with Stevens recorders shall be monitored according to procedure (See Attachment). Recorders should be checked daily to ensure clock is running, that float is not caught, chart does not need changing, and that pen (or pencil) is recording. Manually check water level at least every other day during test and for 1 week following and mark level, time, and date on chart. Label all charts with well number, test number and title, date, and chart speed.

RRGO Date

A 9.4 S.O. Testing; Line/Wellbore Warmup

9.4.1 S.O. Testing

9.4.1.1 Perform all portions of "Operating Procedure RRGI-6 Injection Testing System Feeding from RRGE-2", that are permissible within the water disposal parameters.

9.4.1.2 Valve out all instrumentation prior to flushing.

NOTE: If flushing to the RRGI-6 pit is allowed steps 9.1.1.3 to 9.4.2.6 shall not be performed.

A

9.4.1.3 As strainers plug, clean and collect their residue in plastic bags. Label with time, date and strainer designation and deliver to chemist.

9.4.2 Sample collection during downhole flush and line/wellbore warmup.

9.4.2.1 Chemist shall tare 2.0 micron filters and prepare 2-20 liter sample containers.

9.4.2.2 Connect filters to condenser coils and set up sample bottles, see Figure 6, prior to start of flush.

9.4.2.3 Line up valves per Figure 2, and begin taking filtered samples at start of flush.

9.4.2.4 Collect 20 liter samples. Record sample quantity, collection time, and residue weight on Data Sheet 3. Repeat sampling until flush is complete.

9.4.2.5 If filter plugs before 20 liters are collected, record sample quantity, collection time and residue weight on Data Sheet 3. Repeat sampling until flush is complete.

9.4.2.6 During line warmup, collect a filtered 20 liter sample downstream of pump per valve lineup in Figure 3. Collect one sample at line/wellbore warmup start and one every 24 hours for the duration of line/wellbore warmup.

9.4.3 Line/Wellbore Warmup

C

9.4.3.1 Prior to startup of line/wellbore warmup change orifice plate at FE 6-23 to 3.370" bore for 8" pipe.

9.4.3.2 Connect manometer across orifice.

9.4.3.3 Ensure continuous recorder for temperature and flow and pressure transducer set at 20 minutes at RRGE-2 set up and recording. Record temperature chart speed on chart.

9.4.3.4 Confirm valve line up for flowing RRGE-2 and RRGI-[illegible]

See Table 3.

9.4.3.5 Start a low artesian flow from RRGE-2 to RRGI-[illegible]

9.4.3.6 Close 6AV5 (controller in manual).

9.4.3.7 Using the manometer as backup, slowly open 6AV5 and check flow rate at FI 6-23. Stop valve adjustment when flow reaches 100 gpm.

A 9.4.3.8 Adjust setpoint of 6AV6 to 100 gpm (null meter reads zero; balanced).

9.4.3.9 Set controller in automatic, and confirm flow with FI 6-10 and manometer.

C 9.4.3.10 Begin taking observation well data at minimum 4 hour intervals at beginning of warmup.

9.4.3.11 Continue artesian flow from RRGE-2 for approximately two weeks, until temperature at RRGI-6 has stabilized (over 200°F).

9.4.3.12 Record manometer and flow indicator values every 12 hours on Data Sheet 5. Ensure pressure and temperature recorders are functioning each day. Record discrepancies in comments on Data Sheet 5.

C B 9.4.3.13 Within twenty-four (24) hours prior to step 9.5.1.2, clean strainer at RRGI-6.

9.4.3.14 Continue injection through step 9.5.1.1.

9.4.3.15 Prior to pulse testing, run a temperature log using the Geophysical Measurements Laboratory.

C 9.4.3.16 Send warmup temperature and pressure data to FET-UPD.

RRFO____________________ Date____________

NOTE: A) At start of test, begin collection of fluid samples and RRGE-1 data.

