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OIL RECOVERY BY CARBON DIOXIDE INJECTION

Annual Report, July 1976—July 1977

By
George P. SanFilippo

November 1977
(TIC Issuance Date)

Work Performed Under Contract No. EF-76-C-05-5301

Pennzoil Company
Vienna, West Virginia

U. S. DEPARTMENT OF ENERGY

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Annual Report for the
Period July 1976-July 1977

George P. SanFilippo

PENNZOIL COMPANY
Vienna, West Virginia 26105

Date Published-September 1977

PREPARED FOR THE UNITED STATES
ENERGY RESEARCH AND DEVELOPMENT ADMINISTRATION

Under Contract No. EF-76-C-05-5301

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INTRODUCTION

The Rock Creek Field, which has produced from the Big Injun Sand since 1906, is located in Roane County, West Virginia. During the 71 year life of the field, seven separate projects utilizing three different secondary recovery methods, have been attempted. Low pressure gas recycling, which was implemented in 1935 and continues today, has proven to be the only effective extra recovery mechansim. Waterflooding efforts failed to bank significant quantities of oil with failure attributed to the high connate water saturation, and steamflooding efforts failed due to the low injectivity encountered in the project. Primary recovery by solution-gas drive and the secondary recovery by gas recycle account for a total recovery of approximately 20% of the original stock tank oil-in-place (OSTOIP). Therefore, 80% of the OSTOIP will remain after gas recycling. The amount of oil remaining in place coupled with a favorable reservoir temperature, a permeability profile with a high degree of homogeneity, and successful laboratory miscibility tests provided the incentive for a pilot test of a miscible carbon dioxide flood.

Pennzoil Company designed, developed, and installed this pilot project with financial assistance from the Energy Research and Development Administration of the United States Government (ERDA).

The pilot consists of two contiguous five-spot patterns encompassing approximately ten acres each. These dual five spots are surrounded by thirteen back-up water injection wells drilled as or converted to water injection wells for the sole purpose of containing the injected carbon dioxide. Prior to carbon dioxide injection, the reservoir pressure of 91 psia must be increased to near 1000 psia. This pressure increase will be accomplished by water injection and monitored by pressure fall-off tests. The project is currently in the water injection or pressure build-up phase.

The objectives of this pilot are to determine the oil recovery efficiency of a multiple contact carbon dioxide miscible flood and to define and evaluate operational problems associated with this particular recovery method. The quantitative data gathered as a result of the installation of the project and the injection performance experienced thus far conform to expectations.

SUMMARY

The pilot test site was selected and designed to utilize a maximum number of existing wells and cause minimal disruption of the active low pressure gas recycle while considering the area of most advantageous reservoir characteristics. The pilot area contains two contiguous five-spot patterns, each containing approximately ten acres. (See Figure No. 1)

The two center producing wells were drilled and completed in 1908 and 1909. Each well was reconditioned for this project by a cable tool clean-out. The existing 5-1/2" casing was replaced by new 4-1/2" casing which was run on a packer and set immediately above the producing horizon. The wells were equipped with new tubing, rods, and electrified pumping jacks. New producing facilities were also installed for each well. Separation facilities consist of gas-fluid separators and water-oil separators. Gas production will be continuously monitored through individual meters, while the produced oil and water from each well will be pumped into separate holding tanks, thus providing accurate daily measurements of all produced fluids.

The six pattern injection wells will serve as both water and carbon dioxide injection wells. These six wells were drilled, logged, cored, and completed as part of this project. Whole core analyses were completed on five of the cores and a conventional analysis was done on the sixth core. This conventional or plug analysis was necessitated by a highly irregular core surface. A set through, cemented completion with 4-1/2" casing was done on each well. Final completion of each well consisted of the selective perforating of the net sand interval followed by a 2,000 gallon hydrochloric acid breakdown. Prior to carbon dioxide injection, internally plastic coated tubing will be run on a packer for an injection string in an attempt to minimize possible corrosion problems.

Containment of the injected carbon dioxide in this pilot will be attempted by peripheral pressure maintenance by water injection. Originally, eleven such pressure maintenance wells were designated. After the core data had been received and incorporated into a computer simulation model study which pointed out gaps in the peripheral pressure maintenance scheme, it was decided to drill two additional back-up water injection wells. One of these two wells was cored. Of the thirteen back-up water injection wells, six were drilled and completed as part of this project. The remaining seven back-up water injection wells were converted from five active producing wells and two low pressure gas injection wells. The new wells were completed in the same manner as the six carbon dioxide-water injection wells, while the old wells converted to injection wells were cleaned out and logged before an injection string was run. The injection string in these reconditioned wells consists of 2-inch tubing set with an inflatable packer immediately above the Big Injun Sand. An anchor, extending to within fifteen feet of the total depth, was run below each packer. One producing well, located just outside of the pattern area, was converted to an observation well by the installation of 2-inch tubing set on a packer immediately above the producing horizon.

The injection water for the pilot is supplied by two subsurface water sources approximately seven miles apart. One source is five miles north of the injection plant and the other source is two miles southwest of the injection plant. Because of the high iron content of the southern water source, the two waters are not mixed. The water supply facility at the southern water source is maintained solely as a back-up water supply.

The injection water is chemically treated at the water supply well for both bacteria and scale prevention. Treatment for scale prevention is accomplished by continuous chemical injection while bacteria prevention is accomplished by a weekly batch biocide treatment. After being pumped to the plant site, the water is filtered to eliminate solid impurities. Three 300 barrel clear well tanks remain filled during normal operation to provide approximately eight hours of injection in case of an interruption in the water supply. Prior to injection, the water is continuously treated with an oxygen corrosion inhibitor. Two electric driven triplex pumps, each capable of pumping 2,100 barrels per day, are used for injection. A constant pressure is kept on the field injection system by a back-pressure regulator. Extreme care is exercised in the maintenance of this constant pressure in order to prevent parting or fracturing of the sand face.

Carbon dioxide will be maintained in the liquid state during the project. Four insulated tanks, each capable of storing 44 tons of carbon dioxide, have been installed at the plant site. Carbon dioxide will be hauled to the plant in tank trucks during the carbon dioxide injection phase. The carbon dioxide will be stored at approximately 0° F and 250 psi. A gear pump will take suction from the bottom of the tanks and charge a triplex pump with a 300 psi liquid. The triplex pump will then pressurize the carbon dioxide to the desired injection pressure. This injection pressure will be maintained through a by-pass system consisting of a series of back-pressure regulators.

After pressuirzation, the carbon dioxide will pass through an in-line indirect heater capable of heating the fluid to 70° F. The heated carbon dioxide then travels to an injection header via an uncoated 2-inch line. From the injection header, internally coated 2-inch lines run to each of the six injection wells. The injection header is constructed so that either water or carbon dioxide can be injected into any well at any time. This header was constructed in this manner to allow alternate water and carbon dioxide injection into each well individually instead of simultaneously during the WAG phase of the project.

On October 16, 1976, water injection started into eight of the thirteen back-up water injection wells. Injection into the remaining five back-up wells was initiated by November 11, 1976. As of July 1, 1977, 351,219 barrels of water had been injected into these thirteen wells.

The start of injection into the six pattern injection wells was delayed until April 22, 1977 which corresponds to the completion of the northern water supply system. As of July 1, 1977, cumulative injection into these six wells was 48,600 barrels of water.

Contract negotiations and the finding of an adequate source of water for injection caused a delay of four months in the initial project schedule. The start of carbon dioxide injection could possibly be delayed until the first quarter of 1978 to insure an uninterrupted carbon dioxide supply.

CONCLUSION

The decision to install the Rock Creek Carbon Dioxide pilot project was made using known reservoir characteristics and successful laboratory miscibility tests as a basis. The quantitative data gathered during the installation of the project together with the injection history acquired to date, support the original criteria deemed necessary for a successful project.

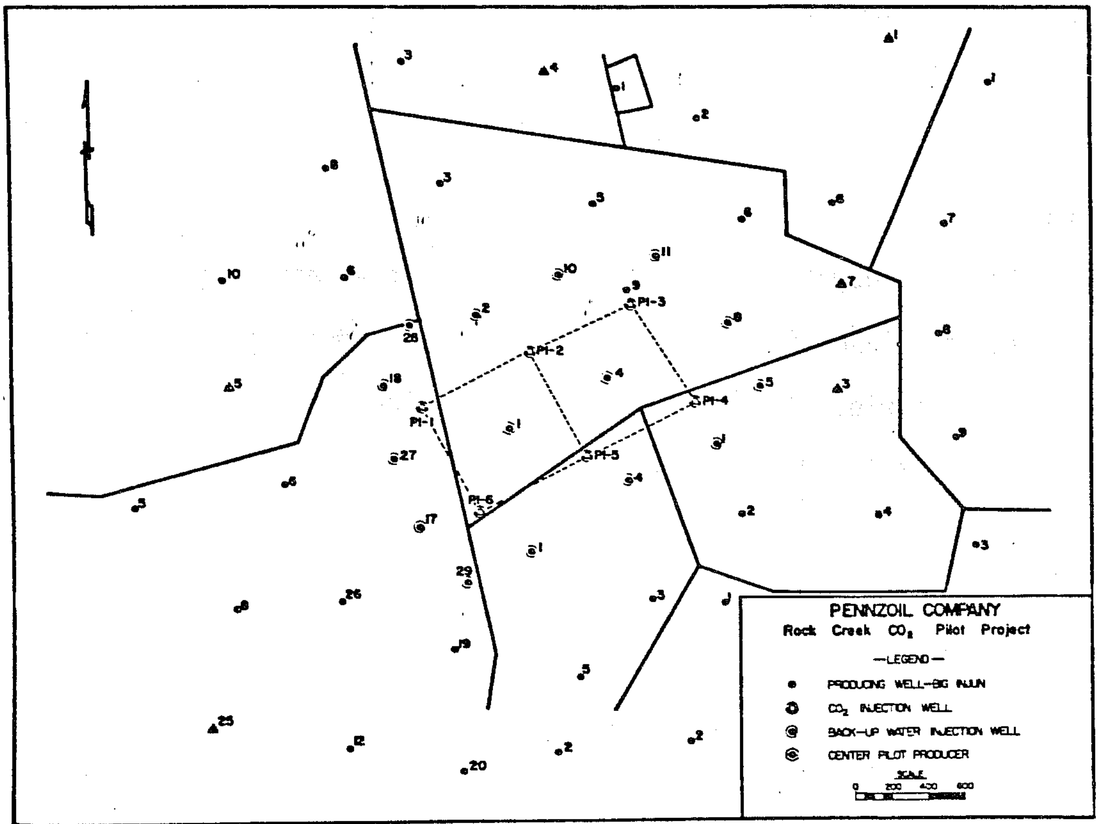


Figure 1

INTRODUCTION

This report is the first in a series of monthly reports on the progress of the Rock Creek carbon dioxide pilot project in Roane County, West Virginia. Since this is the first report, a summation of all activity and quantitative information that has been completed or received as of August 1, 1976 is presented.

WELL WORK

Producing Wells

Both center producing wells for the pilot project have been completely reconditioned. Copies of the Gamma Ray and Caliper logs of the Big Injun section are presented in Appendix A. The following is a chronological record of the reconditioning of both wells.

L. W. Shaffer No. 1 T.D. = 2070 ft. G.L.

April 22, 1976	-	Clean-out operations commenced.
May 4, 1976	-	Ran Gamma Ray and Caliper logs.
June 8, 1976	-	Ran 4-1/2", 10.5 lb., CW-55 casing with a Parmaco tension packer set at 2013 ft. G.L.
June 9, 1976	-	Ran 2-3/8", 4.6 lb. tubing, 5/8" rods, and 1-1/2" pump.
July 20, 1976	-	Set pumping jack, electrified, and put on pump.

L. W. Shaffer No. 4 T.D. = 1994 ft. G.L.

April 1, 1976	- Clean-out operations commenced.
April 27, 1976	- Pulled 5-1/2" casing.
May 4, 1976	- Ran Gamma Ray and Caliper logs.
May 6, 1976	- Ran 4-1/2", 10.5 lb., CW-55 casing with a Parmaco tension packer set at 1926 ft. G.L.
May 13, 1976	- Ran 2-3/8", 4.6 lb. tubing, 5/8" rods, and 1-1/2" pump.
July 20, 1976	- Set pumping jack, electrified, and put on pump.

The new tanks and separators for both wells had not been delivered as of August 1, 1976. Production equipment for each well will be separate for accurate records of all oil, water, and gas produced. Until these facilities are completed, the old producing facilities will be used.

Since being reconditioned, these wells have produced as listed below:

	BO	BW	Hours Pumped
L. W. Shaffer No. 1	19.0	7.6	7.75
L. W. Shaffer No. 4	0	5.9	3.75

Carbon Dioxide Injection Wells

The six carbon dioxide injection wells making up the dual five-spot pattern were drilled, logged, and cored by June 4, 1976. The cores were described in the field noting lithology and despositional characteristics, and then packaged in plastic bags and sealed. They were then delivered within 24 hours to a representative of Oilfield Research Laboratories who performed all of the core analyses. Whole core analyses were performed on five of the six cores. Core analysis on the R. C. Elmore P.I. No. 5 was done by conventional analysis (i.e. plugs) due to the highly irregular surface of the core.

Twenty-four samples, taken approximately every other foot, from the L. W. Shaffer P.I. No. 2 were sent for sand grain densities. The plugs used in the core analysis of the R. C. Elmore P.I. No. 5, taken approximately every foot, were also sent to Oilfield Research for sand grain density determinations. Four additional sand grain densities were determined for selected samples from the J. H. Looney P.I. No. 4. A detailed discussion of the data obtained from the core analyses are presented under Reservoir Characteristics. Gamma Ray, Caliper, and Compensated Density logs were run on all six wells with the addition of a Dual Induction-Laterolog being run on L. W. Shaffer P.I. No. 6. Copies of each log over the Big Injun section are included in Appendix B.

The following is a chronological record of the completion to date of these six wells.

E. Lewis P.I. No. 1 T.D. = 2135 ft. R.K.B.

May 8, 1976	- Started drilling.
May 9, 1976	- Ran 8-5/8", 20 lb., H-40 casing set at 270 ft. R.K.B. Cemented with 170 sacks of regular neat cement.
May 12, 1976	- Started to core. Recovered 54 ft. of core.
May 13, 1976	- Ran Gamma Ray, Caliper, and Compensated Density logs. Ran 4-1/2", 10.5 lb., CW-55 casing set at 2130 ft. R.K.B. Cemented with 50 sacks of 50/50 Posmix cement.

L. W. Shaffer P.I. No. 2 T.D. = 2186 ft. R.K.B.

May 3, 1976	- Started drilling.
May 4, 1976	- Ran 8-5/8", 20 lb., H-40 casing set at 313 ft. R.K.B. Cemented with 200 sacks of regular neat cement.
May 6, 1976	- Started to core. Recovered 52.5 ft. of core.
May 8, 1976	- Ran Gamma Ray, Caliper, and Compensated Density logs. Ran 4-1/2", 10.5 lb., CW-55 casing set at 2182 ft. R.K.B. Cemented with 50 sacks of 50/50 Posmix cement.

L. W. Shaffer P.I. No. 3 T.D. = 1970 ft. R.K.B.

May 24, 1976	- Started drilling.
May 25, 1976	- Ran 8-5/8", 20 lb., H-40 casing set at 95 ft. R.K.B. Cemented with 60 sacks of regular neat. cement.
May 28, 1976	- Started to core. Recovered 50 ft. of core.
May 29, 1976	- Ran Gamma Ray, Caliper, and Compensated Density logs. Ran 4-1/2", 10.5 lb., CW-55 casing set at 1970 ft. R.K.B. Cemented with 50 sacks of 50/50 Posmix cement.

J. H. Looney P.I. No. 4 T.D. = 2024 ft. R.K.B.

May 29, 1976	- Started drilling.
May 30, 1976	- Ran 8-5/8", 20 lb., H-40 casing set at 136 ft. R.K.B. Cemented with 70 sacks of regular neat cement.
June 2, 1976	- Started to core. Recovered 55 ft. of core.
June 4, 1976	- Ran Gamma Ray, Caliper, and Compensated Density logs. Ran 4-1/2", 10.5 lb., CW-55 casing set at 2022 ft. R.K.B. Cemented with 50 sacks of 50/50 Posmix cement.

R. C. Elmore P.I. No. 5 T.D. = 2006 ft. R.K.B.

May 19, 1976	- Started drilling. Ran 8-5/8", 20 lb., H-40 casing set at 96 ft. R.K.B. Cemented with 60 sacks of regular neat cement.
May 22, 1976	- Started to core. Recovered 52 ft. of core.
May 24, 1976	- Ran Gamma Ray, Caliper, and Compensated Density logs. Ran 4-1/2", 10.5 lb., CW-55 casing set at 2004 ft. R.K.B. Cemented with 50 sacks of 50/50 Posmix cement.

L. W. Shaffer P.I. No. 6 T.D. = 2044 ft. R.K.B.

May 14, 1976	- Started drilling. Ran 8-5/8", 20 lb., H-40 casing set at 182 ft. R.K.B. Cemented with 95 sacks of regular neat cement.
May 17, 1976	- Started to core. Recovered 51 ft. of core.
May 19, 1976	- Ran Gamma Ray, Caliper, Compensated Density, and Dual Induction logs. Ran 4-1/2", 10.5 lb., CW-55 casing set at 2060 ft. R.K.B. Cemented with 50 sacks of 50/50 Posmix cement.

Back-up Water Injection Wells

Containment of the injected carbon dioxide in this pilot will be attempted by peripheral pressure maintenance by water injection. Eleven such pressure maintenance wells have been designated. Of these eleven wells four wells are new drilled wells. On June 19, 1976 the last of these four wells had been drilled. The remaining seven back-up water injection wells are old producing wells to be reconditioned and coverted to injection wells. As of

August 1, 1976, four of these seven conversions were complete.

Gamma Ray, Caliper, and Compensated Density logs were run on the four new wells with the addition of an Induction log being run on L. W. Shaffer No. 10. Gamma Ray and Caliper logs were run on the old well conversions. Copies of these logs over the Big Injun section are presented in Appendix C.

The following is a chronological record of the completion of the four new back-up injection wells.

E. Lewis No. 27 — T.D. = 2058 ft. R.K.B.

- June 14, 1976 - Started drilling. Ran 8-5/8", 20 lb., H-40 casing set at 178 ft. R.K.B. Cemented with 90 sacks of regular neat cement.
- June 19, 1976 - Ran Gamma Ray, Caliper, and Compensated Density logs. Ran 4-1/2", 10.5 lb., CW-55 casing set at 2055 ft. R.K.B. Cemented with 50 sacks of 50/50 Posmix cement.

E. Lewis No. 28 — T.D. = 2248 ft. R.K.B.

- April 30, 1976 - Started drilling. Ran 8-5/8", 20 lb., H-40 casing set at 444 ft. R.K.B. Cemented with 285 sacks of regular neat cement.
- May 3, 1976 - Ran Gamma Ray, Caliper, and Compensated Density logs. Ran 4-1/2", 10.5 lb., CW-55 casing set at 2250 ft. R.K.B. Cemented with 50 sacks of 50/50 Posmix cement.

L. W. Shaffer No. 10 T.D. = 2044 ft. R.K.B.

June 9, 1976 - Started drilling. Ran 8-5/8", 20 lb., H-40 casing set at 177 ft. R.K.B. Cemented with 90 sacks of regular neat cement.

June 13, 1976 - Ran Gamma Ray, Caliper, Compensated Density, and Induction logs. Ran 4-1/2", 10.5 lb., CW-55 casing set at 2043 ft. R.K.B. Cemented with 50 sacks of 50/50 Posmix cement.

L. W. Shaffer No. 11 T.D. = 2021 ft. R.K.B.

June 4, 1976 - Started drilling. Ran 8-5/8", 20 lb., H-40 casing set at 134 ft. R.K.B. Cemented with 70 sacks of regular neat cement.

June 9, 1976 - Ran Gamma Ray, Caliper, and Compensated Density logs. Ran 4-1/2", 10.5 lb., CW-55 casing set at 2020 ft. R.K.B. Cemented with 50 sacks of 50/50 Posmix cement.

The following is a chronological record of the reconditioning and conversion of the old producing wells as of August 1, 1976.

R. C. Elmore No. 1 T.D. = 1989 ft. G.L.

June 2, 1976 - Clean-out operations commenced.

June 4, 1976 - Ran Gamma Ray and Caliper logs.

June 9, 1976 - Ran 2-3/8", 4.6 lb., H-40 tubing with a Lynes packer set at 1942 ft. G.L. A 2-7/8", 6.4 lb., J-55, 31 ft. anchor was run below the packer.

R. C. Elmore No. 4 T.D. = 1978 ft. G.L.

June 16, 1976 - Clean-out operations commenced.

June 29, 1976 - Ran Gamma Ray and Caliper logs.

July 27, 1976 - Ran 2-3/8", 4.6 lb., H-40 tubing with a Lynes packer set at 1910 ft. G.L. A 2-3/8", 6.4 lb., J-55, 36 ft. anchor was run below the packer.

E. Lewis No. 18 T.D. = 2081 ft. G.L.

June 25, 1976 - Clean-out operations commenced.
July 7, 1976 - Ran Gamma Ray and Caliper logs.
July 22, 1976 - Ran 2-3/8", 4.6 lb., H-40 tubing with a Lynes packer set at 2033 ft. G.L. A 2-7/8", 6.4 lb., J-55, 45 ft. anchor was run below the packer.

L. W. Shaffer No. 2 T.D. = 2098 ft. G.L.

June 11, 1976 - Clean-out operations commenced.
June 15, 1976 - Ran Gamma Ray and Caliper logs.
June 23, 1976 - Ran 2-3/8", 4.6 lb., H-40 tubing with a Lynes packer set at 2039 ft. G.L. A 2-7/8", 6.4 lb., J-55, 45 ft. anchor was run below the packer.

L. W. Shaffer No. 8 T.D. = 2063 ft. G.L.

July 28, 1976 - Clean-out operations commenced.