Collect data per Table 1 for 72-hour test and Table 2 for pulse tests. Plot for all tests per Figure 1. If at any time during injection and recovery a digiquartz recorder fails, manually record data. At the end of pulse testing, 72-hour injection, and 72-hour recovery, data including digiquartz tapes shall be sent to Idaho Falls. (All data)

B) If injection testing is interrupted (see Schedule Z) proceed to the recovery portion of the test as necessary and collect data accordingly. Contact Reservoir Engineer.

C) The Johnston Injection Pump at RRGI-6 shall not be operated continuously below 400 gpm. The Peerless production pump in RRGE-2 shall not be operated continuously below 700 gpm.

C D) During recovery periods, utilize artesian flow from RRGE-2 to fill RRGE-2 to RRGI-6 line. After line is filled begin 20 gpm flow to RRGI-6 pond.

9.5 Pulse Tests

9.5.1 ~~900~~ 820 gpm Pulse Test

9.5.1.1 Install downhole pressure/temperature probe with Geophysical Measurements Laboratory.

A 9.5.1.2 Pump RRGE-2 and inject into RRGI-6 at 900 gpm ± 10% maintained constant (± 3%) for 1 hour. Collect data per Table 2, and Figure 1.

B 9.5.1.3 Stop the pumps at RRGE-2 and RRGI-6. Flow RRGE-2 to the #6 pond at approximately 20 gpm using valves 6V14 and 6V15. Flow RRGI-6 to the #6 pond at approximately 20 gpm using the wellhead warmup line. Collect data per Table 2 and Figure 1 for one (1) hour.

9.5.2. ~~700~~ 800 gpm Pulse Test   FC-1 HMM

C A 9.5.2.1 Pump RRGE-2 and inject into RRGI-6 at ~~700~~ 800 gpm ± 10 maintained constant for 1 hour. Collect data per Table 2, and Figure 1.

B 9.5.2.2 Stop the pumps at RRGE-2 and RRGI-6. Flow RRGE-2 to the #6 pond at approximately 20 gpm using valves 6V14 and 6V15. Flow RRGI-6 to the #6 pond at approximately 20 gpm using the wellhead warmup line. Collect data per Table 2 and Figure 1 for one (1) hour.

C A 9.6 Flow and Inject at ~~800~~ 700 gpm for 72 hours   FC-1 HMM

9.6.1 Pump RRGE-2 and inject into RRGI-6 at ~~800~~ 700 gpm ± 10% maintained constant (± 3%) for 72 hours. Collect data per Table 1. Plot wellhead pressure vs time on semilog graph paper; see Figure 1.

9.6.2 After 24 hours of injection and before the end of injection, remove the downhole pressure/temperature probe with the Geophysical Measurements Laboratory. Install the temperature probe and run a temperature profile of the borehole. Remove the temperature probe and reinstall the downhole pressure/temperature probe.

B 9.6.3 Stop the pumps at RRGE-2 and RRGI-6. Flow RRGE-2 to the #6 pond at approximately 20 gpm using valves 6V14 and 6V15. Flow RRGI-6 to the #6 pond at approximately 20 gpm using the wellhead warm-up line. Collect data per Table 1 and Figure 1.

9.6.4 At the end of 72 hour recovery remove downhole probe with Geophysical Measurements Laboratory. Install temperature probe and run a temperature log to total depth. Reinstall the downhole pressure/temperature probe.

9.6.4.1 → new step for warming flow 2 to 6 100 gpm. See next page for procedure.   FC-6 NH   FC-1 HMM

C 9.7 ~~700~~ 800 gpm Pulse Test

9.7.1 Pump RRGE-2 and inject into RRGI-6 at ~~700~~ 800 gpm ± 10% maintained constant (± 3%) for 1 hour. Collect data per Table 2, and Figure 1.

B 9.7.2 Stop the pumps at RRGE-2 and RRGI-6. Flow RRGE-2 to the #6 pond at approximately 20 gpm using valves 6V14 and 6V15.