WATER SYSTEM

Water Supply Wells

To date, two new water supply wells have been drilled and tested and one other existing water supply well has been reconditioned and tested. I. A. Donohoe WSW No. 1 was drilled through the Pittsburgh and Connellsville sands but completed in only the Pittsburgh Sand. Testing of this well indicated a water source of approximately 200 barrels per day. D. T. Cummings WSW No. 5, near Green Creek, was drilled through and completed in the Connellsville Sand. This well is an offset well to D. T. Cummings WSW No. 1 by approximately 1,100 feet. In testing of D. T. Cummings WSW No. 5 it is apparent that direct communication with D. T. Cummings WSW No. 1 exists. Fluid level drawn-down in one well is paralleled in the other well. Together, approximately 1,200 to 1,500 barrels per day can be expected from these two wells. Since the total daily capacity of water from the three wells will near 1,600 barrels, additional water supply wells will be drilled in an attempt to increase availability to over 2,500 barrels per day.

Water Handling

Two triplex pumps with the capability of handling 2,000 BPD each have been delivered and mounted. Delivery of the water filter and the water storage tanks is scheduled for August.

The right-of-way for the water transfer line from Green Creek has been acquired with construction scheduled for August. After completion of this transfer line, the injection line system will be installed.

CARBON DIOXIDE SYSTEM

Carbon Dioxide Storage

Four carbon dioxide storage tanks have been purchased with a capacity of 10,000 gallons each. These tanks will be tested to 500 psig with water before shipment.

Carbon Dioxide Handling

Plastic coated tubing for use in the six carbon dioxide injection wells has been ordered. This tubing will also be used as line pipe for carbon dioxide and water injection.

RESERVOIR CHARACTERISTICS

Lithology

The "Big Injun" Sand in the Rock Creek Field is a very light gray to very light greenish-gray, very fine- to medium-grained, well sorted (as to grain size), sub-round to round sandstone. The "Big Injun" interval indicates a coarsening upward sequence concurrent with a decrease in matrix material and an increase in cementing material. An occasional pebble lense (0.5 cm), one to two pebbles thick, occurs in the upper one-third of the interval. Lithological plots can be found in Appendix D. The "Big Injun" is slightly to moderately calcareous for the most part as indicated by staining with Alizarin Red S in 7% Hydrochloric Acid.

In addition, the carbonate minerals ankerite and siderite are also present. The latter, with a S.G.=3.83-3.88, occurs primarily as small concretionary lenses. Ankerite, with a S.G.=2.95-3.00, occurs in varying percentages as disseminated cement throughout most of the "Big Injun" interval. Ankerite is probably responsible for those sand grain densities greater than, or equal to, 2.70. Where sand grain densities are equal to, or greater than, 2.75, siderite probably accounts for the very high values. The average grain density for the L. W. Shaffer P.I. No. 2 is 2.69 (based on the uppermost 20 samples) and 2.70 for the R. C. Elmore P.I. No. 5. The complete sand grain density analyses are contained in Appendix E

The concentrated occurrence of these two iron carbonate minerals is readily detectable on the permeability and porosity plots derived from core analyses (Appendix D). Where these minerals are present in concentrated amounts the permeability is very low, and likewise, so is the porosity. By analogy, where the bulk density is high and the porosity is low on the compensated density log one can probably assume that the permeability is also low in that interval. Ankerite is most noticeable after the core has been baked and analyzed. Small brown spots appear on the surface of the core giving it the appearance of having the "measles".

When comparing the porosity curves derived from core data with those derived from the compensated density log, the shape of the curves is very similar, however, there does exist a difference of less than one-half percent to two percent in the porosity values. The core data are higher than the log derived data, averaging approximately 1.5% higher even when a grain density of 2.70 is used in logging. This average was arrived at visually by laying the plot of the core derived porosity over that of the log. The difference can best be explained by, and attributed to, the different techniques by which the porosity was determined. Empirical knowledge must be exercised in deciding which technique is best.

Matrix material consists of the following clay minerals in order of decreasing abundance: Chlorite, mixed layer clay and illite. Chlorite, which is an iron rich variety, exists as a film coating on the sand grains with microporosity between the clay platelets (X-Ray Diff. & Petrographic Anal., App. F) . It is interesting to note the occurrence of two iron carbonates and an iron rich variety of chloritic clay in the "Big Injun" interval. Only a detailed petrographic study can establish the exact origin for these minerals.

The sedimentary mineral glauconite is reported (Robert Pryce, personal communication) in the upper part of the "Big Injun" interval. Only in the upper few inches of the core from the J. H. Looney P.I. No. 4 was glauconite readily visible as discrete grains. The presence of a green color or tint does not signify the occurrence of glauconite, especially when petrographic and SEM analyses indicate the presence of chlorite which also imparts a green color to the rock. The occurrence of glauconite, probably in an abraded form, is best detected on the Gamma Ray by the appearance of a "hot streak" in an otherwise quartz sandstone interval. The presence of glauconite does indicate a marine environment of deposition for the "Big Injun" Sand.

Depositional environment indicators, in addition to the textural and mineralogical data, are for the most part non-existent. Cross-bedding, when present is very low angle and is of the hummocky type indicative of the lower shore-face environment. For the most part crossbedding is not very well defined, and is in sharp contrast to the well defined crossbedding found in the overlying "Big Lime" (Greenbrier). Micro-crosslamination formed by current ripples is the second type of environmental characteristic present and is limited to the upper one-third of the "Big Injun" interval. Micro-crosslamination is most noticeable in the J. H. Looney P.I. No. 4 and the conglomeratic lenses in the R. C. Elmore P.I. No. 5.

Permeability and Porosity

In the six wells that were cored the "Big Injun" Sandstone averaged 47 feet per core and ranged from 44 feet to 50 feet in thickness. A lower limit equal to, or greater than, 5 md was selected as the lower limit in determining net pay (h), permeability capacity (kh) and total porosity feet (Øh). Results of the core analyses are summarized in Table I. The complete core analysis for each well can be found in Appendix G.

TABLE I

Summation of Core Data

Well No.	h	kh (max. k)	Avg. k	kh (k @ 90°)	Øh %	Avg. Ø
P.I. 1	30.9	667.9	21.8	610.0	661.0	21.5
P.I. 2	31.2	595.2	19.1	575.4	701.7	22.5
P.I. 3	32.8	458.0	14.0	429.4	700.7	21.4
P.I. 4	37.3	560.3	15.0	508.4	806.8	21.6
P.I. 5	29.4	928.3	31.6	N.A.	655.0	22.3
P.I. 6	32.9	774.3	23.5	735.6	738.2	22.4
Avg. per Well	32.4	664.0	20.5	571.8*	710.4	21.9

*5 well avg.

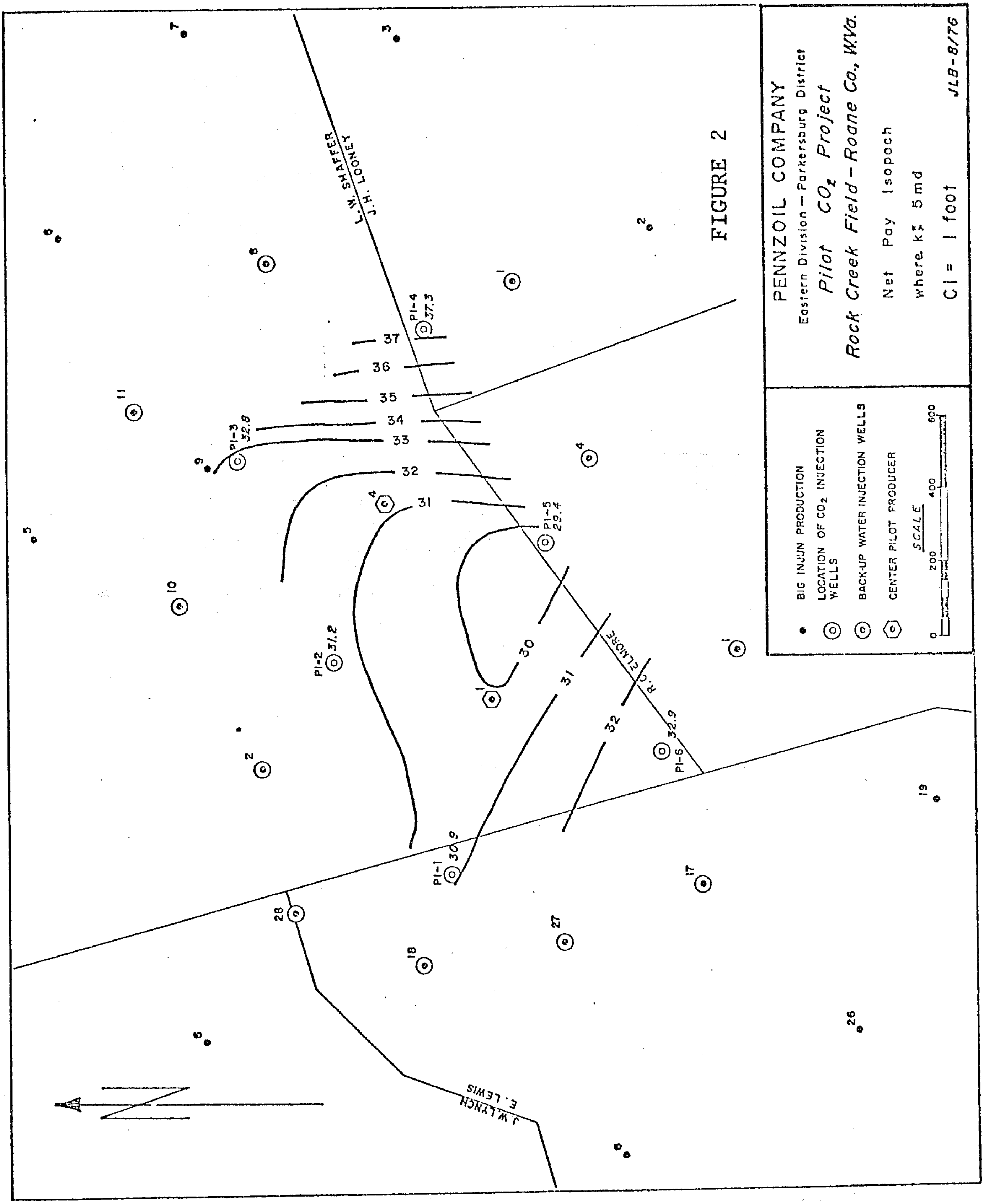


FIGURE 2
PENNZOIL COMPANY
Eastern Division – Parkersburg District
Pilot CO_2 Project
Rock Creek Field – Roane Co., W.Va.
Net Pay Isopach
where k ≥ 5 md
CI = 1 foot
JLB-8/76
BIG INJUN PRODUCTION
LOCATION OF CO_2 INJECTION WELLS
BACK-UP WATER INJECTION WELLS
CENTER PILOT PRODUCER
SCALE
0
200
400
600
L. W. SHAFFER
J. H. LOONEY
R. C. ELMORE
J. W. LYNCH
E. LEWIS
PI-1 30.9
PI-2 31.2
PI-3 32.8
PI-4 37.3
PI-5 29.4
PI-6 32.9
37
36
35
34
33
32
31
30
31
32

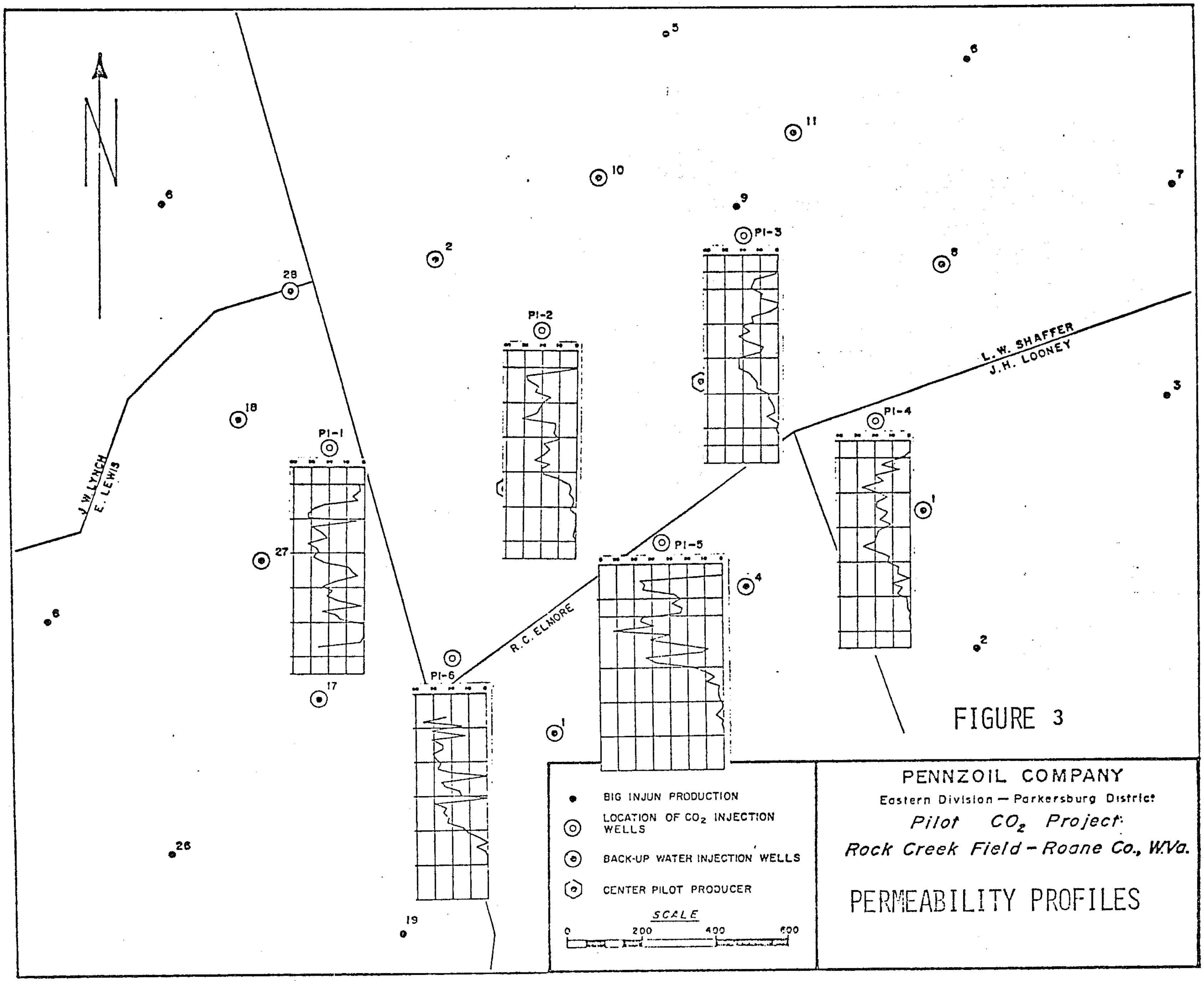

PENNZOIL COMPANY
Eastern Division — Parkersburg District
Pilot CO_2 Project:
Rock Creek Field - Roane Co., W.Va.
PERMEABILITY PROFILES
BIG INJUN PRODUCTION
LOCATION OF CO_2 INJECTION WELLS
BACK-UP WATER INJECTION WELLS
CENTER PILOT PRODUCER
SCALE
0
200
400
600
L. W. SHAFFER
J.H. LOONEY
R.C. ELMORE
J.W. LYNCH
E. LEWIS
PI-1
PI-2
PI-3
PI-4
PI-5
PI-6

FIGURE 3

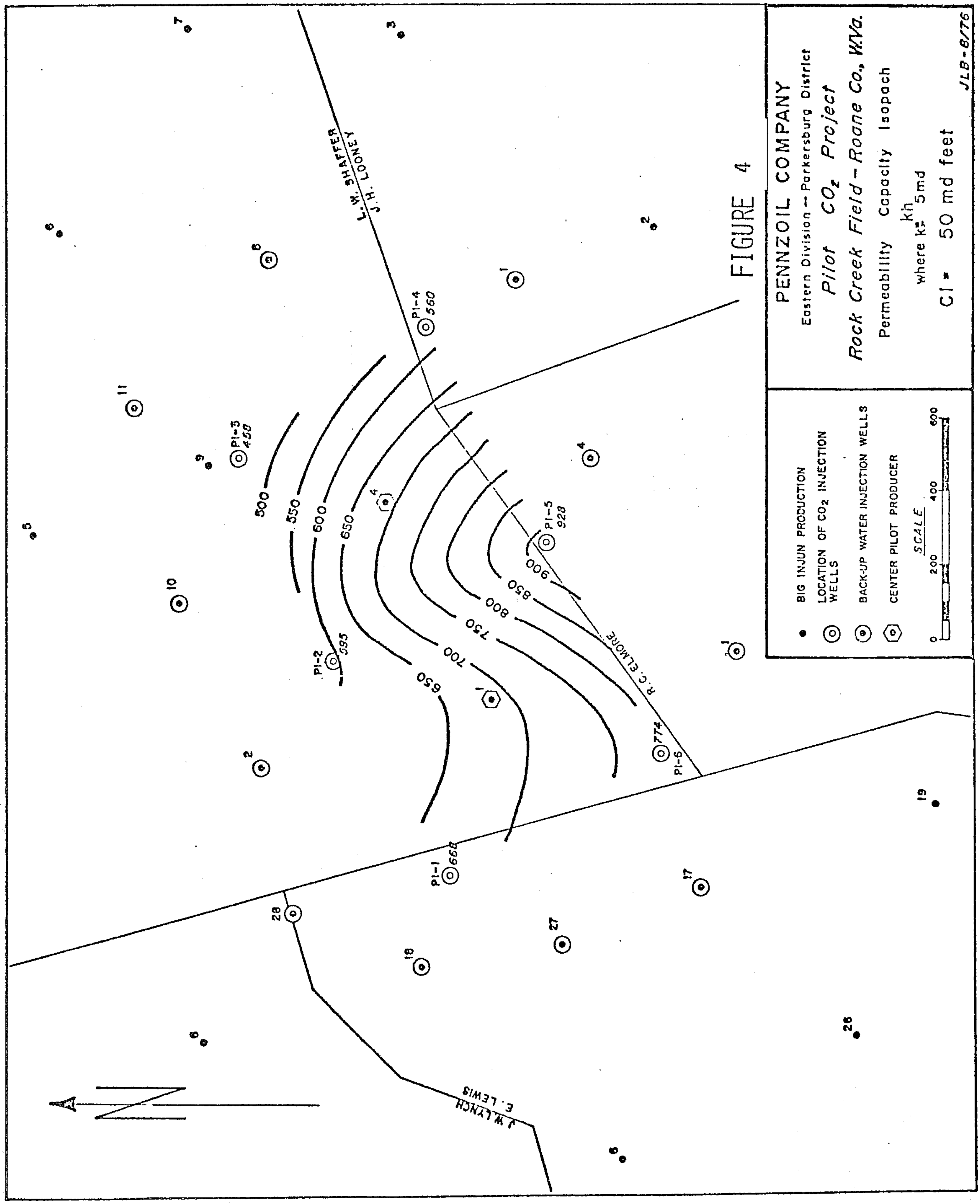


FIGURE 4
PENNZOIL COMPANY
Eastern Division — Parkersburg District
Pilot CO_2 Project
Rock Creek Field – Roane Co., W.Va.
Permeability Capacity Isopach
where $k = \frac{kh}{5\ md}$
CI = 50 md feet
JLB-8/76
BIG INJUN PRODUCTION
LOCATION OF CO_2 INJECTION WELLS
BACK-UP WATER INJECTION WELLS
CENTER PILOT PRODUCER
SCALE
0
200
400
600
L. W. SHAFFER
J. H. LOONEY
R. C. ELMORE
J. W. LYNCH
E. LEWIS
PI-1 668
PI-2 595
PI-3 458
PI-4 560
PI-5 928
PI-6 774
500
550
600
650
700
750
800
850
900

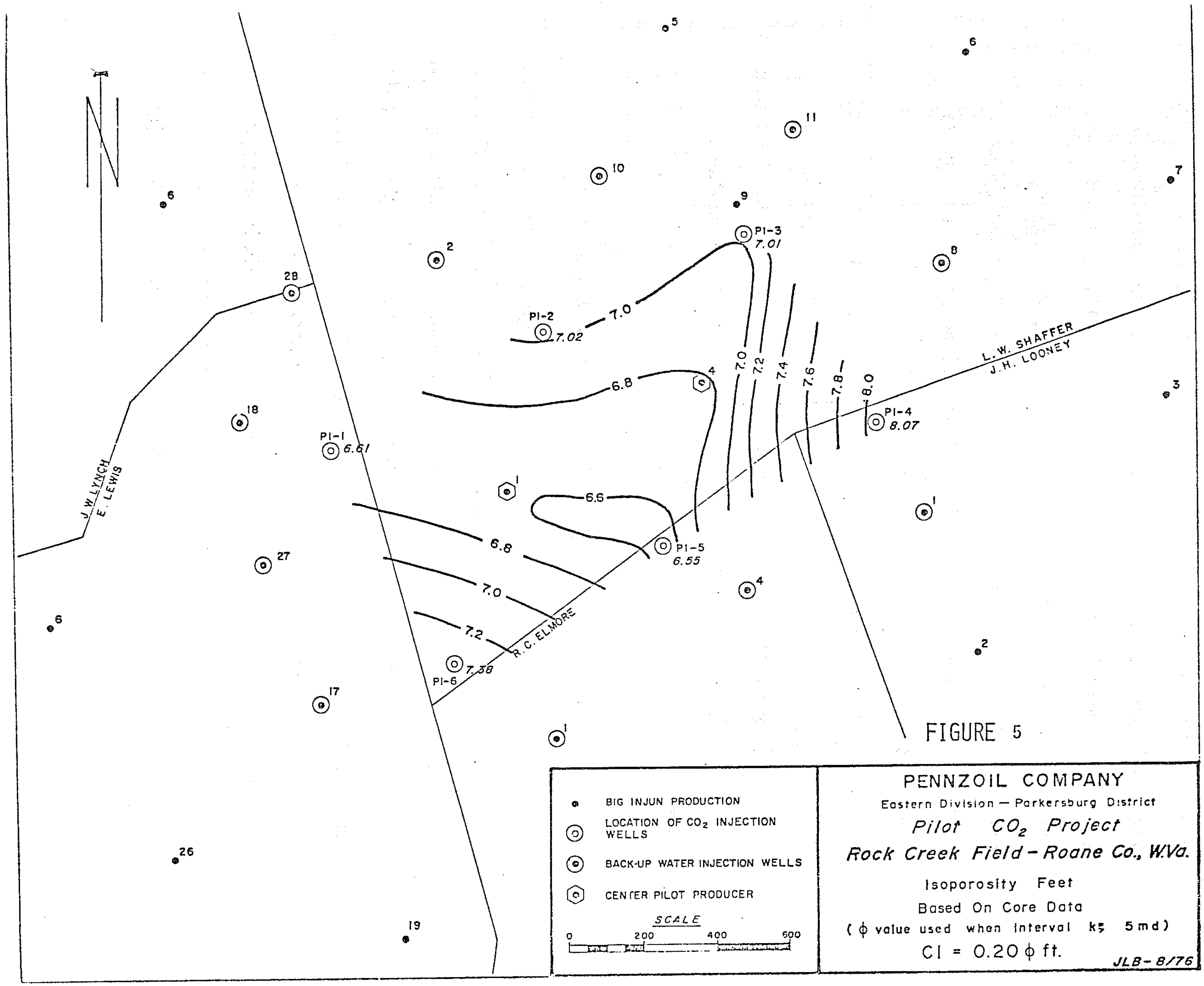

PENNZOIL COMPANY
Eastern Division — Parkersburg District
Pilot CO_2 Project
Rock Creek Field – Roane Co., W.Va.
Isoporosity Feet
Based On Core Data
(ϕ value used when interval k ≥ 5 md)
CI = 0.20 ϕ ft.
JLB-8/76
BIG INJUN PRODUCTION
LOCATION OF CO_2 INJECTION WELLS
BACK-UP WATER INJECTION WELLS
CENTER PILOT PRODUCER
SCALE
0
200
400
600
L.W. SHAFFER
J.H. LOONEY
R.C. ELMORE
J.W. LYNCH
E. LEWIS
PI-1 6.61
PI-2 7.02
PI-3 7.01
PI-4 8.07
PI-5 6.55
PI-6 7.38
6.6
6.8
7.0
7.2
7.4
7.6
7.8
8.0

FIGURE 5

For the "Big Injun" Sandstone the percentage of the interval that was equal to, or greater than, 5 md averaged 68.8% and ranged from 64.6% to 74.8%. From the data there does not appear to be any direct correlation between the thickness of the "Big Injun" interval and the total thickness of h. The L. W. Shaffer P.I. No. 6, which has the least amount of "Big Injun" present, has the greatest percentage (74.8%) of the interval equal to, or greater than, 5 md.

The net pay isopach, Figure 2, indicates an increase in h of 8 feet from the R. C. Elmore P.I. No. 5 to the J. H. Looney P.I. No. 4. This increase can be attributed to an increase in the number of feet in the lower part of the "Big Injun" interval in the J. H. Looney P.I. No. 4 which has an h equal to, or greater than, 5 md (Figure 3).

In the permeability and porosity profiles (Appendix D) the sharp decrease in permeability can be attributed to the concentrated presence of ankerite and/or siderite which has already been discussed in the section on lithology. There does appear to be a stratigraphic correlation of these ankeritic intervals, especially in the E. Lewis P.I. No. 1, L. W. Shaffer P.I. No. 6 and R. C. Elmore P.I. No. 5 (Figure 3). What effect these ankeritic intervals will have on injection rates and fronts is not known, however, their presence must be kept in mind when selecting perforation intervals.

The loss in permeability in the lower part of the "Big Injun" interval is attributed to an increase in the amount of matrix material present and a concurrent decrease in grain size, or a decrease in the degree of sorting.

When comparing the permeability capacity isopach map (Figure 4) with the net pay map (Figure 2) there does not appear to be any correlation other than that the well with the lowest amount of net pay has the highest permeability capacity. On the other hand, comparison of the net pay (Figure 2) with the isoporosity feet map (Figure 5) shows a definite correlation. Where the net pay is less so is the total amount of porosity feet.

In four of the six wells there occurs in the lower part of the "Big Injun" interval a thin shale to very argillaceous siltstone 3 feet to 10 feet above the base. The "Big Injun" sand below this interval exhibits permeabilities of less than 10 md except in the E. Lewis P.I. No. 1 in which case approximately 4 feet of this same interval has permeabilities greater than 10 md.

The average core porosity per well is 21.9% and ranges from 21.3% to 22.4%. A linear relationship exists when porosity and permeability are crossplotted. For the most part, as the permeability increases so does the porosity.

Studies on recent sediments interpretated as lower shoreface also exhibit the same relationship, i.e. as the permeability increases so does the porosity. In addition, in these same sediments permeability values increase upward which is reflected in the permeability profiles for the Rock Creek cores (Figure 3). This upward increase in permeability can be attributed to better sorting in the "Big Injun" interval.

In the synthesis of the core data one thing did emerge that is considered important and that is the reliability of conventional analyses (i.e. plugs) versus whole core analyses. The R. C. Elmore P.I. No. 5 with an h of 29.4 feet, the least of all the cores, has the highest permeability capacity (kh = 928.3) and the lowest porosity feet (Øh = 6.55). Also of concern is the number of permeability readings in all of the cores, except the R. C. Elmore P.I. No. 5, where the vertical permeability is greater than the maximum horizontal permeability. An average of 39.1%, range 4.5% to 68.0%, of the vertical permeability readings were greater than the maximum horizontal permeability values. The 4.5% value, which was only one sample, was from the R. C. Elmore P.I. No. 5, and then this was where whole core analyses procedures were used in determining the vertical permeability. It was learned that in the core analysis procedure, a shape correction factor is applied to Darcy's Equation when calculating horizontal whole core permeability. This shape factor was established by API. When calculating permeabilities for vertical whole core and conventional analyses, the shape factor is not used in Darcy's Equation. The maximum horizontal permeability for the five wells, as determined by whole core analyses, suggest that the permeabilities reported actually only represent a percent of the maximum permeability present when compared with the vertical permeabilities.

INTRODUCTION

This report is the seventh report on the progress of the Rock Creek carbon dioxide project in Roane County, West Virginia.

Designed, developed and operated by Pennzoil Company, this project will demonstrate the feasibility of miscible carbon dioxide oil recovery in the Rock Creek Big Injun Field. A successful demonstration of this process will lead to a field wide commercial development. Also, the technical success of this project would be utilized in the development of other miscible carbon dioxide oil recovery projects in numerous fields within the Appalachian area.

SUMMARY

A two month delay in the start of the project due to contract negotiations and an additional two month delay before an adequate source of water was developed resulted in a four month delay before initial injection. This delay will, in turn, delay most other start-up dates throughout the life of the project.

Work completed to date includes the reconditioning of the two pattern producing wells and the start-up of construction of the new producing facilities. Inclement weather delayed the completion of

the producing facilities thus necessitating an extension to the original schedule. Besides the reconditioning of the two center producing wells, seven old wells have been converted to water injection wells. Also, twelve new wells have been drilled and completed as injection wells with seven of these wells being cored. Originally only four back-up water injection wells were scheduled to be drilled, but a model study revealed the necessity of two additional back-up water injection wells. The back-up water injection well schedule extension was caused by the drilling of these two wells. Three water supply wells have been drilled and completed.

In conjunction with the completion of the water and carbon dioxide handling system, nearly 25,000 feet of line has been laid. Possibly, an additional 18,000 feet of line will be installed in the near future in order to increase the water supply capacity if current water source tests prove acceptable. The storage and handling facilities for the liquid carbon dioxide have been purchased, but not installed. The first carbon dioxide injection is scheduled for the first quarter of 1978. This schedule for carbon dioxide injection is approximately eight months behind the original schedule. Besides the four month delay already mentioned, an additional five month delay is anticipated due to the same unavailability of liquid carbon dioxide next winter as occurred this winter. This additional

OIL RECOVERY BY CARBON DIOXIDE INJECTION
ROCK CREEK FIELD, ROANE COUNTY, WEST VIRGINIA

PROJECT SCHEDULE

As of January 1, 1977

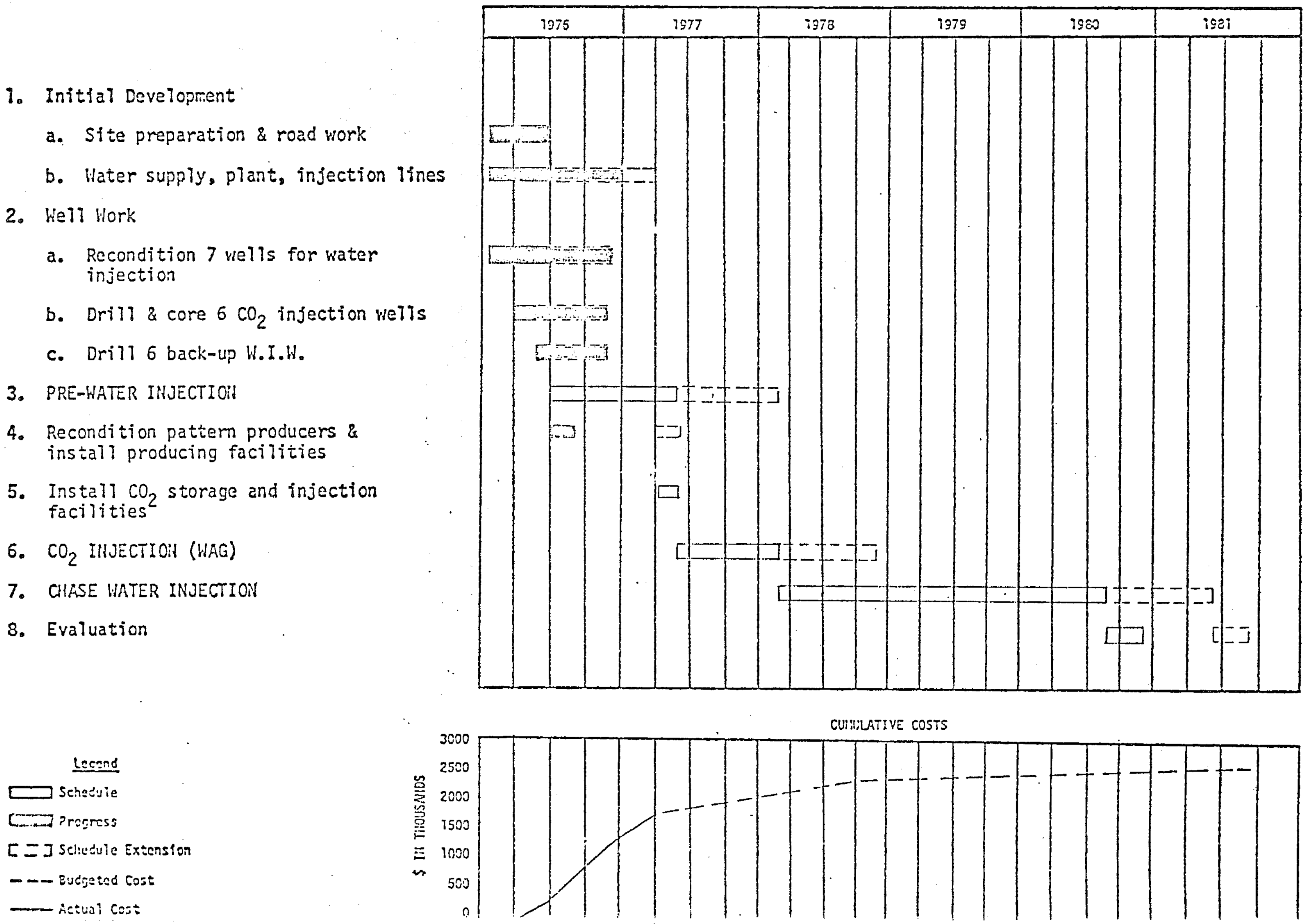


Figure 6

five month delay will, in turn, delay the chase water injection by five months.

Figure No. 6 graphically details the work schedule as it has progressed to date indicating the needed schedule extensions.

WELL WORK

Producing Wells - Work Accomplished

Both center producing wells have been completely reconditioned. The following is a chronological record of the reconditioning of both wells.

L. W. Shaffer No. 1 T.D. = 2070 ft. G.L.

April 22, 1976	- Clean-out operations commenced.
May 4, 1976	- Ran Gamma Ray and Caliper logs.
June 8, 1976	- Ran 4-1/2", 10.5 lb., CW-55 casing with a Parmaco tension packer set at 2013 ft. G.L.
June 9, 1976	- Ran 2-3/8", 4.6 lb. tubing, 5/8" rods, and 1-1/2" pump.
July 20, 1976	- Set pumping jack, electrified, and put on pump.

L. W. Shaffer No. 4 T.D. = 1994 ft. G.L.

April 1, 1976 - Clean-out operations commenced.
April 27, 1976 - Pulled 5-1/2" casing.
May 4, 1976 - Ran Gamma Ray and Caliper logs.
May 6, 1976 - Ran 4-1/2", 10.5 lb., CW-55 casing with a Parmaco tension packer set at 1926 ft. G.L.
May 13, 1976 - Ran 2-3/8", 4.6 lb. tubing, 5/8" rods, and 1-1/2" pump.
July 20, 1976 - Set pumping jack, electrified, and put on pump.

Producing Wells - Work Forecast

The equipment for the producing facilities has been delivered and construction has begun. Depending on weather conditions, these facilities will possibly be completed during the first quarter of 1977.

Carbon Dioxide Injection Wells - Work Accomplished

The six carbon dioxide injection wells have been drilled, cored, logged, perforated and acidized. The results of the core analyses are presented under Reservoir Properties. The following is a chronological record of these completions.

E. Lewis P.I. No. 1 — T.D. = 2135 ft. R.K.B.; P.B.D. = 2106 ft. R.K.B.

May 8, 1976	- Started drilling.
May 9, 1976	- Ran 8-5/8", 20 lb., H-40 casing set at 270 ft. R.K.B. Cemented with 170 sacks of regular neat cement.
May 12, 1976	- Started to core. Recovered 54 ft. of core.
May 13, 1976	- Ran Gamma Ray, Caliper, and Compensated Density logs. Ran 4-1/2", 10.5 lb., CW-55 casing set at 2130 ft. R.K.B. Cemented with 50 sacks of 50/50 Posmix cement.
November 15, 1976	- Ran correlation logs. Perforated 2059'-2060'; 2065'-2066'; 2073'-2074'; 2077'-2078'; 2085'-2086'; 2093'-2094'; 2097'-2098' with 21 holes or 3 holes per foot. Broke down formation and displaced 2,000 gal. of 15% HCl acid. B.D.P. = 2200 psig; Max T.P. = 4000 psig; Min. T.P. = 1700 psig; Avg. T.P. = 3400 psig; Avg. T.R. = 3 BPM; ISIP = 600 psig; 2 min. SIP on vacuum.

L. W. Shaffer P.I. No. 2 — T.D. = 2186 ft. R.K.B.; P.B.D. = 2155 ft. R.K.B.

May 3, 1976	- Started drilling.
May 4, 1976	- Ran 8-5/8", 20 lb., H-40 casing set at 313 ft. R.K.B. Cemented with 200 sacks of regular neat cement.
May 6, 1976	- Started to core. Recovered 52.5 ft. of core.
May 8, 1976	- Ran Gamma Ray, Caliper, and Compensated Density logs. Ran 4-1/2", 10.5 lb., CW-55 casing set at 2182 ft. R.K.B. Cemented with 50 sacks of 50/50 Posmix cement.

L. W. Shaffer P.I. No. 2 - Continued

November 16, 1976 - Ran correlation logs. Perforated 2098'-2099'; 2103'-2104'; 2111'-2112'; 2117'-2118'; 2123'-2124'; 2129'-2130'; 2137'-2138' with 21 holes or 3 holes per foot. Broke down formation and displaced 2,000 gal. of 15% HCl acid. B.D.P. = 1650 psig; Max. T.P. = 2200 psig; Min. T.P. = 1200 psig; Avg. T.P. = 1400 psig; Avg. T.R. = 5 BPM; ISIP = 350 psig; 1 min. SIP on vacuum.

L. W. Shaffer P.I. No. 3

T.D. = 1970 ft. R.K.B.
P.B.D. = 1948 ft. R.K.B.

May 24, 1976 - Started drilling.

May 25, 1976 - Ran 8-5/8", 20 lb., H-40 casing set at 95 ft. R.K.B. Cemented with 60 sacks of regular neat cement.

May 28, 1976 - Started to core. Recovered 50 ft. of core.

May 29, 1976 - Ran Gamma Ray, Caliper, and Compensated Density logs. Ran 4-1/2", 10.5 lb., CW-55 casing set at 1970 ft. R.K.B. Cemented with 50 sacks of 50/50 Posmix cement.

November 11, 1976 - Ran correlation logs. Perforated 1889'-1890'; 1897'-1898'; 1903'-1904'; 1909'-1910'; 1915'-1916'; 1921'-1922'; 1928'-1929' with 21 holes or 3 holes per foot. Broke down formation and displaced 2,000 gal. of 15% HCl acid. B.D.P. = 1550 psig; Max. T.P. = 2600 psig; Min. T.P. = 800 psig; Avg. T.P. = 1600 psig; Avg. T.R. = 12 BPM; ISIP = 600 psig; 3 min. SIP on vacuum.

J. H. Looney P.I. No. 4 | T.D. = 2024 ft. R.K.B.
P.B.D. = 1999 ft. R.K.B.

May 29, 1976	- Started drilling.
May 30, 1976	- Ran 8-5/8", 20 lb., H-40 casing set at 136 ft. R.K.B. Cemented with 70 sacks of regular neat cement.
June 2, 1976	- Started to core. Recovered 55 ft. of core.
June 4, 1976	- Ran Gamma Ray, Caliper, and Compensated Density logs. Ran 4-1/2", 10.5 lb., CW-55 casing set at 2022 ft. R.K.B. Cemented with 50 sacks of 50/50 Posmix cement.
November 9, 1976	- Ran correlation logs. Perforated 1937'-1938'; 1942'-1943'; 1951'-1952'; 1956'-1957'; 1961'-1962'; 1967'-1968'; 1976'-1977' with 21 holes or 3 holes per foot. Broke down formation and displaced 2,000 gal. of 15% HCl acid. B.D.P. = 1650 psig; Max, T.P. = 6400 psig; Min. T.P. = 300 psig; Avg. T.P. = 1200 psig; Avg. T.R. = 10 BPM; ISIP = 400 psig.

R. C. Elmore P.I. No. 5 | T.D. = 2006 ft. R.K.B.
P.B.D. = 1983 ft. R.K.B.

May 19, 1976	- Started drilling. Ran 8-5/8", 20 lb., H-40 casing set at 96 ft. R.K.B. Cemented with 60 sacks of regular neat cement.
May 22, 1976	- Started to core. Recovered 52 ft. of core.
May 24, 1976	- Ran Gamma Ray, Caliper, and Compensated Density logs. Ran 4-1/2", 10.5 lb., CW-55 casing set at 2004 ft. R.K.B. Cemented with 50 sacks of 50/50 Posmix cement.

R. C. Elmore P.I. No. 5 - Continued

November 11, 1976 - Ran correlation logs. Perforated 1918'-1919'; 1924'-1925'; 1930'-1931'; 1936'-1937'; 1942'-1943'; 1953'-1954'; 1957'-1958' with 21 holes or 3 holes per foot. Broke down formation and displaced 2,000 gal. of 15% HCl acid. B.D.P. = 1450 psig; Max. T.P. = 4800 psig; Min. T.P. = 200 psig; Avg. T.P. = 1000 psig; Avg. T.R. = 5 BPM; ISIP = 450 psig; 3 min. SIP on vacuum.

L. W. Shaffer P.I. No. 6

T.D. = 2044 ft. R.K.B.
P.B.D. = 2033 ft. R.K.B.

May 14, 1976 - Started drilling. Ran 8-5/8", 20 lb., H-40 casing set at 182 ft. R.K.B. Cemented with 95 sacks of regular neat cement.

May 17, 1976 - Started to core. Recovered 51 ft. of core.

May 19, 1976 - Ran Gamma Ray, Caliper, Compensated Density, and Dual Induction logs. Ran 4-1/2", 10.5 lb., CW-55 casing set at 2060 ft. R.K.B. Cemented with 50 sacks of 50/50 Posmix cement.

November 15, 1976 - Ran correlation logs. Perforated 1973'-1974'; 1977'-1978'; 1982'-1983'; 1988'-1989'; 1995'-1996'; 2001'-2002'; 2007'-2008' with 21 holes or 3 holes per foot. B.D.P. = 1150 psig; Max. T.P. = 5250 psig; Min. T.P. = 1450 psig; Avg. T.P. = 1500 psig; Avg. T.R. = 5 BPM; ISIP = 500 psig; 1 min. SIP on vacuum.

Carbon Dioxide Injection Wells - Work Forecast

Water injection into these six wells is scheduled to begin in the first quarter of 1977.

Back-up Water Injection Wells - Work Accomplished

Containment of the injected carbon dioxide in this project will be attempted by peripheral pressure maintenance by water injection. Thirteen such pressure maintenance wells have been designated. Of these thirteen wells, six wells are new drilled wells and seven wells are old producing wells that have been converted to water injection wells. Continuous injection of water started on October 16, 1976 for eight of the thirteen wells. The following chronologically lists the completion of these thirteen wells.

R. C. Elmore No. 1 — T.D. = 1989 ft. G.L.

June 2, 1976	- Clean-out operations commenced.
June 4, 1976	- Ran Gamma Ray and Caliper logs.
June 9, 1976	- Ran 2-3/8", 4.6 lb., H-40 tubing with a Lynes packer set at 1942 ft. G.L. A 2-7/8", 6.4 lb., J-55, 31 ft. anchor was run below the packer.