#2 1-16-79

FET-22C-79

ARTESIAN FLOW PROCEDURE

REFERENCE STEP 9.6.4.1 - STARTUP OF ARTESIAN FLOW BETWE RRGE-2 TO RRGI-6

PREREQUISITES:

1. PERFORMING STEP 9.6.4 OF FET-22C-79.
2. DATA SHEETS AVAILABLE AT SITES 2 AND 6.
3. 6AV6 CONTROLLER IN ~~AUTOMATIC~~ MANUAL.

PROCEDURE

1. SHUT WELL #6 3/4" BYPASS WARMUP FLOW.
2. SHUT 6V19 - WARMUP FLOW FROM WELL #2
3. OPEN 6V5 - WELL 6 INLET VALVE.
4. THROTTLE 2V3 AT WELL #2 TO MAINTAIN 80-100 PSIG LINE PRESSURE.
5. IN MANUAL, ADJUST 6AV6 CONTROLLER UNTIL FLOW INTO #6 WELL IS ≈100 GPM. REPEAT STEP 4 & 5 AS REQUIRED
6. WHEN 100 GPM FLOW IS ACHIEVED, MATCH THE CONTROL SIGNALS ON THE CONTROLLER AND SHIFT TO AUTOMATIC. MONITOR THE FLOW RATE AND CONTROLLER FOR STEAD OPERATION.
7. ENSURE THE STRIP CHART RECORDERS FOR #6 WELL HEAD PRESSURE, TEMPERATURE, AND FLOWRATE ARE RECORDING.

8. TAKE DATA AT SITES 2 AND 6 HOURLY BY HAND.

9. ENSURE THE STRIP CHART RECORDER AT SITE 2 IS RECORDING ANNULUS PRESSURE.

Flow RRGI-6 to the #6 pond at approximately 20 gpm using the wellhead warmup line. Collect data per Table 2 and Figure 1 for one (1) hour.

9.8 900 gpm Pulse Test

9.8.1 Pump RRGE-2 and inject into RRGI-6 at 900 gpm ± 10% maintained constant (± 3%) for 1 hour. Collect data per Table 2, and Figure 1.

9.8.2 Stop the pumps at RRGE-2 and RRGI-6. Flow RRGE-2 to the #6 pond at approximately 20 gpm using valves 6V14 and 6V15. Flow RRGI-6 to the #6 pond at approximately 20 gpm using the wellhead warmup line. Collect data per Table 2 and Figure 1 for one (1) hour.

9.8.3 After recovery remove the downhole pressure/temperature probe.

RRFO *RS Hope* Date *1-19-79*

9.9 Chemist receives all samples not tested and tests.

Chemist has received all samples required by test and performed testing per 8.0.

Time________ Chemist____________ Date________

9.10 All data required on data sheet for flow rate of Well #1 collected.

Time *16:00* RRFO Eng. *RS Hope* Date *1-19-79*
Time________ Res. Eng.____________ Date________

9.11 Remove, store, preserve, and protect all piping and instrumentation per 9.1. Perform general clean-up of well area.

NOTE: Do not remove any permanent piping or instrumentation.

10.0 DATA REDUCTION SURVEY

Reservoir Engineer will perform a data reduction survey on data collected with objectives of test in mind and report results not more than 14 working days after completion of test. (Flow test data required to size 5MW plant pumps will be evaluated by Design Engineering and will not be part of the 14 day reported results.)

On completion of test at RRFO one copy of completed test plan with sign-offs, to be delivered to RRFO at Site #1.

RRFO________________ Date________

APPENDIX A

DATA SHEET INFORMATION AND SAMPLES

Table 3

C

Valve Number	Valve Condition		RRFO Sign-Off, Date and Time
	Open	Shut	
2V-4		X	
2V-5		X	
2V-1	X		
2V-2	X		
2V-3 (Throttled)			
6V-4		X	
6V-5		X	
6V-1	X		
6V-2	X		
6V-3 (Open)	X		
2V-6	X		
2V-7	X		
2V-8		X	
2V-9		X	
1V-16	X		
1V-11		X	
1V-17	X		
1V-19	X		
1V-14		X	
1V-13		X	
1V-15	X		
3V-9	X		
3V-6	X		
3V-3		X	
3V-7		X	
6V-12		X	
6V-13	X		
3V-10	X		
3V-11		X	
6V-11	X		
6V-8	X		
6V-10	X		
6V-9	X		
6V-7	X		
6AV-6	X		
6V-14		X	
6V-15	X		

Data Sheet for Well #1.

Data will be collected and recorded on data sheet as follows:

A) Prior to start of flow test on Well #5, record data every 4 hours.

B) During flow test of Well #5, record data at start and every hour thereafter.

C) If any change occurs in flow rate at Well #1, hand throttle as follows:

1) Record rate and time.

2) Throttle back to 225 GPM

3) Record rate and time

DATA SHEET WELL #1.

TIME	GPM GAUGE	RECORDER'S NAME & DATE	TIME	GPM GAUGE	RECORDER'S NAME & DATE

1.	Time	Hr-Min	2400 cloc[illegible]
2.	Δt	Minutes	From start of test [illegible] flow or injection
3.	Flow Δp	psi	From orifice plate gauge (tenths of psi)
4.	GPM	GPM	From orifice curve
5.		Adjustment to flow	Open or close valve
6.	Pump Discharge	psi	
7.			
8.	Wellhead or vapor pressure	psi	Pressure on flow [illegible] vapor pressure [illegible] after start of test (from gauge)
9.	Δp	Δp	Change from start [illegible]
10.	Water level	Δp	See elec. tube [illegible]
11.	Water level	ft	convert Δp to ft of water
12.	Nitrogen pressure	psi	Record gauge pressure [illegible] tank
13.	Back pressure	psi	Down stream orifice [illegible]
14.	Temp. water	°F	T/C J type 1/2°F
15.	HP Probe	psi	As instructed
16.	HP Probe	Δp	From start up test

17. Comments

a) Any column not being used can be converted to other use.

b) Comment column should be used as necessary but use a complete line when needed to explain and change or condition.

c) Date and initial each data sheet.

SCHEDULE 2

TIME SINCE PUMPING OR INJECTION STARTED	
0 - 2 hours	Terminate test if any interruption > ~~[illegible]~~ 10 min F.C.4 83.97
2 hours - 6 hours	Terminate test if interruptions > ~~[illegible]~~ 20 min. F.C.4 83.97
6 hours - 24 hours	Terminate test if interruptions >20 minutes
1 day - 3 days	Terminate test if interruptions >1-1/4 hour
3 days - 10 days	Terminate test if interruptions >4 hours

F.E.T. TEST PLAN
Field Change Sheet

Title Flow Well #2 Injecting in Well #6

WBS NO.
FET No. FET-22C
F.C. No. 1

Requester B. Meyer   Time 1400 hrs.   Date 1-8-79

☑ Cancellation   Basis Instrument Breakdown

☐ Hold   Basis

☐ Hours Update Only (Budget Manager's concurrence required for all hours in excess of estimated hours)   Hours
Hours
Hours

☐ Due Date Change   Basis

Change Description

1) Step 7.2 - 60 hours will be sufficient data collection and control time on RRGE-1.
2) Step 9.3.2 - Check recorder at BLM offset well to ensure clock is wound and on time, and pen is inking before start of test.
3) Step 9.3.1 - Since no more digiquartz are available, data at RRGE-2 will be hand recorded.
4) The first pulse test will be run at 900 gpm, the second at 800 gpm and the 72 hrs at 700 gpm then pulses at 800 and 900 gpm (steps 9.5.1, 9.5.2, 9.6, 9.7 and 9.8).

Justification

1) Data collection at RRGE-1 not started 72 hrs. prior to test start-up. Do not delay because of it.
2) BLM offset was not included in an observation well. Res. Engrs. now believe there may be interference between BLM offset and RRGE-2.
3) Digiquartz at RRGE-2 was blown out. No others available.
4) Well will draw down too rapidly at previous rates.