R. C. Elmore No. 4 — T.D. = 1978 ft. G.L.

June 16, 1976	- Clean-out operations commenced.
June 29, 1976	- Ran Gamma Ray and Caliper logs.
July 27, 1976	- Ran 2-3/8", 4.6 lb., H-40 tubing with a Lynes packer set at 1910 ft. G.L. A 2-3/8", 6.4 lb., J-55 36 ft. anchor was run below the packer.

E. Lewis No. 17 T.D. = 2008 ft. G.L.

August 24, 1976	- Clean-out operations commenced.
September 8, 1976	- Ran Gamma Ray and Caliper logs.
September 16, 1976	- Ran 2-3/8", 4.6 lb., H-40 tubing with a Lynes packer set at 1945 ft. G.L. A 2-7/8", 6.4 lb., J-55, 35 ft. anchor was run below the packer.

E. Lewis No. 18 T.D. = 2081 ft. G.L.

June 25, 1976	- Clean-out operations commenced.
July 7, 1976	- Ran Gamma Ray and Caliper logs.
July 22, 1976	- Ran 2-3/8", 4.6 lb., H-40 tubing with a Lynes packer set at 2033 ft. G.L. A 2-7/8", 6.4 lb., J-55, 45 ft. anchor was run below the packer.

E. Lewis No. 27 T.D. = 2058 ft. R.K.B.
P.B.D. = 2024 ft. R.K.B.

June 14, 1976	- Started drilling. Ran 8-5/8", 20 lb., H-40 casing set at 178 ft. R.K.B. Cemented with 90 sacks of regular neat cement.
June 19, 1976	- Ran Gamma Ray, Caliper, and Compensated Density logs. Ran 4-1/2", 10.5 lb., CW-55 casing set at 2055 ft. R.K.B. Cemented with 50 sacks of 50/50 Posmix cement.
October 29, 1976	- Ran correlation logs. Perforated 1975'-1976'; 1980'-1981'; 1985'-1986'; 1994'-1995'; 1999'-2000'; 2006'-2007'; 2011'-2012' with 21 holes or 3 holes per foot. Broke down formation and displaced 2,000 gallons of 15% HCl acid. B.D.P. = 2000 psig; Max. T.P. = 2650 psig; Min. T.P. = 800 psig; Avg. T.P. = 1200 psig; Avg. T.R. = 5 BPM; ISIP = 500 psig; 2 min. SIP on vacuum.

E. Lewis No. 28

T.D. = 2248 ft. R.K.B.
P.B.D. = 2225 ft. R.K.B.

April 30, 1976	- Started drilling. Ran 8-5/8", 20 lb., H-40 casing set at 444 ft. R.K.B. Cemented with 285 sacks of regular neat cement.
May 3, 1976	- Ran Gamma Ray, Caliper, and Compensated Density logs. Ran 4-1/2", 10.5 lb., CW-55 casing set at 2250 ft. R.K.B. Cemented with 50 sacks of 50/50 Posmix cement.
September 28, 1976	- Ran correlation logs. Perforated 2173'-2174'; 2176'-2177'; 2186'-2187'; 2191'-2192'; 2201'-2202'; 2205'-2206'; 2211'-2212' with 21 holes or 3 holes per foot.
September 29, 1976	- Broke down formation and displaced 1,400 gallons of 15% HCl acid. B.D.P. = 1000 psig; Max. T.P. = 4700 psig; Min. T.P. = 3200 psig; Avg. T.P. = 4000 psig; Avg. T.R. = 14 BPM; ISIP = 100 psig; on vacuum in 30 seconds.

E. Lewis No. 29

T.D. = 2019 ft. R.K.B.
P.B.D. = 1998 ft. R.K.B.

September 8, 1976	- Started drilling. Ran 8-5/8", 20 lb., H-40 casing set at 170 ft. R.K.B. Cemented with 100 sacks of regular neat cement.
September 13, 1976	- Started to core. Recovered 50 ft. of core.
September 14, 1976	- Ran Gamma Ray, Caliper, Dual Induction-Laterolog, and Compensated Density logs.
September 15, 1976	- Ran 4-1/2", 10.5 lb., ERW-55 casing set at 2018 ft. R.K.B. Cemented with 50 sacks of 50/50 Posmix cement.

E. Lewis No. 29 - Continued

November 9, 1976	-	Ran correlation logs. Perforated 1937'-1938'; 1945'-1946'; 1950'-1951'; 1955'-1956'; 1960'-1961'; 1965'-1966'; 1975'-1976' with 21 holes or 3 holes per foot. Broke down formation and displaced 2,000 gallons of 15% HCl acid. B.D.P. = 2200 psig; Max. T.P. = 2950 psig; Min. T.P. = 1100 psig; Avg. T.P. = 1250 psig; Avg. T.R. = 12 BPM; ISIP = 500 psig; 2 min. SIP on vacuum.

J. H. Looney No. 1 — T.D. = 1957 ft. G.L.

August 6, 1976	-	Clean-out operations commenced.
August 11, 1976	-	Ran Gamma Ray and Caliper logs.
August 20, 1976	-	Ran 2-3/8", 4.6 lb., H-40 tubing with a Lynes packer set at 1905 ft. G.L. A 2-7/8", 6.4 lb., J-55, 30 ft. anchor was run below the packer.

J. H. Looney No. 5 — T.D. = 2031 ft. R.K.B.
P.B.D. = 2006 ft. R.K.B.

September 17, 1976	-	Started drilling.
September 18, 1976	-	Ran 8-5/8", 20 lb., H-40 casing set at 169 ft. R.K.B. Cemented with 100 sacks of regular neat cement.
September 23, 1976	-	Ran Gamma Ray, Caliper, Dual Induction-Laterolog, and Compensated Density logs. Ran 4-1/2", 9.5 lb., J-55 casing set at 2033 ft. R.K.B. Cemented with 50 sacks of 50/50 Posmix cement.

J. H. Looney No. 5 - Continued

November 8, 1976	- Ran correlation logs. Perforated 1947'-1948'; 1953'-1954'; 1959'-1960'; 1965'-1966'; 1971'-1972'; 1980'-1981'; 1985'-1986' with 21 holes or 3 holes per foot. Broke down formation and displaced 1,300 gallons of 15% HCl acid. B.D.P. = 2100 psig; Max. T.P. = 4600 psig; Min. T.P. = 1000 psig; Avg. T.P. = 1600 psig; Avg. T.R. = 12 BPM; ISIP = 700 psig; 2 min. SIP on vacuum.

L. W. Shaffer No. 2 — T.D. = 2098 ft. G.L.

June 11, 1976	- Clean-out operations commenced.
June 15, 1976	- Ran Gamma Ray and Caliper logs.
June 23, 1976	- Ran 2-3/8", 4.6 lb., H-40 tubing with a Lynes packer set at 2039 ft. G.L. A 2-7/8", 6.4 lb., J-55, 45 ft. anchor was run below the packer.

L. W. Shaffer No. 8 — T.D. = 2063 ft. G.L.

July 28, 1976	- Clean-out operations commenced.
August 5, 1976	- Ran Gamma Ray and Caliper logs.
August 19, 1976	- Ran 2-3/8", 4.6 lb., H-40 tubing with a Lynes packer set at 2007 ft. G.L. A 2-7/8", 6.4 lb., J-55, 35 ft. anchor was run below the packer.

L. W. Shaffer No. 10 — T.D. = 2044 ft. R.K.B.
P.B.D. = 2021 ft. R.K.B.

June 9, 1976	- Started drilling. Ran 8-5/8", 20 lb., H-40 casing set at 177 ft. R.K.B. Cemented with 90 sacks of regular neat cement.

L. W. Shaffer No. 10 - Continued

June 13, 1976 - Ran Gamma Ray, Caliper, Compensated Density, and Induction logs. Ran 4-1/2", 10.5 lb., CW-55 casing set at 2043 ft. R.K.B. Cemented with 50 sacks of 50/50 Posmix cement.

November 2, 1976 - Ran correlation logs. Perforated 1956'-1957'; 1963'-1964'; 1969'-1970'; 1975'-1976'; 1983'-1984'; 1989'-1990'; 1996'-1997' with 21 holes or 3 holes per foot. Broke down formation and displaced 2,000 gallons of 15% HCl acid. B.D.P. = 1250 psig; Max. T.P. = 6300 psig; Min. T.P. = 750 psig; Avg. T.P. = 2000 psig; Avg. T.R. = 6 BPM; ISIP = 300 psig; 1 min SIP on vacuum.

L. W. Shaffer No. 11

T.D. = 2021 ft. R.K.B.
P.B.D. = 1992 ft. R.K.B.

June 4, 1976 - Started drilling. Ran 8-5/8", 20 lb., H-40 casing set at 134 ft. R.K.B. Cemented with 70 sacks of regular neat cement.

June 9, 1976 - Ran Gamma Ray, Caliper, and Compensated Density logs. Ran 4-1/2", 10.5 lb., CW-55 casing set at 2020 ft. R.K.B. Cemented with 50 sacks of 50/50 Posmix cement.

November 7, 1976 - Ran correlation logs. Perforated 1933'-1934'; 1943'-1944'; 1948'-1949'; 1953'-1954'; 1958'-1959'; 1963'-1964'; 1971'-1972' with 21 holes or 3 holes per foot. Broke down formation and displaced 300 gallons of 15% HCl acid. B.D.P. = 1100 psig; Max. T.P. = 5900 psig; Min. T.P. = 2100 psig; Avg. T.R. = 12 BPM. Split tubing during ball-off is responsible for low acid volume into formation.

The injection history of these thirteen wells for the past quarter is listed below.

TABLE II

Injection History
Back-up Water Injection Wells

	Date of First Injection	Injection, BW October	November	December	Avg. WHP* PSIG	Cum. Inj. 1/1/77
R. C. Elmore No. 1	10/16/76	1,785	2,461	4,479	0	8,725
R. C. Elmore No. 4	10/16/76	1,244	2,326	2,263	800	5,833
E. Lewis No. 17	10/16/76	1,909	3,288	3,318	800	8,515
E. Lewis No. 18	10/16/76	1,754	3,196	2,951	800	7,901
E. Lewis No. 27	11/2/76		2,878	3,016	800	5,894
E. Lewis No. 28	10/16/76	1,990	1,926	1,342	765	5,258
E. Lewis No. 29	11/11/76		967	1,198	815	2,165
J. H. Looney No. 1	10/16/76	1,928	3,646	4,723	480	10,297
J. H. Looney No. 5	11/11/76		1,768	1,326	800	3,094
L. W. Shaffer No. 2	10/16/76	1,923	2,615	5,139	0	9,677
L. W. Shaffer No. 8	10/16/76	2,046	3,417	3,156	495	8,619
L. W. Shaffer No. 10	11/4/76		687	287	805	974
L. W. Shaffer No. 11	11/6/76		452	327	845	779
Total or Average		14,579	29,627	33,525	630	77,731

*Average wellhead pressure for December

Back-up Water Injection Wells - Work Forecast

The next quarter will continue to see water injection maintained into all back-up injection wells. Action will be taken to help improve injectivity into those wells that have below average injection rates.

WATER SYSTEM

Water Supply Wells - Work Accomplished

To date, the project has been supplied by water being produced from D. T. Cummings WSW Nos. 1 and 5 which are drilled through the Connellsville Sand. Productivity from these two wells nears 1,500 barrels per day. The I. A. Donohoe WSW No. 1, productive from only the Pittsburgh Sand at a rate of 200 barrels per day, was drilled and completed but not used as an injection water source due to its low productivity. The T. Henderson WSW No. 1 was drilled through and completed in the Pittsburgh Sand during December. Its productivity is currently being tested as an additional or an alternate water source.

Water Supply Wells - Work Forecast

Both D. T. Cummings water supply wells will be continued to be produced in an effort to adequately supply the project's water needs.

Water Handling - Work Accomplished

The transfer and injection of water has necessitated the installation of nearly 17,000 feet of line. Figures 7 and 8 are schematics of the water handling and water supply systems,

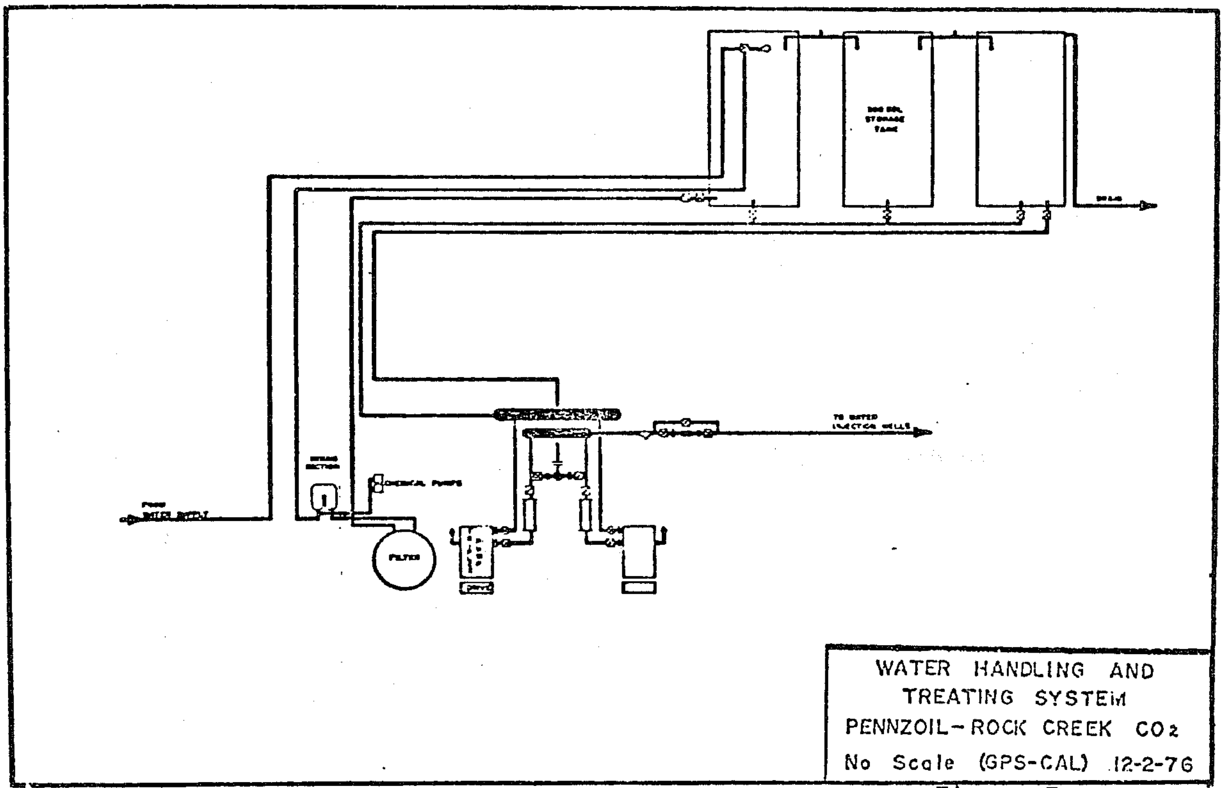


Figure 7

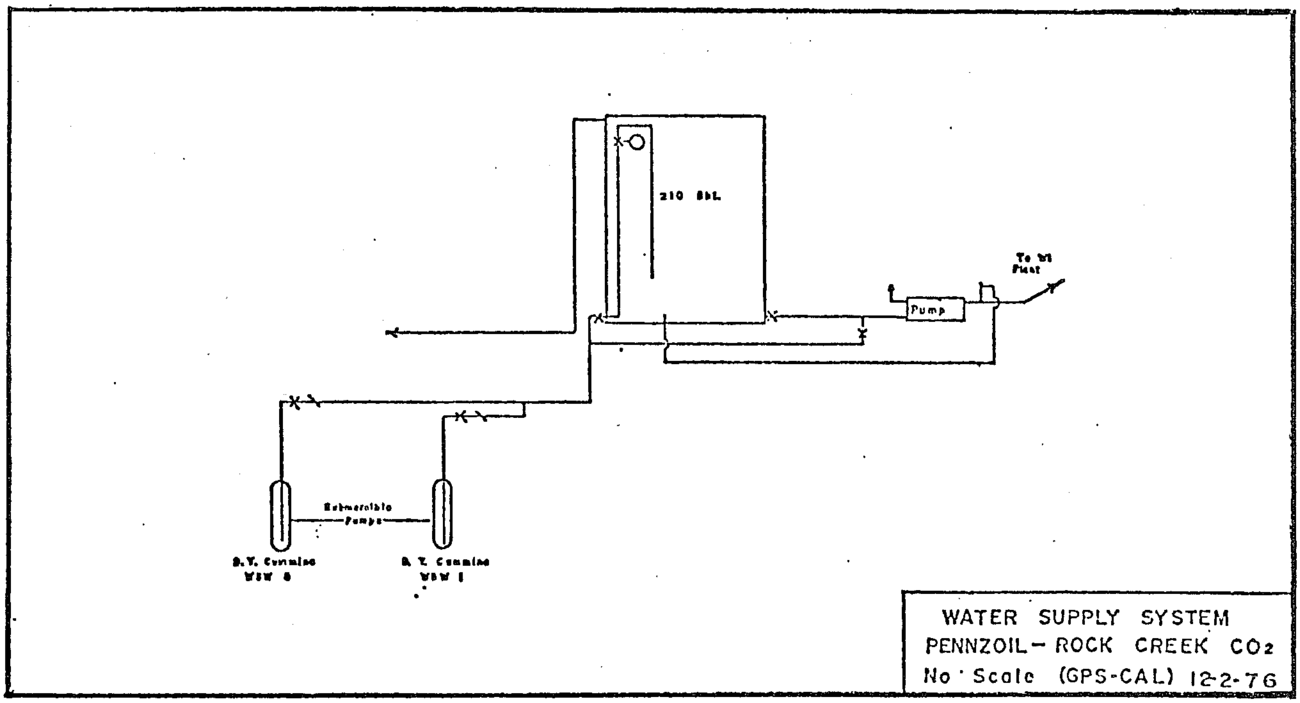
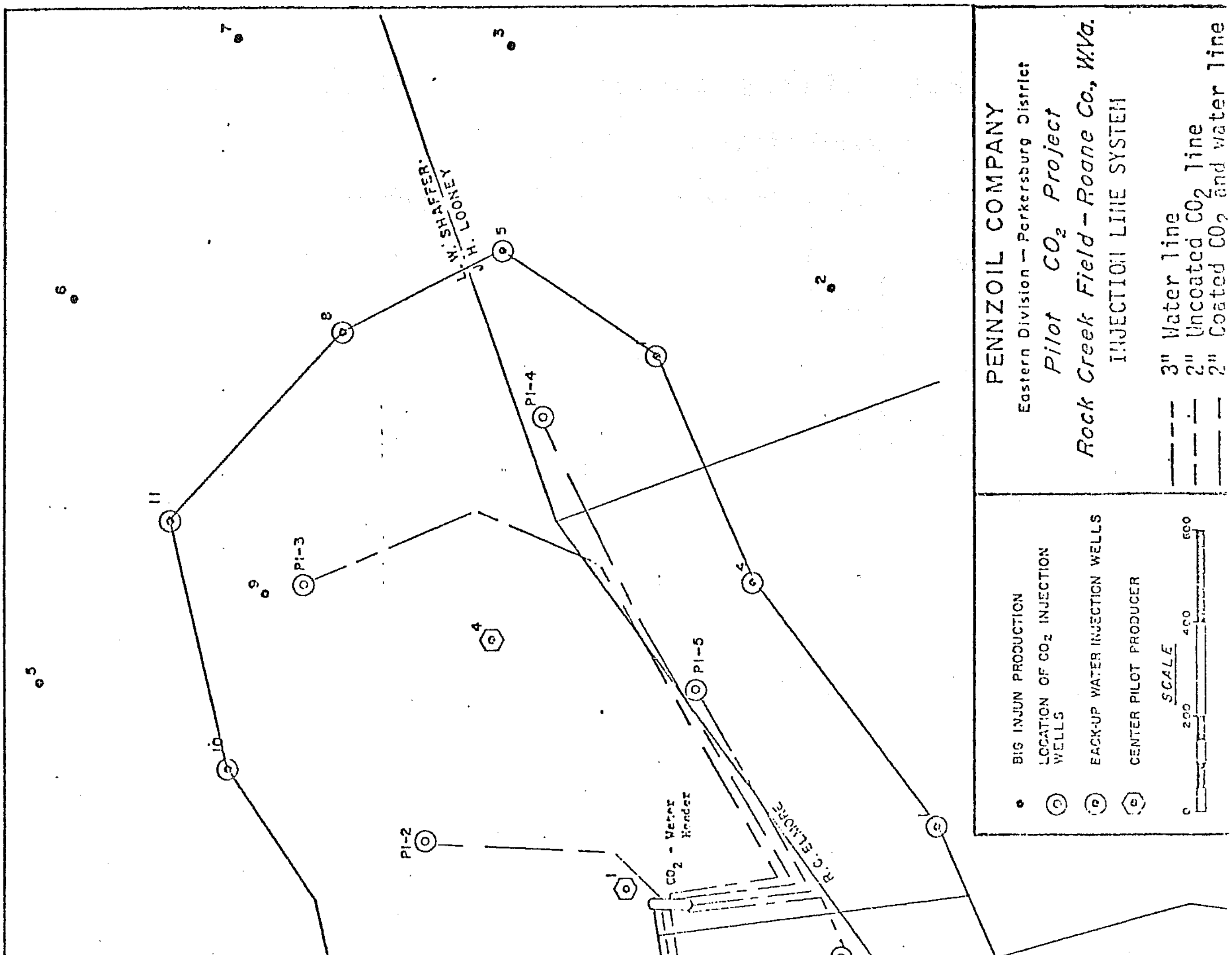


Figure 8

Figure 9


PENNZOIL COMPANY
Eastern Division — Parkersburg District
Pilot CO2 Project
Rock Creek Field - Roane Co., W.Va.
INJECTION LINE SYSTEM
3" Water line
2" Uncoated CO2 line
2" Coated CO2 and water line
BIG INJUN PRODUCTION
LOCATION OF CO2 INJECTION WELLS
BACK-UP WATER INJECTION WELLS
CENTER PILOT PRODUCER
SCALE
0
200
400
600
L. W. SHAFFER
J. H. LOONEY
R. C. ELMORE
J. W. LYNCH
E. LEWIS
CO2 - Water Header
From Plant Site
PI-1
PI-2
PI-3
PI-4
PI-5
PI-6

respectively. Figure 9 is a schematic of the line system. Water is pumped by submersible pumps from the water supply wells to a holding tank. A duplex pump then transfers this water approximately 9,000 feet to the water injection plant. The raw water is chemically treated then filtered to remove iron and manganese before injection. Three 300 barrel tanks hold an eleven hour supply of water to provide uninterrupted injection in case of needed maintenance in the water supply system. Two triplex pumps, each capable of pumping 2,000 BWPD, are used for injection.