Concurrence

Austin E. Driscoll	1500	1/8/79
Requesting Manager	Time	Date
Brenda S. Meyer	1500	1/8/79
Budget Manager	Time	Date

Approval

Gary M. Miller	1215	1-9-79
Facility/Area Manager	Time	Date

Distribution

Facility/Area Supervisor
Budget Manager
Requester

Job Supervisor
FET Coordinator
Res. Engineer

Entered Change
1-9-79 GM Miller

F.E.T. TEST PLAN
Field Change Sheet

Title Flow Well #2 Inject into Well #6
WBS No.
FET No. 22C
F.C. No. 2

Requester B. Meyer Time 1400 Date 1/9/79

- [x] Cancellation Basis
- [ ] Hold Basis
- [ ] Hours Update Only (Budget Manager's concurrence required for all hours in excess of estimated hours) Hours Hours Hours
- [ ] Due Date Change Basis

Change Description

BMM 1) Delete digiquartz and line voltage recorder at RRGI-2. Step 9.1.1
BMM 2) Delete PI 1.2 Step 9.1.10
BMM 3) Delete "per dwg 410181 and 410291" Step 9.2
BMM 4) Add "at site #6" Step 9.3.1
BMM 5) Delete BLM Offset requirement in Field Change 1.

Justification

1) No digiquartz or line voltage recorder available.
2) This pressure indicator is on a dead line.
3) Bubbler is installed, but dwgs no available as a check.
4) Clarification. 5) Not able to get into well house to check.

Concurrence

	Time	Date
Requesting Manager: J. E. Driscoll	1357	1-9-78 (corrected to 79)
Budget Manager: Brenda S. Meyer	1430	1-9-78 (corrected to 79)

Approval

	Time	Date
Facility/Area Manager: Gary M Miller	1354	1-9-78

Distribution

Facility/Area Supervisor
Budget Manager
Requester

Job Supervisor
FET Coordinator
Res. Engineer

Entered 1-9-79 BMM

KMW 6) In Table 1, delete the 1 min. data requirements on RRGE-2 bubbler. Collect data as rapidly as possible and record time.

KMW 7) Add Step 8.1.3 During testing collect 3 filtered samples- 1 liter. Collect one at start-up, one during, and one at the end of the 72 hour injection testing. Collect at the RRGI-6 sample tap. Collect and analyse per Chemistry Engr. requirements. Collect filtered 1 liter samples every 24 hours of injection testing.

Justification

6) It is not possible to collect bubbler data at 1 min. intervals.

7) Additional chemistry data for chemistry on RRGE-2 and RRGI-6.

FET Test Plan

Field Change Sheet

Title. Flow Well #2 Injecting in Well #6
FET-22C Field Change #3

Requestor: Lynn Nelson Time: 01:45
Date: 1-10-79

Change Description

The 1.5 min. pump downtime at 01:39; 1-10-79, will be treated as if no pump downtime occurred.

L R Nelson RRRE
W W Meyer RETE
B.S Meyer FET

F.E.T. TEST PLAN
Field Change Sheet

Title Flow RRGE-2, Inject RRGI-6 WBS No. ______
FET No. 22C
F.C. No. 4

Requester Lynn Nelson Time 23:00 Date 1-10-79

- [ ] Cancellation — Basis ______
- [ ] Hold — Basis ______
- [ ] Hours Update Only (Budget Manager's concurrence required for all hours in excess of estimated hours) — Hours ______ Hours ______ Hours ______
- [ ] Due Date Change — Basis ______

Change Description

1) In schedule Z - terminate and restart test if pump down over 10 min. in the first 2 hours of pumping and if over 20 min. from 2 to 6 hours of testing.
2) In Table 1, take (Heise gauge) PI 6-1 readings at 5 min intervals from

Justification

1) 30 seconds and 5 min will not allow sufficient time to identify and start up pumps after shutdown.
2) Present Table 1 will not allow accurate analysis.

Concurrence

Signature	Time	Date
L B Nelson — Requesting Manager	2315	10 Jan 79
B8 Minger — Budget Manager	2315	1-10-79

Approval

Signature	Time	Date
Gary M Miller — Facility/Area Manager	2318	1-10-79

Distribution

Facility/Area Supervisor
Budget Manager
Requester
Job Supervisor
FET Coordinator
Res. Engineer

1 to 2 hrs of testing, 10 min intervals from 2 to 3 hrs, 20 min intervals from 3 to 5 hrs, and 1 hr intervals from 5 to 72 hrs.

F.E.T. TEST PLAN
Field Change Sheet

Title Flow RRGE-1 and Inject into RRGE6

WBS No.
FET No. 22C
F.C. No. 5

Requester Brenda Meyer Time 11:00 Date 1/12/79

- [ ] Cancellation — Basis
- [ ] Hold — Basis
- [ ] Hours Update Only (Budget Manager's concurrence required for all hours in excess of estimated hours) — Hours / Hours / Hours
- [ ] Due Date Change — Basis

Change Description

1) Take three(3) one liter samples within 2 hours of the end of injection. Mark the bottles with the date, time, "FET-22C", initials, and "for complete analysis." Transport to Idaho Falls with the next available carrier.

2) Install instrumentation per Ray Sander's sketch of 1/11/79. Take pressure and temperature readings at four(4) hour intervals on Data Sheet 7.

Justification

1) The rise in temperature at RRGE-2 may indicate a chemical change.

2) To define line temperature losses from RRGE-2 to RRGE-1.

Concurrence

	Time	Date
J. E. Driscoll — Requesting Manager	11:25	1-12-79
Brenda S. Meyer — Budget Manager	11:25	1-12-79

Approval

	Time	Date
Terry M Miller — Facility/Area Manager	1148	1-12-79

Distribution

Facility/Area Supervisor
Budget Manager
Requester
Job Supervisor
FET Coordinator
Res. Engineer

F.E.T. TEST PLAN
Field Change Sheet

Title FLOW RRGE-1 AND INJECT INTO RRGI-6 — WBS No. ______ FET No. FEG 22C-79 F.C. No. 6

Requester G. M. MILLAR Time 1730 Date 1-16-79

- [ ] Cancellation — Basis ______
- [ ] Hold — Basis ______
- [ ] Hours Update Only (Budget Manager's concurrence required for all hours in excess of estimated hours) — Hours ______ Hours ______ Hours ______
- [ ] Due Date Change — Basis ______

Change Description

1. STEP 9.6.4: Change "At the end.." to "Before the end..".
2. Add a new step 9.6.4.1 to read: After ≈ 66 hours of recovery flow RRGE-2 to RRGI-6 using artesian pressure to warm up the Transite pipeline between site 2 and site 6. Adjust flow to ≈ 100 GPM by adjusting 6AV6. Continue the warmup flow until (CONT'D)

Justification

1. This will allow the temperature log to be taken near the end of the 72 hour recovery which gives the required data but does not delay the beginning of the post test pulse tests.
2) The 20 GPM flow rate is not sufficient to warm up the transite flow line.

Concurrence

G. M. Millar — 1845 — 1-16-79
Requesting Manager — Time — Date

J. E. Driscoll per telecon Hma 1912 — 1-16-79
Budget Manager — Time — Date
D. Goldman per telecon Hma 1912 — 1-16-79

Approval

G. M. Millar — 1845 — 1-16-79
Facility/Area Manager — Time — Date

Distribution

Facility/Area Supervisor	Job Supervisor
Budget Manager	FET Coordinator
Requester	Res. Engineer

commencing step 9.7 pulse tests. Take data hourly on Data Sheets RRGI-6 Temperature and Pressure Data and RRGE-2 Data Sheet.