Water Handling - Work Forecast

If the T. Henderson WSW No. 1 proves productive, an additional 18,000 feet of line will be installed. Possible additions to the water filtering system will be necessitated, but a decision as to these changes will not be made until such time that this water source is used.

CARBON DIOXIDE SYSTEM

Carbon Dioxide Supply and Storage - Work Accomplished

Southwest Cryogenics, Inc. has been contracted to supply the carbon dioxide needed for this pilot project. The carbon dioxide will be trucked to the injection plant site and stored in four 10,000 gallon storage tanks. These tanks have been purchased and renovated but not installed.

Carbon Dioxide Supply and Storage - Work Forecast

The four storage tanks are scheduled to be installed during the next quarter.

Carbon Dioxide Handling - Work Accomplished

A triplex pump will be used to inject the carbon dioxide. This pump has also been purchased but not installed. Nearly 8,000 feet of line, of which 5,000 feet is internally coated, has been installed for carbon dioxide injection. This coated line will be used for both water and carbon dioxide injection from a common header (Figure 9). Coated tubing for each of the six carbon dioxide injection well's injection string has been purchased, but not installed.

Carbon Dioxide Handling - Work Forecast

No progress will be made on this system during the next quarter.

RESERVOIR PROPERTIES

Lithology

The Big Injun Sand in the Rock Creek Field is a very light gray to very light greenish-gray, very fine to medium-grained, well sorted, sub-round to round sandstone that is slightly to moderately calcareous. The Big Injun interval indicates a coarsening upward sequence concurrent with a decrease in matrix material and an increase in cementing material with an occasional pebble lense occurring in the upper third of the section.

The matrix material consists of three clay minerals which are, in order of decreasing abundance, chlorite, mixed layer clay and illite. The carbonate minerals ankerite (S.G. = 2.95-3.00) and siderite (3.83-3.88) are also present. Ankerite, which occurs in varying percentages as disseminated cement throughout the interval, is probably responsible for sand grain densities of 2.70 to 2.75. Where densities are greater than 2.75, siderite probably is responsible.

Three of the seven cores underwent grain density determination. The average grain densities for these cores are 2.70 for L. W. Shaffer P.I. No. 2, 2.71 for R. C. Elmore P.I. No. 5 and 2.67 for E. Lewis No. 29. Using only those samples with a permeability equal to or greater than 5.0 millidarcies to determine averages, the grain densities for these cores average 2.70 for L. W. Shaffer P.I. No. 2, 2.70 for R. C. Elmore P.I. No. 5 and 2.67 for E. Lewis No. 29. Complete grain densities for all samples taken are shown in Appendix E.

Permeability and Porosity

In the seven wells that were cored, the Big Injun interval ranged from 44 feet to 50 feet in thickness and averaged 47 feet per core. In determining net pay, a lower limit equal to or greater than 5 millidarcies was used. Results of the core analyses are summarized in Table III and the complete core analysis for each well can be found in Appendix G.

TABLE III

Summation of Core Data

Well No.	h	kh (max. k)	Avg. k	kh (k @ 90°)	Øh %	Avg. Ø
P.I. 1	30.9	667.9	21.8	610.0	661.0	21.5
P.I. 2	31.2	595.2	19.1	575.4	701.7	22.5
P.I. 3	32.8	458.0	14.0	429.4	700.7	21.4
P.I. 4	37.3	560.3	15.0	508.4	806.8	21.6
P.I. 5	29.4	928.3	31.6	N.A.	655.0	22.3
P.I. 6	32.9	774.3	23.5	735.6	738.2	22.4
E. Lewis 29	27.0	278.7	10.3	265.8	540.4	20.0
Avg. per Well	31.6	609.0	19.3	520.8*	686.3	21.7

*6 well average

In reference to Table III, two possible permeability anomalies are apparent, i.e., P.I. 5 and Lewis 29. Knowing that the P.I. 5 analysis was conventional (i.e., plugs) and that Lewis 29 was analyzed by Core Labs instead of Oilfield Research as were the other six cores, the possibility of discrepancies in techniques and therefore results becomes apparent. Tests are being made to either prove or disprove this hypothesis. Until then, no definite conclusions on permeability can be made.

Reservoir Pressure

Bottom hole pressures in thirteen of the nineteen injection wells were taken prior to fluid injection. The bottom hole pressure of E. Lewis No. 29 was taken following the injection of 120 barrels of water and a seven day shut-in period.

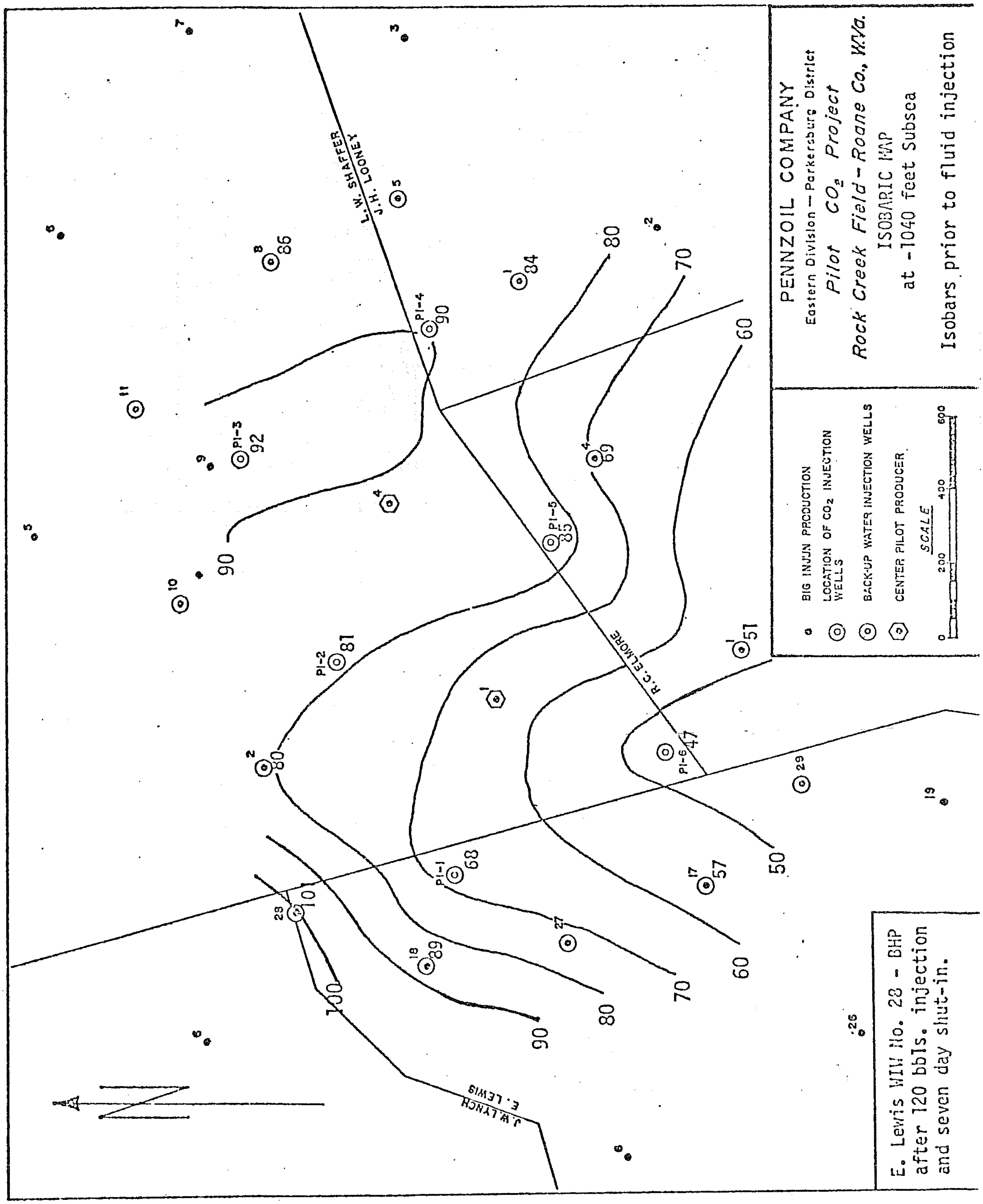
Table IV lists the bottom hole pressures recorded and Figure 5 is an isobaric map of the pilot area using these pressures. Since the subsea depth of the top of the Big Injun section in the two center producing wells is about -1040 feet, all bottom hole pressures were normalize(to this depth.

TABLE IV

Bottom Hole Pressures Before Fluid Injection

	Date Taken	BHP @ -1040 ft.
E. Lewis P.I. No. 1	12/14/76	68 psig
L. W. Shaffer P.I. No. 2	12/14/76	81 psig
L. W. Shaffer P.I. No. 3	12/14/76	92 psig
J. H. Looney P.I. No. 4	12/14/76	90 psig
R. C. Elmore P.I. No. 5	12/9/76	85 psig
L. W. Shaffer P.I. No. 6	12/9/76	47 psig
R. C. Elmore No. 1	10/15/76	51 psig
R. C. Elmore No. 4	10/15/76	69 psig
E. Lewis No. 17	10/12/76	57 psig
E. Lewis No. 18	10/13/76	89 psig
E. Lewis No. 28	10/15/76	101 psig
J. H. Looney No. 1	10/15/76	84 psig
L. W. Shaffer No. 2	10/13/76	80 psig
L. W. Shaffer No. 8	10/13/76	86 psig
	Average	77 psig

Figure 10


PENNZOIL COMPANY
Eastern Division — Parkersburg District
Pilot CO2 Project
Rock Creek Field - Roane Co., W.Va.
ISOBARIC MAP
at -1040 feet Subsea
Isobars prior to fluid injection
BIG INJUN PRODUCTION
LOCATION OF CO2 INJECTION WELLS
BACK-UP WATER INJECTION WELLS
CENTER PILOT PRODUCER
SCALE
0
200
400
600
E. Lewis WIW No. 23 - BHP after 120 bbls. injection and seven day shut-in.
L. W. SHAFFER
J.H. LOONEY
R.C. ELMORE
J.W. LYNCH
E. LEWIS
PI-1
PI-2
PI-3
PI-4
PI-5
PI-6
100
90
80
70
60
50

CONCLUSION

The overall project schedule has, to date, been delayed by four months. An additional five month delay before carbon dioxide injection begins is anticipated if a shortage of liquid carbon dioxide exists during the winter of 1977-78 as it did during this past winter. Due to these delays, carbon dioxide injection is scheduled to start during the first quarter of 1978.

All well work has been completed with the exception of initial water injection into the six pattern wells. Besides the four back-up water injection wells originally scheduled, two additional back-up water injection wells were drilled as dictated by a model study. Construction lacks only the installation of the carbon dioxide storage and pumping facilities and the completion of the producing facilities.

Quantitative information acquired from the core analyses and bottom hole pressure tests equates with the original data used as the basis of this project. Therefore, the original concept of successful miscible carbon dioxide oil recovery is supported by the information gained to date.

INTRODUCTION

This report is the eleventh report on the progress of the Rock Creek carbon dioxide project in Roane County, West Virginia.

Designed, developed and operated by Pennzoil Company, this project will demonstrate the feasibility of miscible carbon dioxide oil recovery in the Rock Creek Big Injun Field. A successful demonstration of this process will lead to a field wide commercial development. Also, the technical success of this project would be utilized in the development of other miscible carbon dioxide oil recovery projects in numerous fields within the Appalachian area.

SUMMARY

No major delays in the project were incurred during the first quarter of 1977. Therefore, the revised project schedule, graphically detailed in Figure No. 11, remained unchanged.

During the past quarter, the new producing facilities were nearly completed. The two center producing wells continued to pump but the inability to run the stock tank oil during the severe weather necessitated a decrease in pumping time which, in turn, caused a decrease in production.

The D. T. Cummings water supply wells continued to be the only source of water for the project. The T. Henderson WSW No. 1, drilled in December, 1976, underwent a three month production test which proved it to be a stable source of water. Installation of the water supply line from the Henderson well to the injection facility was started in late February and neared completion as of April 1, 1977.

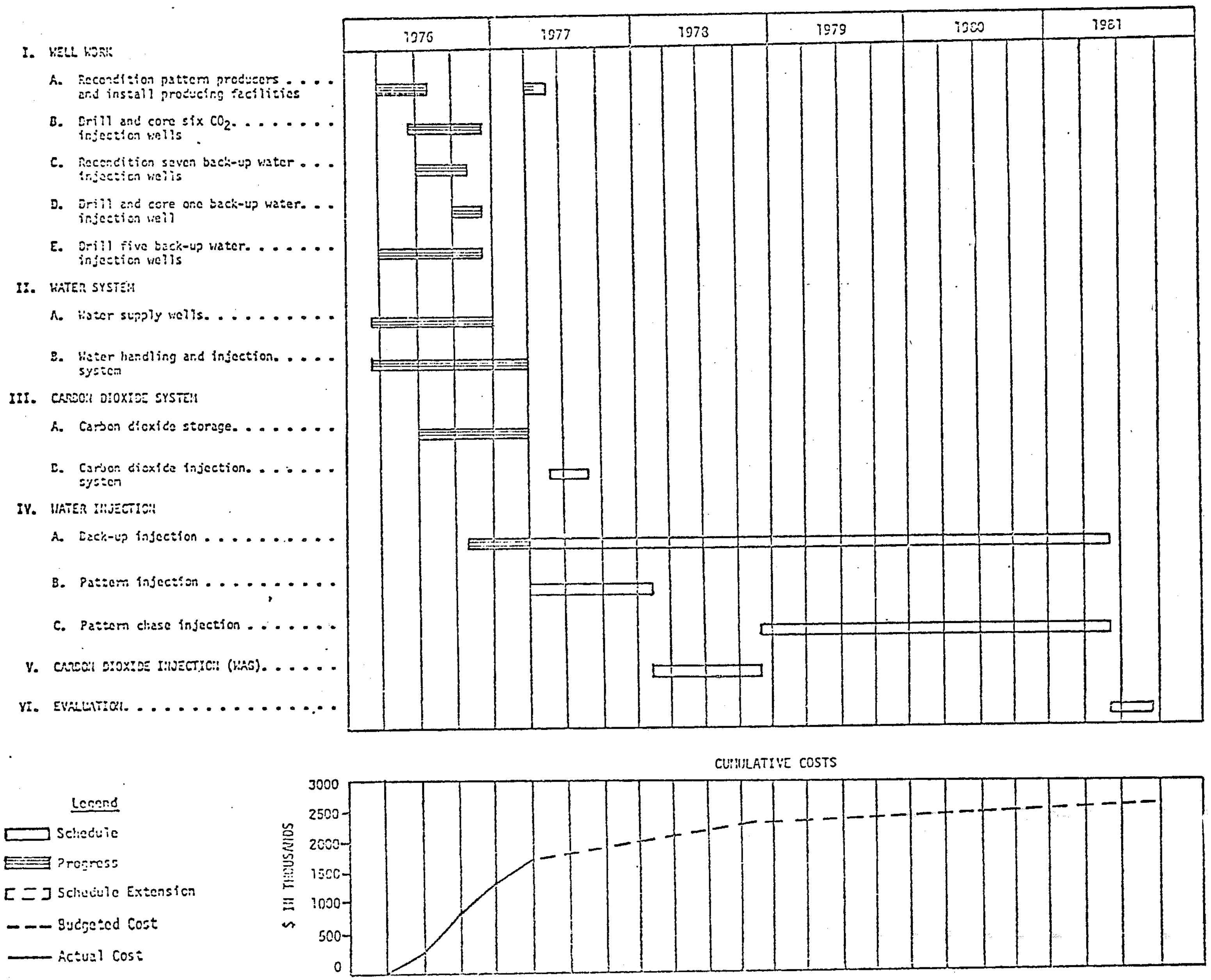
Progress on the carbon dioxide storage system continued on schedule with the four storage tanks being set at the injection facility. No progress was made on the carbon dioxide injection system which is scheduled for completion during the third quarter of 1977.

Water injection into the thirteen back-up water injection wells continued on schedule with the exception of a few problem wells. Since an adequate water supply is forthcoming with the completion of the Henderson water supply line, no action will be taken to increase injectivity until this water supply is on stream. The start of pattern injection will occur coincidentally with the increased water supply.

Figure 11

OIL RECOVERY BY CARBON DIOXIDE INJECTION
ROCK CREEK FIELD, ROANE COUNTY, WEST VIRGINIA

PROJECT SCHEDULE



WELL WORK

Producing Wells - Work Accomplished

The severe weather of January and February made running the stock tank oil impossible for the better part of both months which in turn limited the number of hours that each well could be pumped and therefore reduced production. L. W. Shaffer No. 4 began to show oil production with less water production near the end of the quarter. This oil production indicated that the water contamination of the formation during clean-out neared being overcome. The monthly production of these two wells is listed below and graphically shown in Appendix H.

L. W. Shaffer No. 1

	BO	BW	MCF	Hrs.	WOR	GOR, CFPB
January	40	0	57.6	37	0	1440
February	39	0	67.2	46	0	1723
March	53	0	163.5	62	0	3085
Cumulative*	275	0	509.1		0	1851

L. W. Shaffer No. 4

	BO	BW	MCF	Hrs.	WOR	GOR, CFPB
January	0	15	42.0	34	-	-
February	0	16	56.0	38	-	-
March	22	10	126.8	62	2.2	5764
Cumulative*	25	183	408.8		7.3	16352

*As of October 1, 1976

Both wells continued to be pumped into the old producing facilities throughout the quarter. The new producing facilities have been completed with the exception of the pipeline hook-up. The produced water disposal building was completed, but the installation of the produced water filter and disposal pump has yet to be accomplished.

Producing Wells - Work Forecast

As soon as the pipeline hook-up is secured, both wells will be changed over to pump into the new producing facilities. Both wells will continue to be produced regularly throughout the next quarter.

Carbon Dioxide Injection Wells - Work Accomplished

The original intention of starting water injection into these six wells during the first quarter of 1977 was postponed until the water supply from the T. Henderson WSW No. 1 is on stream. This policy was dictated by the ability of the thirteen back-up injection wells to take all of the water available from the D. T. Cummings water supply wells.

Carbon Dioxide Injection Wells - Work Forecast

Water injection into these six wells will begin coincidentally with the increased water supply.

Back-up Water Injection Wells - Work Accomplished

On January 7, 1977 the element of the packer in E. Lewis No. 17 failed. The reason for the failure could not be determined by the local packer representative so the element was sent into the factory for analysis. To date, no word has been received concerning the outcome of the factory test. On February 2, 1977, the well was returned to injection. The long lag time needed to return the well to injection was caused by the severe weather conditions.

On January 26, 1977, E. Lewis No. 28 was treated with 500 gallons of 15% hydrochloric acid in an attempt to improve injectivity. This treatment did improve injection for three days. On February 17 and 18, 1977, E. Lewis No. 28 was swabbed down with ferric hydroxide being very evident in the swabbed water. The well was returned to injection on February 18. Improved injectivity lasted nine days. On March 1, 1977, the well was treated with 500 gallons of 3% hydrofluoric and 12% hydrochloric acid. The well was returned to injection on March 2. Improved injectivity lasted one day. On March 4, 1977 the chemical treatment to remove dissolved iron from the raw water was suspended. Injectivity into E. Lewis No. 28 started to increase on March 5 and continued to do so throughout the month. No other attempts were made to increase injectivity on the remaining twelve active injection wells pending the increase in water supply from the Henderson well.

Table V lists the injection history for the active water injection wells for the first quarter of 1977. The graphical injection and pressure history of these wells are presented in Appendix J.

TABLE V

Injection History
Back-up Water Injection Wells

	Date of First Injection	Injection, BW			Avg. WHP* PSIG	Cum. Inj. 4/1/77
		January	February	March		
R. C. Elmore No. 1	10/16/76	4,895	7,273	8,558	0	29,451
R. C. Elmore No. 4	10/16/76	2,250	2,213	2,547	810	12,843
E. Lewis No. 17	10/16/76	601	2,279	3,117	775	14,512
E. Lewis No. 18	10/16/76	2,990	2,561	2,595	810	16,047
E. Lewis No. 27	11/2/76	2,696	1,687	1,814	810	12,091
E. Lewis No. 28	10/16/76	1,326	1,194	3,027	740	10,805
E. Lewis No. 29	11/11/76	1,081	782	685	860	4,713
J. H. Looney No. 1	10/16/76	3,658	6,259	6,527	800	26,741
J. H. Looney No. 5	11/11/76	1,344	1,101	1,073	860	6,612
L. W. Shaffer No. 2	10/16/76	7,174	7,634	9,334	0	33,822
L. W. Shaffer No. 8	10/16/76	3,785	4,328	3,961	690	20,693
L. W. Shaffer No. 10	11/4/76	356	191	178	835	1,699
L. W. Shaffer No. 11	11/6/76	484	267	277	865	1,807
Total or Average		32,640	37,772	43,693	680	191,836

*Average wellhead pressure for March.

Back-up Water Injection Wells - Work Forecast

The next quarter will continue to see water injection maintained into all back-up injection wells. The wells that continue to display below average injectivity will be subjected to remedial treatment to improve injection rates. These treatments will begin soon after the water supply from the Henderson water supply well is put on stream.

WATER SYSTEM

Water Supply Wells - Work Accomplished

The project continued to be supplied by water from the D. T. Cummings WSW Nos. 1 and 5. The combined 1,500 BPD productivity of these two wells is not an adequate supply for the entire project. The T. Henderson WSW No. 1, drilled in December, 1976, underwent a three month test which proved it to be a stable water source.

Water Supply Wells - Work Forecast

Until such time that the T. Henderson water supply well is put on stream, the D. T. Cummings wells will continue to provide the water supply for the project.

Water Handling - Work Accomplished

In January, 1977, it was discovered that a bacteria problem existed between the water supply wells and the injection wells. This bacteria was oxidizing both the iron in solution and in the transfer and injection lines. After this bacteria problem was recognized, a large biocide treatment was used to bring the bacteria under control. A bi-weekly batch treatment is now used to prevent the reoccurrence of this problem.

Continued poor performance of the equipment used in the chemical floculation of the dissolved iron in the raw water necessitated the ceasation of this treatment on March 4, 1977. The inability to continually provide a good quality effluent was made evident by the needed repeated attempts to increase the injectivity into E. Lewis No. 28.

Rights-of-way for the installation of the near 20,000 ft. water supply line from the Henderson water supply well to the project site have been secured. Construction on this line started in late February and neared completion as of April 1, 1977.

Water Handling - Work Forecast

The Henderson water supply line will be completed in early April, thus providing an adequate water supply for the project. As soon as this supply line is completed, the six pattern injectors will become active. Although it appears that the supply from the Henderson well will be adequate to completely supply the project, the line system will be connected so that each supply system can be used separately or coincidentally.

CARBON DIOXIDE SYSTEM

Carbon Dioxide Storage - Work Accomplished

On February 10 and 11, 1977, the four carbon dioxide storage tanks were installed at the plant site. This installation completes work to be accomplished under this category.

Carbon Dioxide Handling - Work Accomplished

No progress was made on this system during the first quarter of 1977.

Carbon Dioxide Handling - Work Forecast

The final construction necessary to complete the carbon dioxide handling system is scheduled to begin during the second quarter of 1977.

RESERVOIR PROPERTIES

Permeability and Porosity

The results of the initial tests performed to possibly explain the two permeability anomalies that appeared to exist between R. C. Elmore P.I. No. 5 and E. Lewis No. 29 have been received. Before definite conclusions can be made concerning the hypothesis that technique discrepancies could provide varying results, further testing must be completed. A report on the data obtained from these tests will be presented when all testing is completed.

Water Saturations

The Energy Research and Development Administration at Morgantown, West Virginia, had tests performed to measure both the Formation Resistivity Factor and the Formation Resistivity Index on six preserved core samples from E. Lewis No. 29 and four preserved core samples from J. H. Looney P.I. No. 4. Due to the results of these tests, it was decided to have tests performed to measure the irreducible water saturation in selected preserved core samples. This measurement is currently in the process of being completed. When the irreducible water saturation results become available, both test results will be presented.

CONCLUSION

The project proceeded as outlined in the revised project schedule. Testing proved the stability of the T. Henderson WSW No. 1 as an alternate water source for the project. This water supply will be put on stream in early April, 1977. No attempt was made to increase the injection rate into the problem injection wells. These problem wells will undergo remedial treatment after the new water source becomes available.

To date no insurmountable adverse effects have occurred to inhibit the desired final outcome of a successful project.

INTRODUCTION

This report is the fifteenth report on the progress of the Rock Creek carbon dioxide project in Roane County, West Virginia.

Designed, developed, and operated by Pennzoil Company, this project will demonstrate the feasibility of miscible carbon dioxide oil recovery in the Rock Creek Big Injun Field. A successful demonstration of this process will lead to a field wide commercial development. Also, the technical success of this project would be utilized in the development of other miscible carbon dioxide oil recovery projects in numerous fields within the Appalachian area.

SUMMARY

No major delays in the project were incurred during the second quarter of 1977. Therefore, the revised project schedule, graphically detailed in Figure No 12, remained unchanged.

During the past quarter, the new producing facilities were completed. The two center producing wells continued to pump with little change in rates. Water production from both wells increased slightly, but the source of this water has yet to be determined.

The use of T. Henderson WSW No. 1 as the water source for the project commenced in April. The water from the Henderson and

Cummings water supplies will not be mixed, thus making the Henderson the sole water source during normal operation.

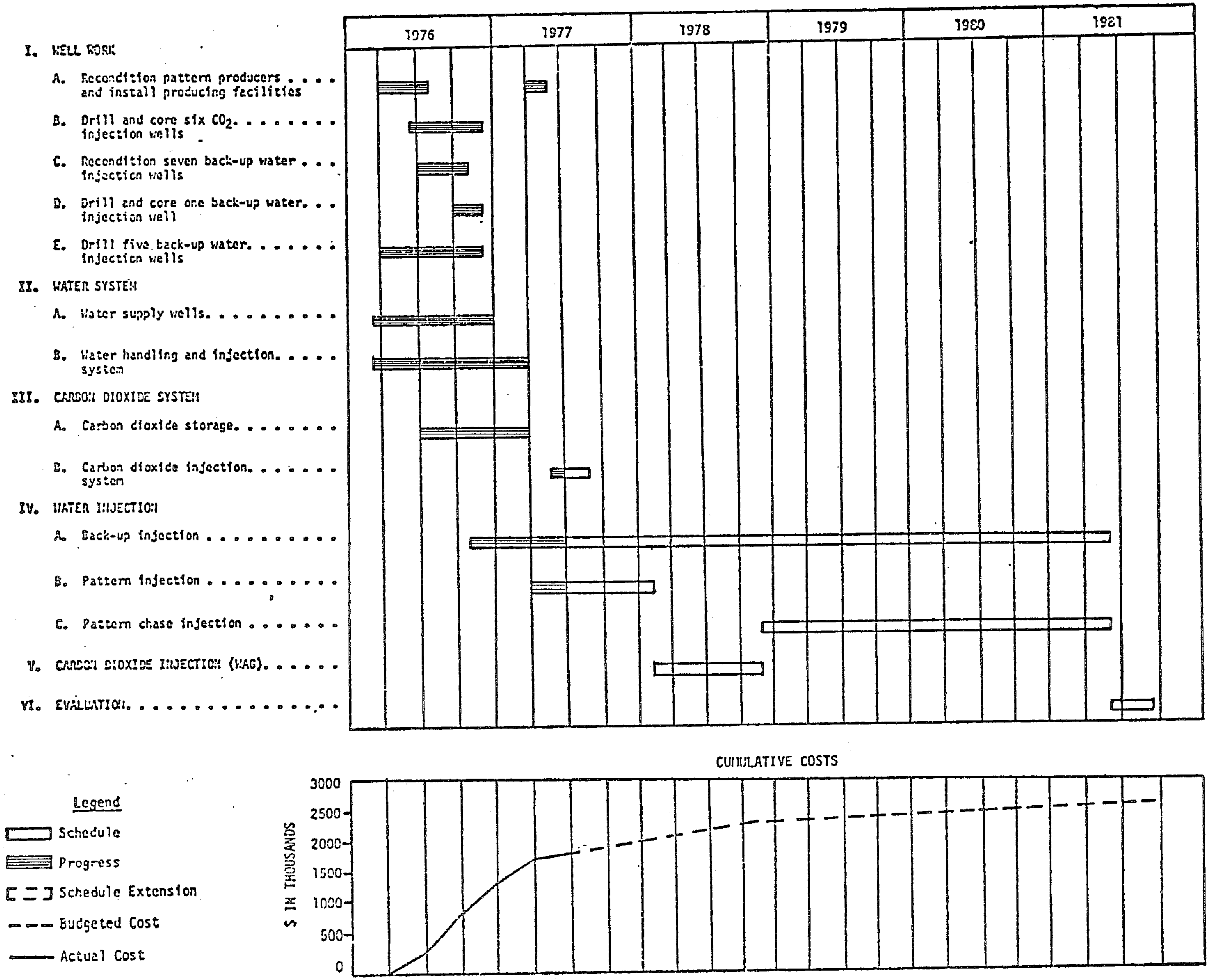
No further progress was made on the carbon dioxide system during the second quarter. Completion of these facilities is scheduled for the third quarter of 1977.

Water injection continued on schedule into the thirteen back-up water injection wells with the exception of a few problem wells. These problem wells were successfully recompleted after the Henderson water source became available. The start of pattern injection occurred coincidently with the change in water sources. Injection into three of the six wells appeared limited due to apparent damage from the initial completion. These wells were successfully recompleted during this quarter.

Figure 12

OIL RECOVERY BY CARBON DIOXIDE INJECTION
ROCK CREEK FIELD, ROANE COUNTY, WEST VIRGINIA

PROJECT SCHEDULE



WELL WORK

Producing Wells - Work Accomplished

On May 11, 1977, the two center producing wells started producing through the new producing facilities. The more accurate fluid measurement obtainable and the higher annulus pressure necessary for separator operation caused, in part, the variances in fluid production. Shaffer No. 1 started to produce water at the end of June. The source of this water is currently being investigated. Shaffer No. 4 continued to increase in oil production. The monthly production of these two wells is listed below and graphically shown in Appendix H.

L. W. Shaffer No. 1

	BO	BW	MMCF	Hrs.	WOR	GOR, CFPB
April	60	0	0.1723	66	0	2,872
May	49	0	0.1527	58	0	3,116
June	56	12	0.0950	65	0.21	1,696
Cumulative*	440	12	0.9291		0.03	2,112

L. W. Shaffer No. 4

	BO	BW	MMCF	Hrs.	WOR	GOR, CFPB
April	28	5	0.1168	60	0.18	4,171
May	24	17	0.1744	54	0.71	7,267
June	34	19	0.1949	60	0.56	5,732
Cumulative*	111	224	0.8949		2.02	8,062

*As of October 1, 1976

Producing Wells - Work Forecast

An investigation to determine the source of the water production from Shaffer No. 1 will be continued. Both wells will continue to pump regularly unless it is decided to shut in the wells in order to help increase the reservoir pressure.

Carbon Dioxide Injection Wells - Work Accomplished

The start of water injection into these six wells occurred coincidently with the completion of the water line from T. Henderson WSW No. 1 on April 22, 1977. The initial injection rates into the pattern wells indicated that three wells were damaged during the initial completion of each well. These wells were successfully retreated with acid. These acid retreatments are listed below.

1) E. Lewis P.I. No. 1 - On June 17, 1977, the subject well was treated with 1,000 gallons of 15% hydrochloric (HCl) acid. The average treating pressure was 1500 psig and the average treating rate was 12 barrels per minute (BPM); 12 perf balls were dropped during the job. After displacing the acid with 36 barrels of water (BW), the instantaneous shut-in pressure (ISIP) was 900 psig; the well went on vacuum in 15 minutes and was returned to injection after a 4 hour shut-in.

2) L. W. Shaffer P.I. No. 3 - On June 17, 1977, the subject well was treated with 1,000 gallons of 15% HCl acid. The average treating pressure was 1300 psig and the average treating rate was 12 BPM; 12 perf balls were dropped during the job. After displacing the acid with 36 BW, the ISIP was 750 psig; the well went on vacuum in 10 minutes and was returned to injection after a 3 hour shut-in.

3) J. H. Looney P.I. No. 4 - On June 17, 1977, the subject well was treated with 1,000 gallons of 15% HCl acid. The average treating pressure was 1400 psig and the average treating rate was 12 BPM; 12 perf balls were dropped during the job. After displacing the acid with 36 BW, the ISIP was 800 psig; the well went on vacuum in 10 minutes and was returned to injection after a 2 hour shut-in.

The injection history for these wells is listed in Table No. VI and graphically presented in Appendix I.

Carbon Dioxide Injection Wells - Work Forecast

Water injection will continue as scheduled. Pressure fall-off tests will be run in an effort to determine the injection front.

Back-up Water Injection Wells - Work Accomplished

After the water supply from Henderson WSW No. 1 became available, remedial treatments were performed on five of the back-up water injection wells. Four of these treatments were with acid, and the fifth was with carbon bisulfide. The carbon bisulfide treatment was the only treatment that failed to overcome wellbore damage. These treatments are listed below.

1) R. C. Elmore No. 4 - On May 5 and 6, 1977, the subject well was treated with 220 gallons of carbon bisulfide in an attempt to eliminate apparent paraffin damage of the wellbore. The carbon bisulfide was displaced with 10 barrels of water (BW). The well was shut in for three days then returned to injection. Injectivity after the treatment indicated that no damage was overcome.

2) E. Lewis No. 29 - On June 17, 1977, the subject well was treated with 2,000 gallons of 15% hydrochloric (HCl) acid. The average treating pressure was 1200 psig and the average treating rate was 10 barrels per minute (BPM); 12 perf balls were dropped during the job. After displacing the acid with 36 barrels of water (BW), the instantaneous shut-in pressure (ISIP) was 500 psig; the well went on vacuum in 7 minutes and was returned to injection after a 1 hour shut-in.

3) J. H. Looney No. 5 - On May 10, 1977, the subject well was treated with 2,000 gallons of 15% HCl acid and 4 gallons of a nonemulsifier. The average treating pressure was 1500 psig and the average treating rate was 13 BPM; 12 perf balls were dropped during the job. After displacing the acid with 32 BW, the ISIP was 750 psig. The well went on vacuum in 5 minutes and was returned to injection after a 3-1/2 hour shut-in. Injectivity after the treatment proved that the damage was overcome.

4) L. W. Shaffer No. 10 - On May 10, 1977, the subject well was treated with 2,000 gallons of 15% HCl acid and 4 gallons of a nonemulsifier. The average treating pressure was 1000 psig and the average treating rate was 12 BPM; 12 perf balls were dropped during the job. After displacing the acid with 32 BW, the ISIP was 500 psig. The well went on vacuum in 2 minutes and was returned to injection after a 5 hour shut-in. Injectivity after the treatment proved that the damage was overcome.

5) L. W. Shaffer No. 11 - On May 5, 1977, the subject well was treated with 2,000 gallons of 15% HCl acid and 4 gallons of a nonemulsifier. The average treating pressure was 1200 psig and the average treating rate was 9 BPM; 10 perf balls were dropped during the job. After displacing the acid with 32 BW, the ISIP was 600 psig. The well went on vacuum in 4 minutes and was returned to injection after a 3-1/2 hour shut-in. Injectivity after the treatment proved that the damage was overcome.

Table No. VI lists the injection history for the thirteen back-up water injection wells for the second quarter of 1977.

The injection and pressure history of these wells is graphically presented in Appendix J.

TABLE NO. VI

Water Injection History

	Date of First Injection	Injection, BW April	Injection, BW May	Injection, BW June	Avg. WHP* PSIG	Cum. Inj. 7/1/77
Carbon Dioxide Injection Wells						
E. Lewis P.I. No. 1	4/22/77	624	2,603	3,117	605	6,344
L. W. Shaffer P.I. No. 2	4/22/77	662	4,622	5,816	900	11,100
L. W. Shaffer P.I. No. 3	4/22/77	380	1,501	2,126	905	4,007
J. H. Looney P.I. No. 4	4/22/77	648	2,304	2,471	615	5,423
R. C. Elmore P.I. No. 5	4/22/77	673	5,230	5,700	825	11,603
L. W. Shaffer P.I. No. 6	4/22/77	818	3,799	5,506	345	10,123
Sub-total		3,805	20,059	24,736	700	48,600
Back-up Water Injection Wells						
R. C. Elmore No. 1	10/16/76	5,166	12,738	7,422	0	54,777
R. C. Elmore No. 4	10/16/76	2,643	2,345	2,694	945	20,525
E. Lewis No. 17	10/16/76	3,376	3,985	4,612	955	26,485
E. Lewis No. 18	10/16/76	2,406	3,039	3,177	940	24,669
E. Lewis No. 27	11/2/76	2,720	3,969	4,803	945	23,583
E. Lewis No. 28	10/16/76	4,899	4,495	5,005	915	25,204
E. Lewis No. 29	11/11/76	976	1,016	2,537	935	9,242
J. H. Looney No. 1	10/16/76	5,905	6,223	6,450	930	45,319
J. H. Looney No. 5	11/11/76	1,359	4,421	4,791	605	17,183
L. W. Shaffer No. 2	10/16/76	4,418	6,451	4,946	0	49,637
L. W. Shaffer No. 8	10/16/76	3,951	4,442	4,824	920	33,910
L. W. Shaffer No. 10	11/4/76	253	2,920	4,843	960	9,715
L. W. Shaffer No. 11	11/6/76	473	4,236	4,454	955	10,970
Sub-total		38,545	60,280	60,558	770	351,219
TOTAL		42,350	80,339	85,294	745	399,819

*Average wellhead pressure for June.

Back-up Water Injection Wells - Work Forecast

Water injection will be maintained into these wells throughout the next quarter. Pressure fall-off tests will begin in an attempt to determine the position of the water front.

Observation Well

The bottom hole pressure of the one observation well, L. W. Shaffer No. 9, was taken on June 23, 1977. Its pressure was recorded as 131 psia. In comparison, the average bottom hole pressure for the area was 91 psia prior to water injection and the bottom hole pressure of Shaffer P.I. No. 3, an immediate offset to Shaffer No. 9, was 106 psia prior to water injection.

The bottom hole pressure of this well will be monitored regularly throughout the life of the pilot.

WATER SYSTEM

Water Supply Wells - Work Accomplished

D. T. Cummings WSW Nos. 1 and 5 supplied the project with water until April 22, 1977. This date corresponds with the completion of the water transferring system of T. Henderson WSW No. 1.

Water Supply Wells - Work Forecast

T. Henderson will continue to supply the pilot area with injection water. The D. T. Cummings water supply will be maintained as a back-up water source.

Water Handling - Work Accomplished

On April 22, 1977, the water transferring system from T. Henderson WSW No. 1 was completed and put-on-stream.

Water Handling - Work Forecast

The water handling system is complete.

CARBON DIOXIDE SYSTEM

Carbon Dioxide Handling - Work Accomplished

No progress was made on this system during the second quarter of 1977.

Carbon Dioxide Handling - Work Forecast

The construction of the carbon dioxide handling system is scheduled for completion in the third quarter of 1977.

CONCLUSION

The project proceeded as outlined in the revised project schedule. The T. Henderson water source is currently supplying the water needs of the pilot. The apparent wellbore damage of the problem injection wells was successfully overcome with remedial acid treatments. Pressure testing has begun in an attempt to determine the advancement of the injection front.

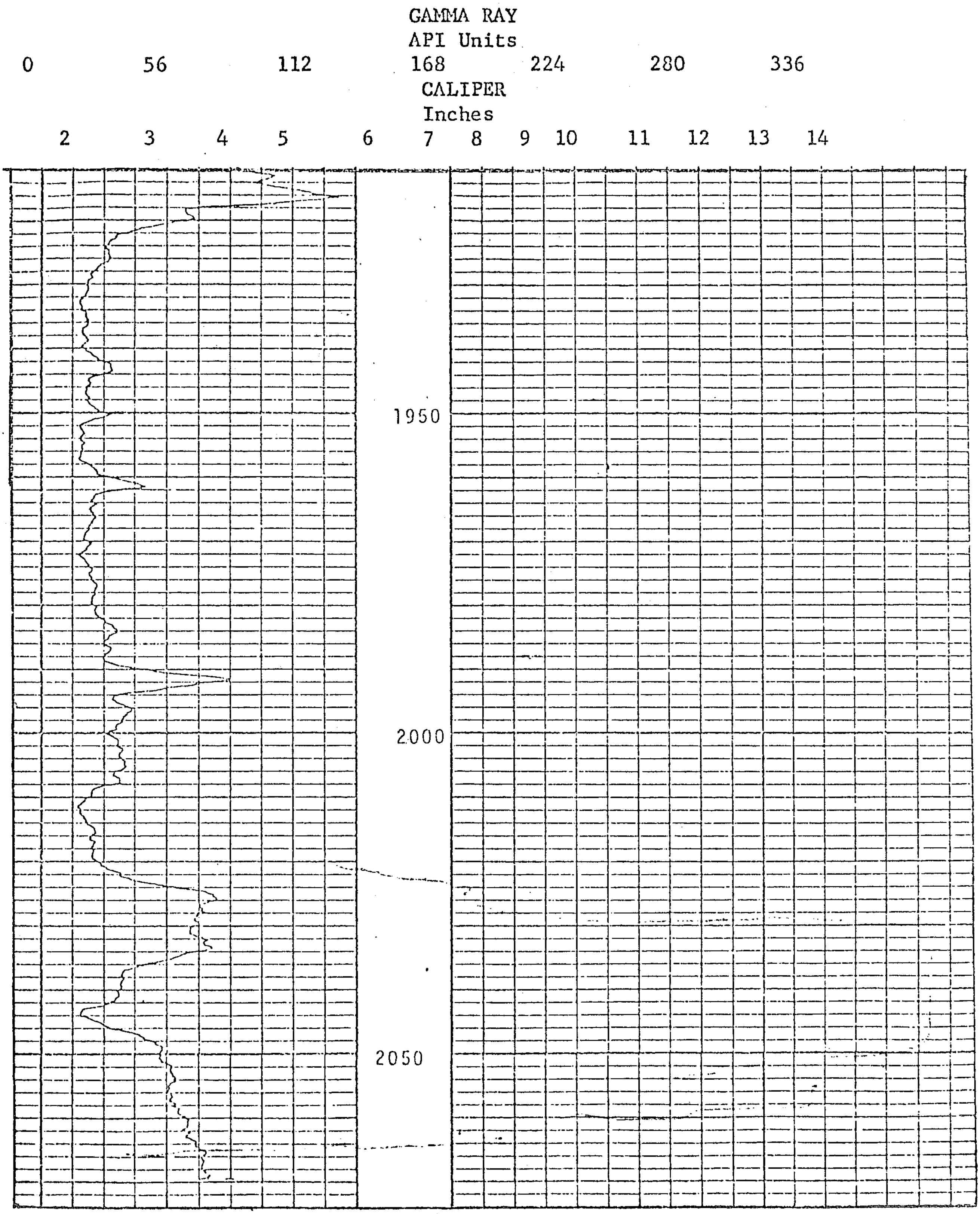
To date, no insurmountable adverse effects have occurred to inhibit the desired final outcome of a successful project.

APPENDIX A

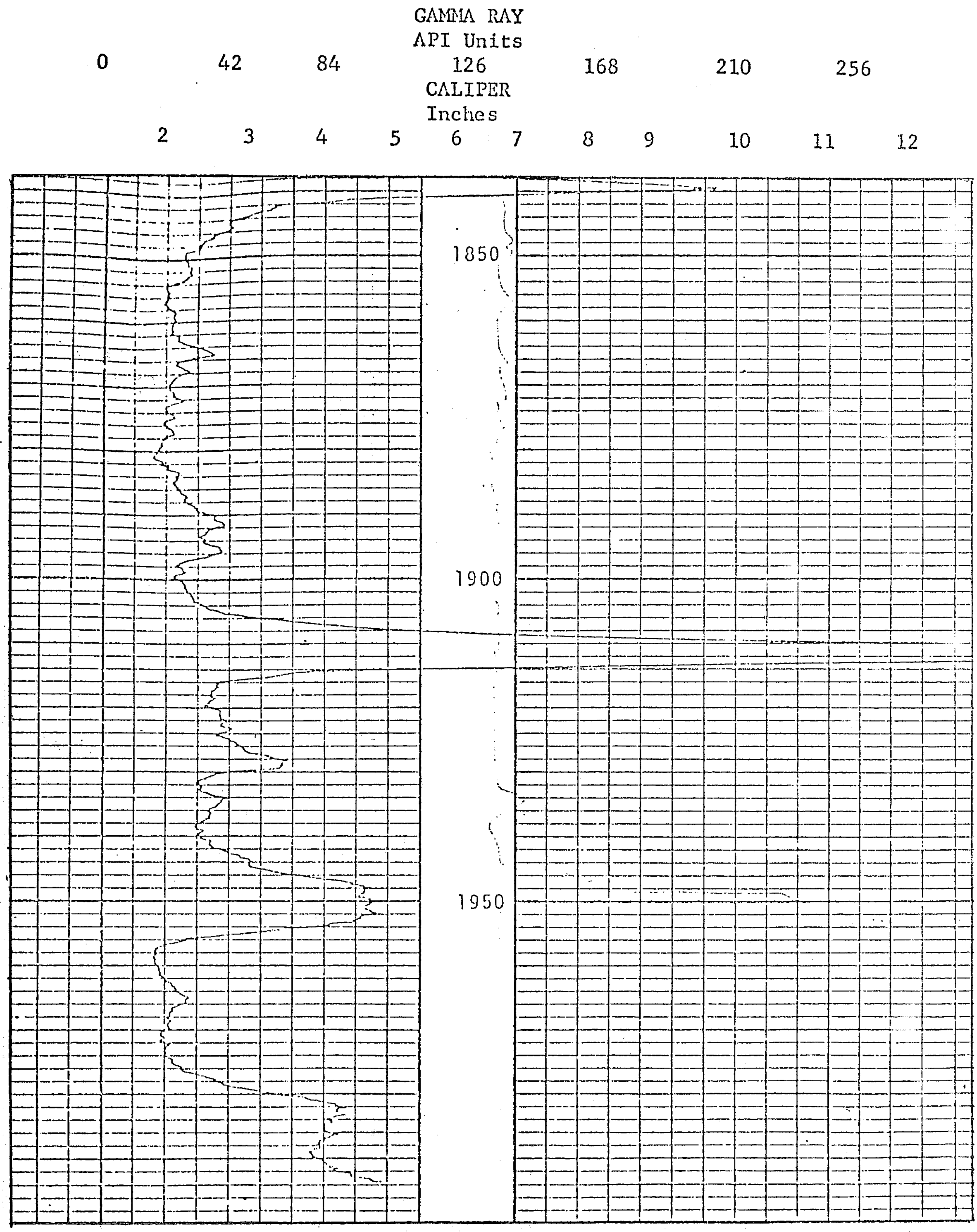
Producing Well Logs

Big Injun Section

L. W. SHAFFER NO. 1
Producing Well



L. W. SHAFFER NO. 4
Producing Well



APPENDIX B

Carbon Dioxide Injection Well Logs

Big Injun Section

E. LEWIS PI NO. 1

Carbon Dioxide Injection Well

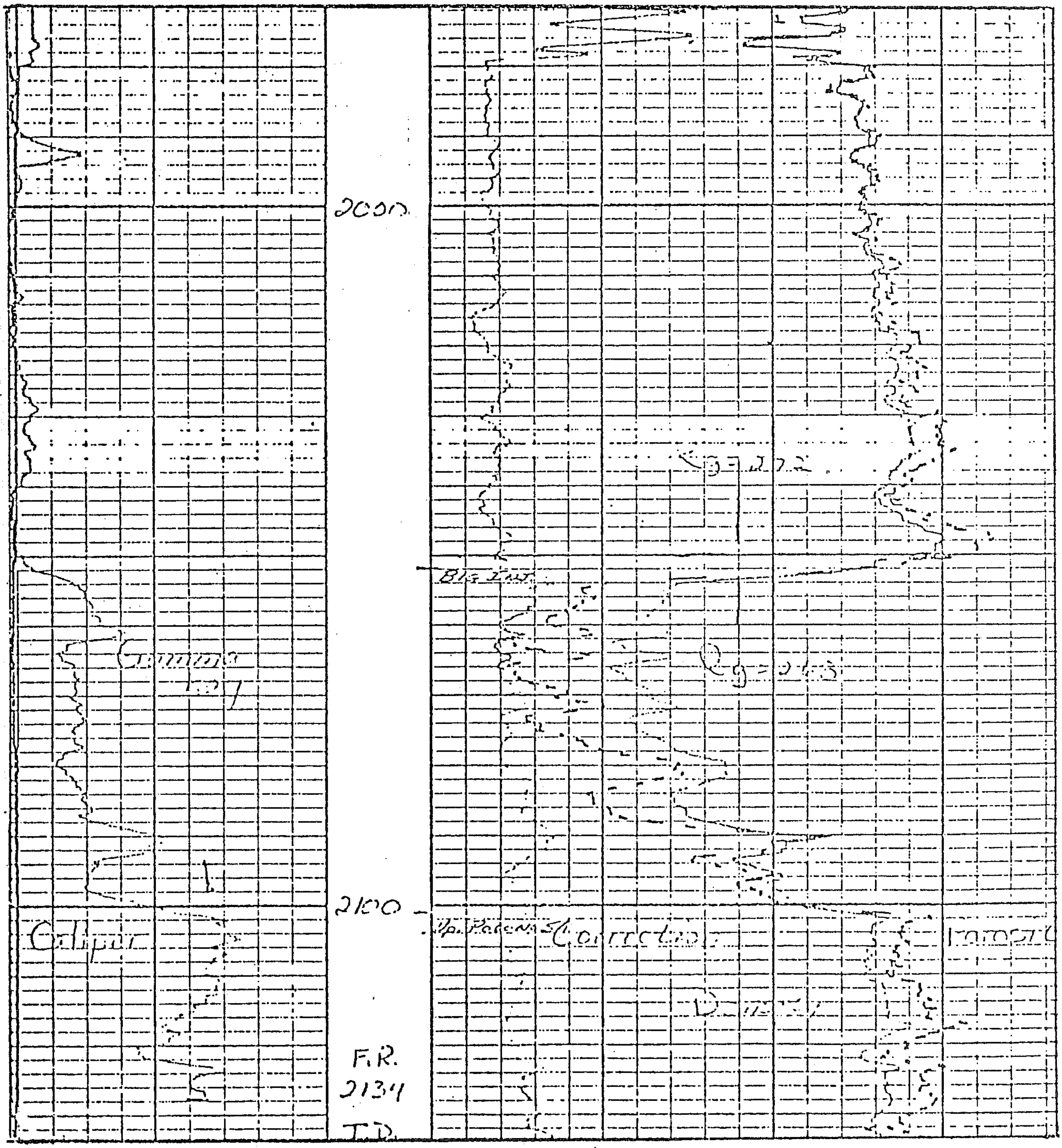
GAMMA RAY
API Units
20 100 200

CALIPER
Inches
7 11 16

POROSITY - %
30 20 10 0

BULK DENSITY - Grams/CC
2.00 2.25 2.50 2.75

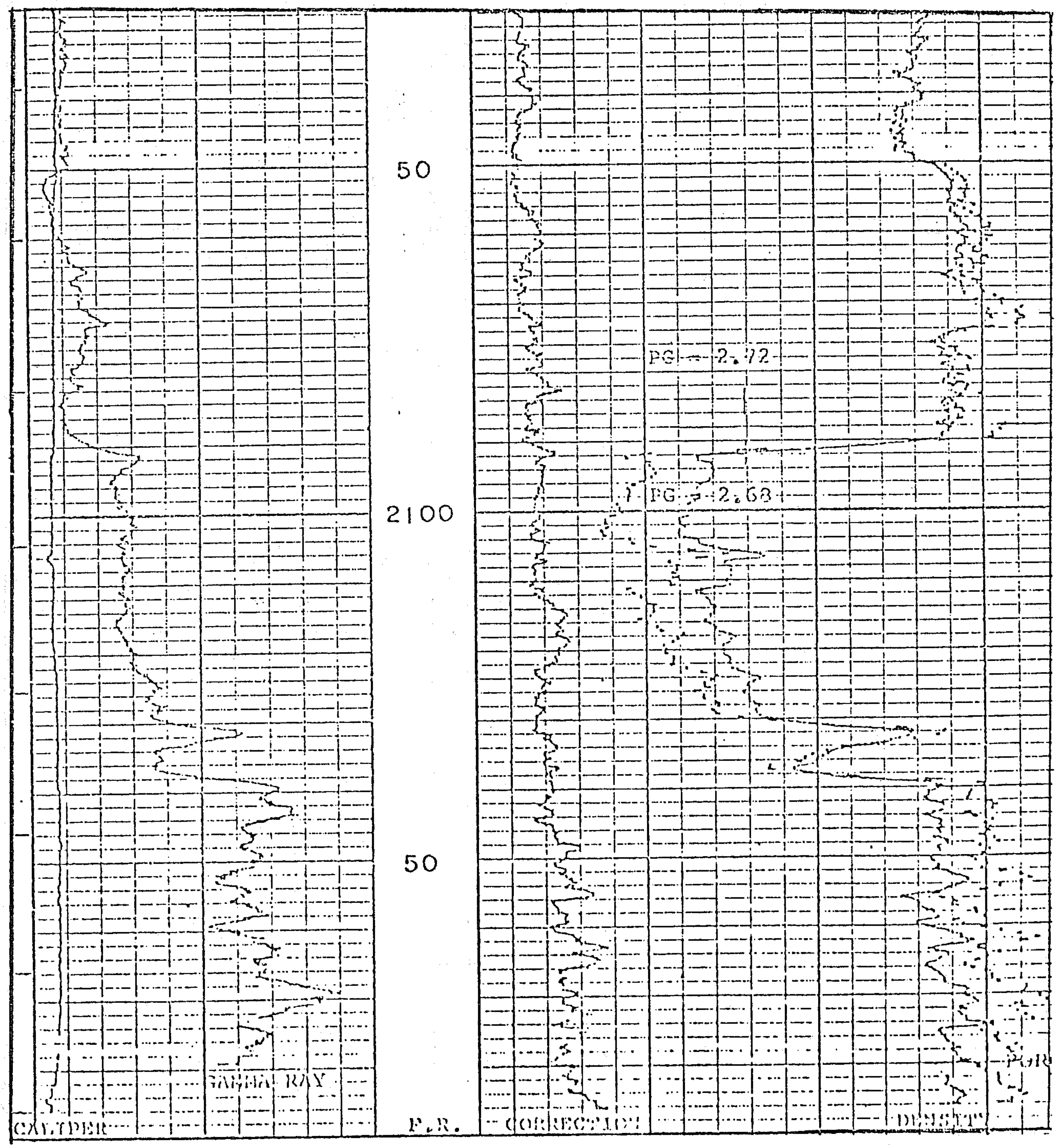
CORRECTION - Grams/CC
0 +0.25



L. W. SHAFFER PI NO. 2
Carbon Dioxide Injection Well

GAMMA RAY
API Units
0 100 200
CALIPER
Inches
6 11 16

POROSITY - %
30 20 10 0
BULK DENSITY - Grams/CC
2.00 2.25 2.50 2.75
CORRECTION - Grams/CC
0 +0.25



L. W. SHAFFER PI NO. 3
Carbon Dioxide Injection Well

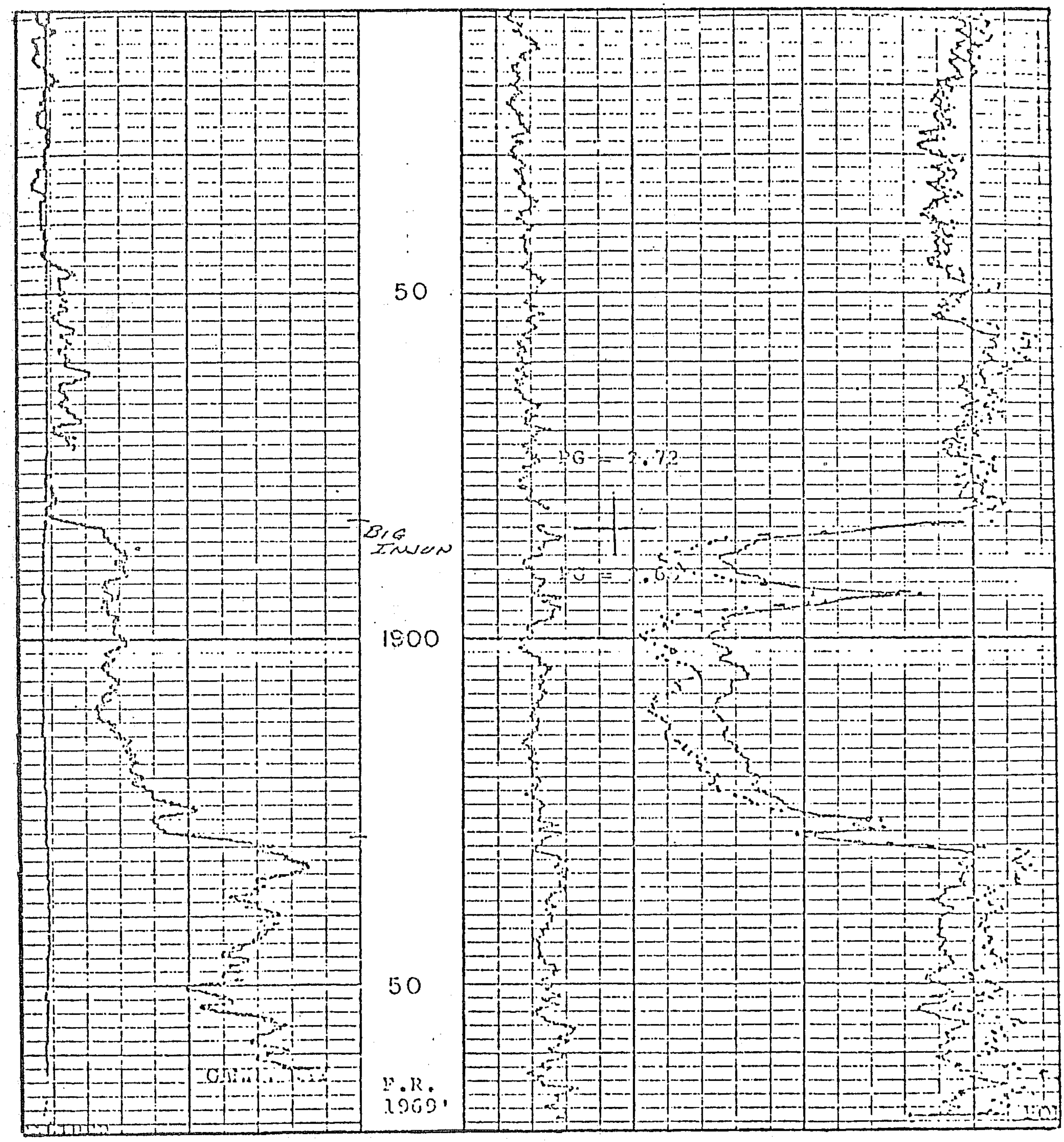
GAMMA RAY
API Units
0 100 200

CALIPER
Inches
6 11 16

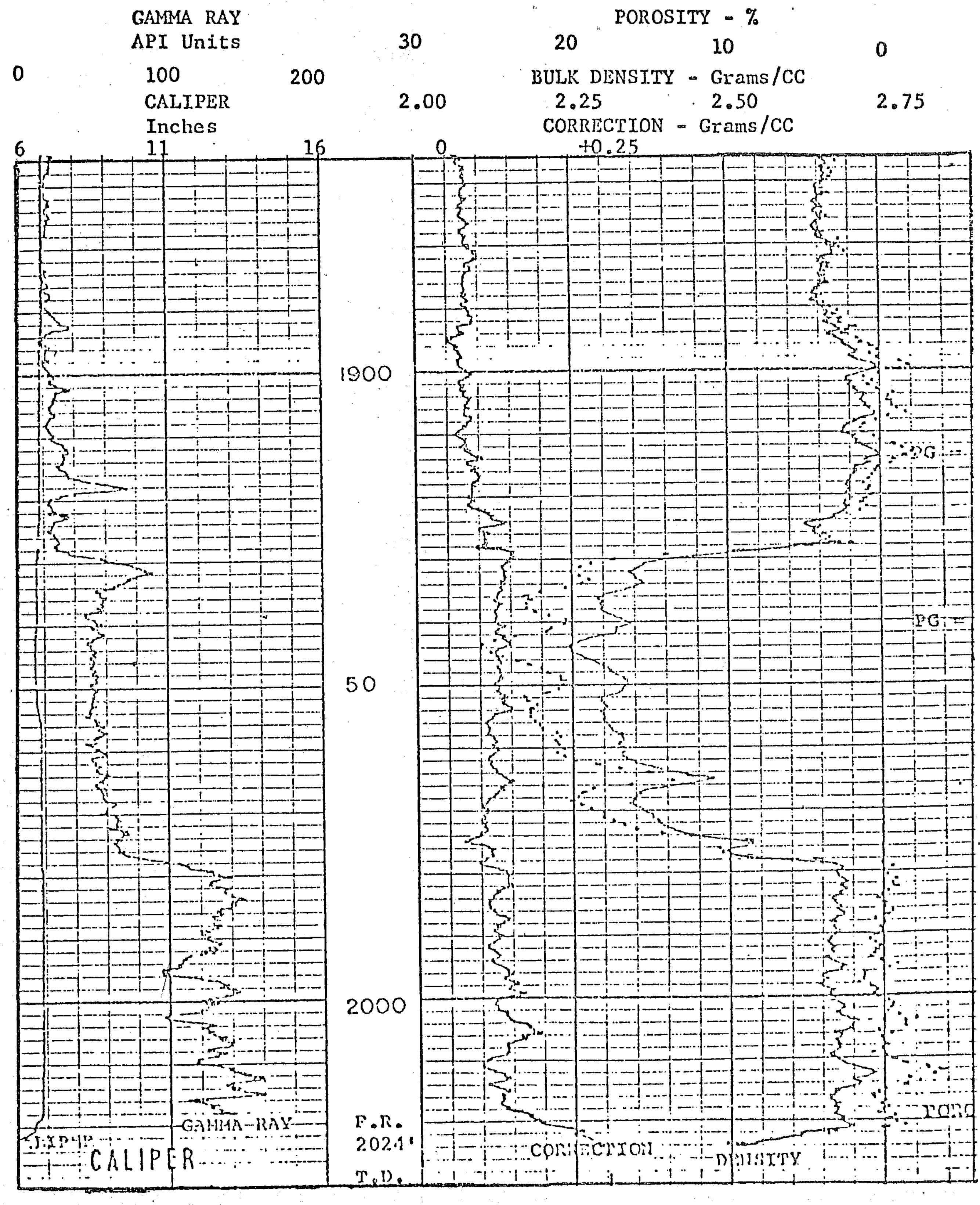
POROSITY - %
30 20 10 0

BULK DENSITY - Grams/CC
2.00 2.25 2.50 2.75

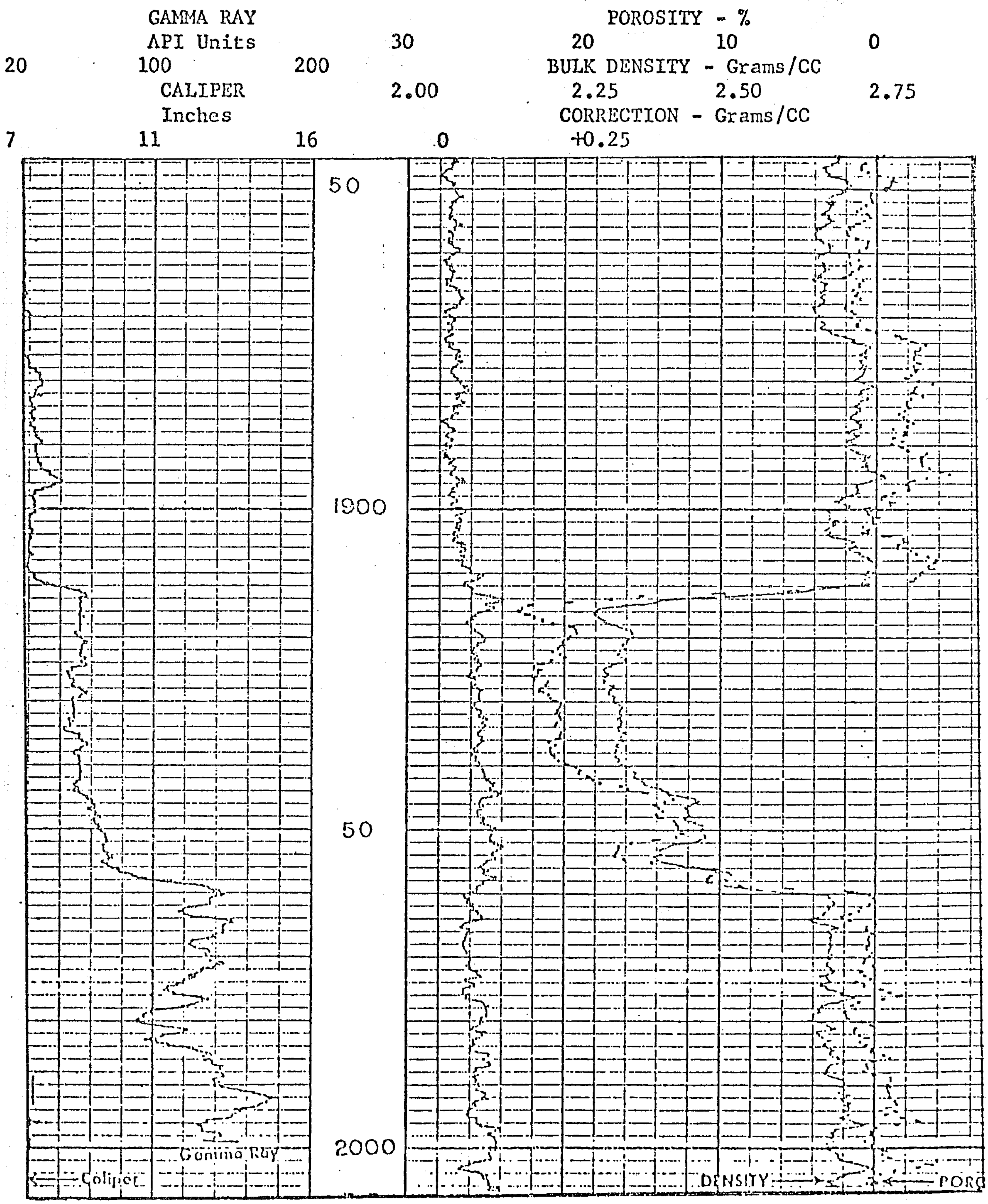
CORRECTION - Grams/CC
.0 +0.25



J. H. LOONEY PI NO. 4
Carbon Dioxide Injection Well



R. C. ELMORE PI NO. 5
Carbon Dioxide Injection Well



L. W. SHAFFER PI NO. 6
Carbon Dioxide Injection Well

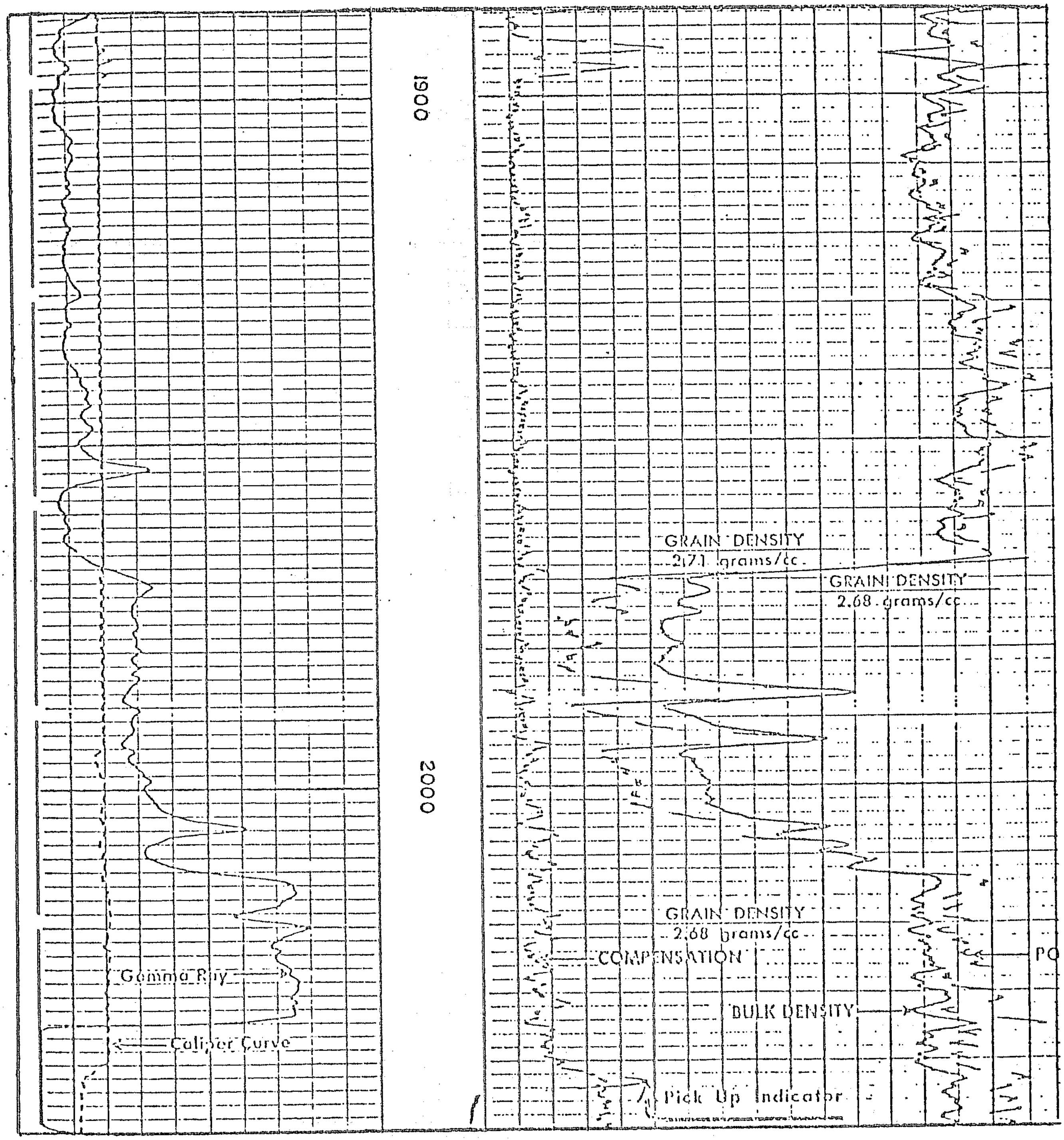
GAMMA RAY
API Units
0 100 200

CALIPER
Inches
5 10 15

POROSITY - %
30 20 10 0

BULK DENSITY - Grams/CC
2.00 2.25 2.50 2.75

CORRECTION - Grams/CC
0 +0.25

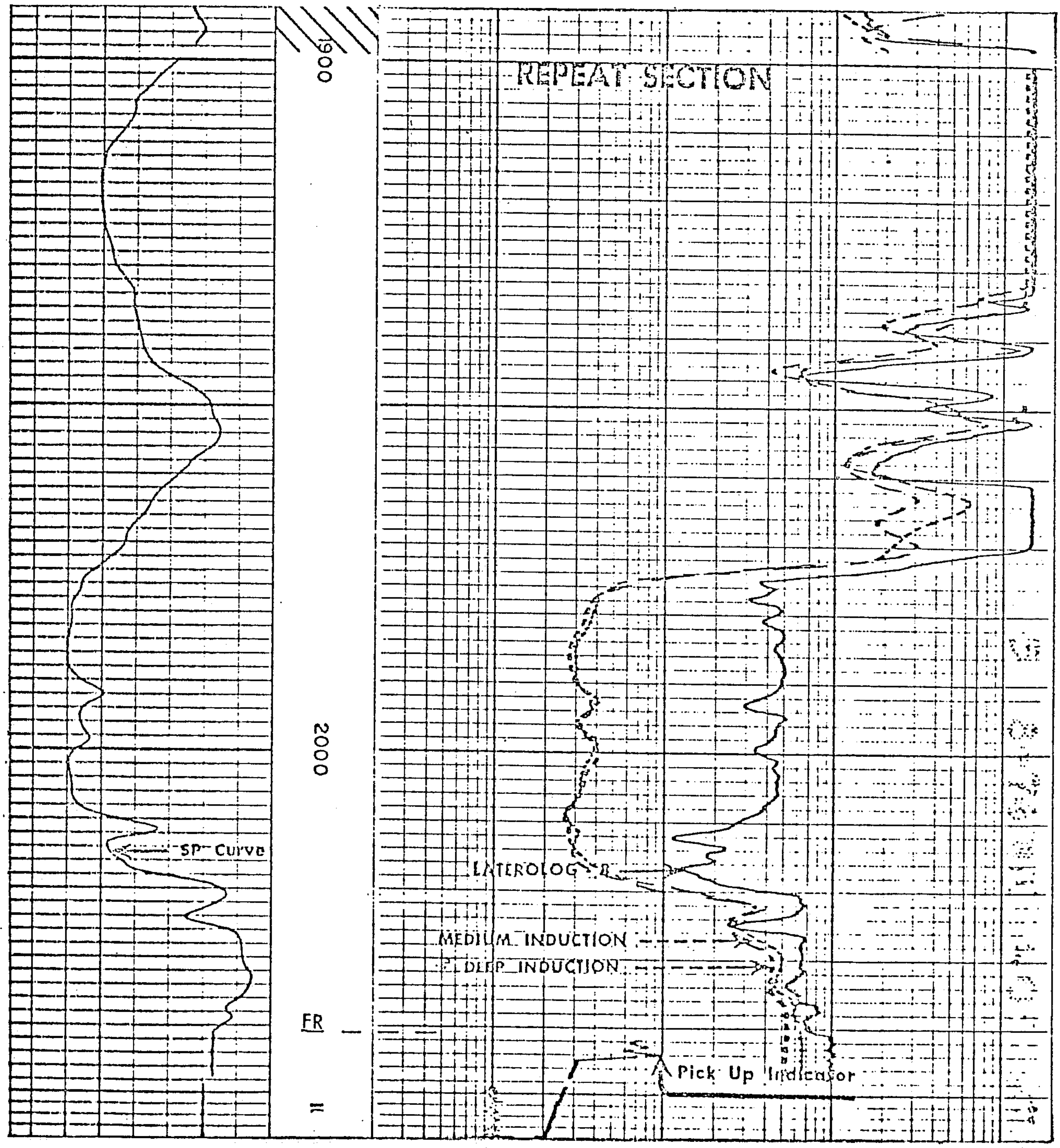


L. W. SHAFFER PI NO. 6
Carbon Dioxide Injection Well

SPONTANEOUS POTENTIAL
Millivolts
20

RESISTIVITY - Ohm m/m
Laterolog - 8
Medium Induction Log
Deep Induction Log

0.2 10 10 100 1000

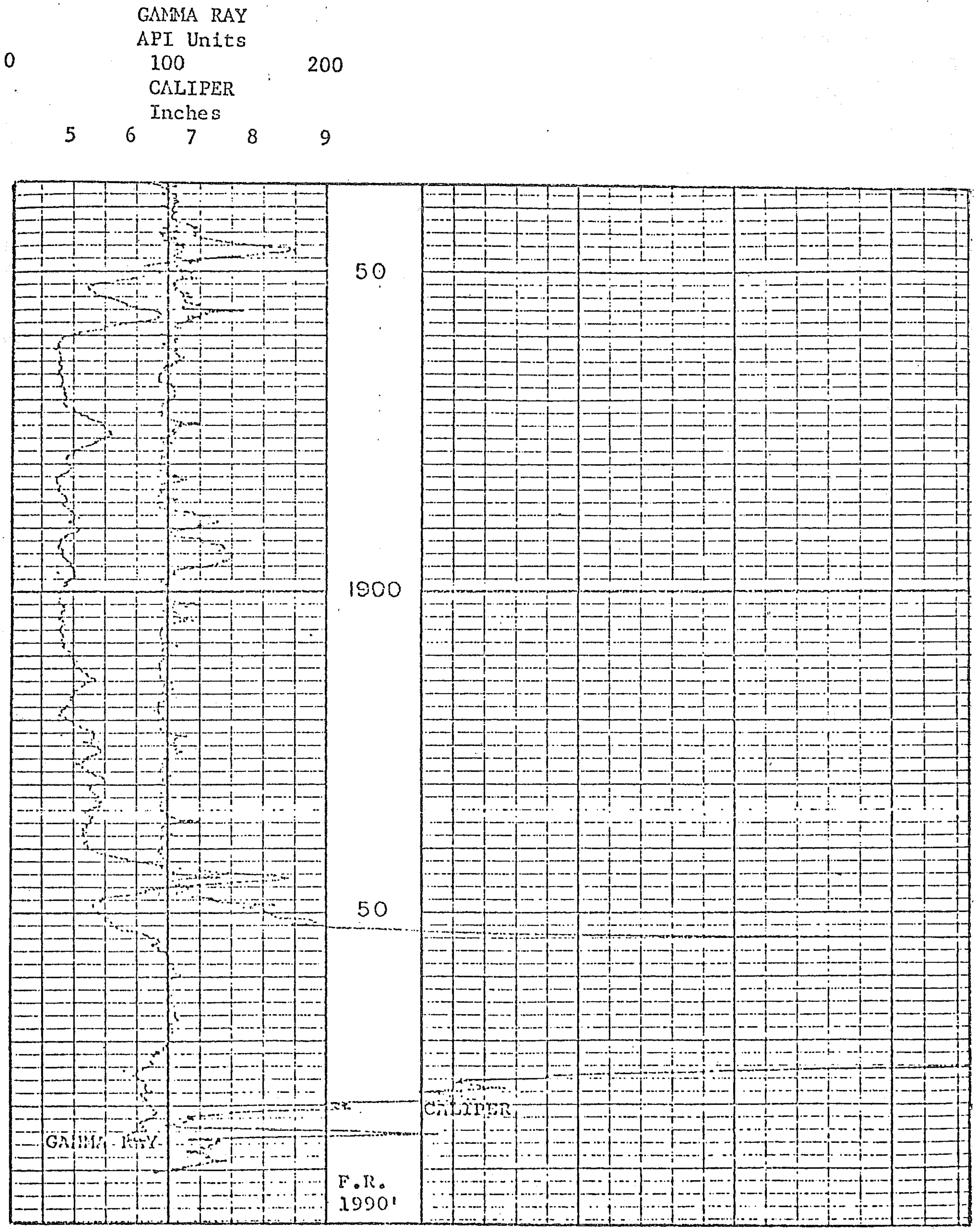


APPENDIX C

Back-up Water Injection
Well Logs

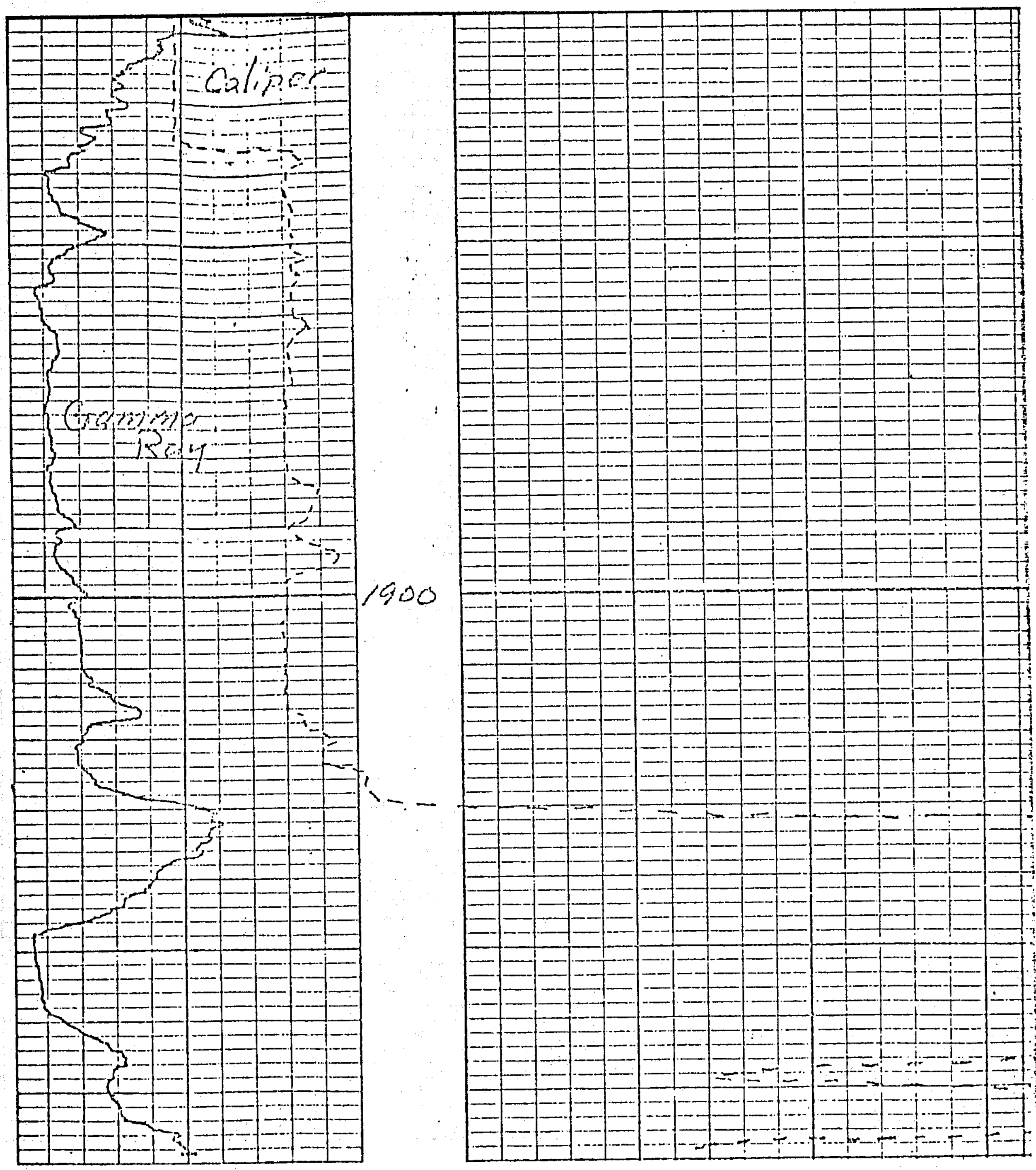
Big Injun Section

R. C. ELMORE NO. 1
Reconditioned Back-up Water Injection Well

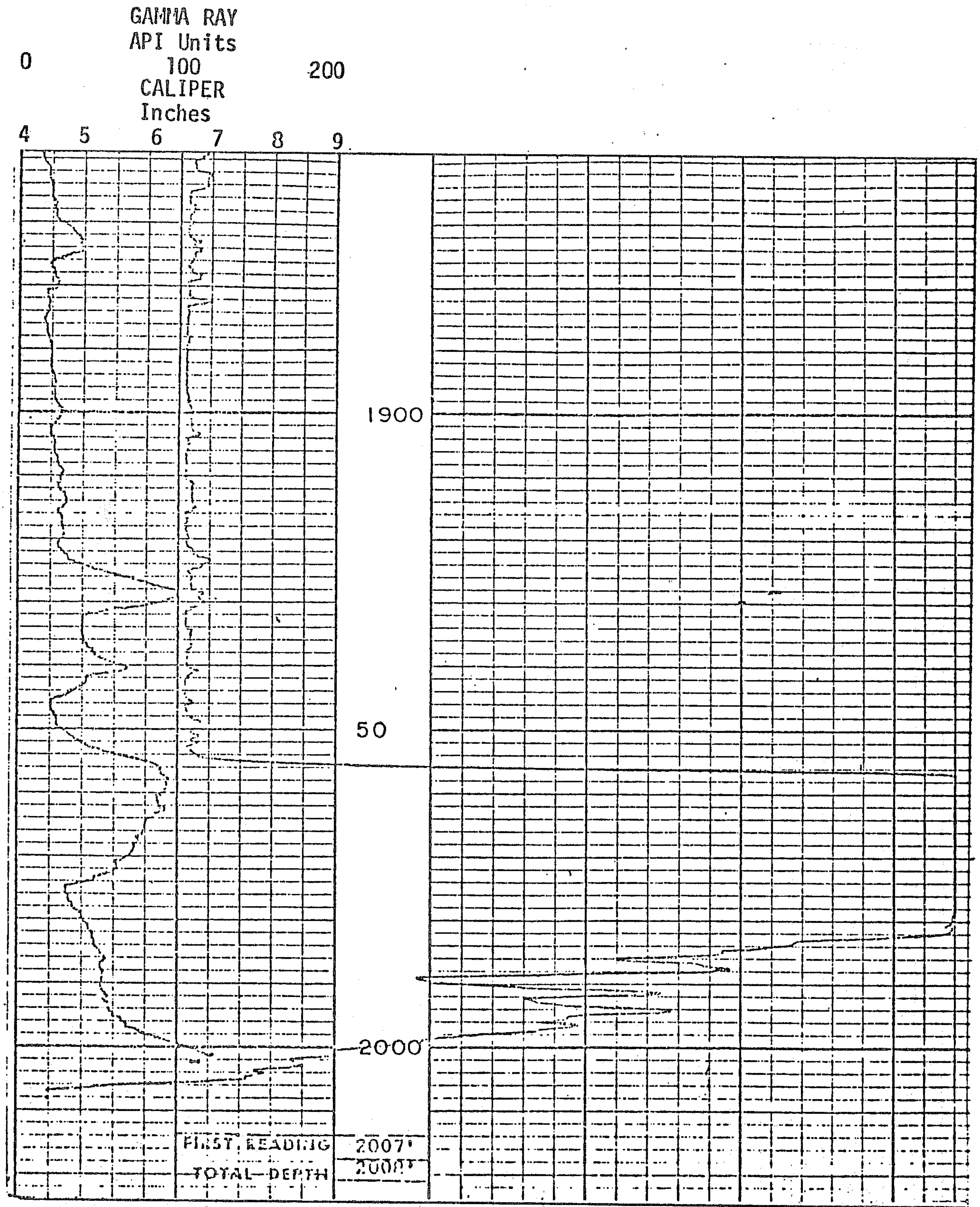


R. C. ELMORE NO. 4
Reconditioned Back-up Water Injection Well

GAMMA RAY
API Units
0 100 200
CALIPER
Inches
3 4 5 6 7 8 9 10 11



E. Lewis No.17
Reconditioned Back-up Water Injection Well



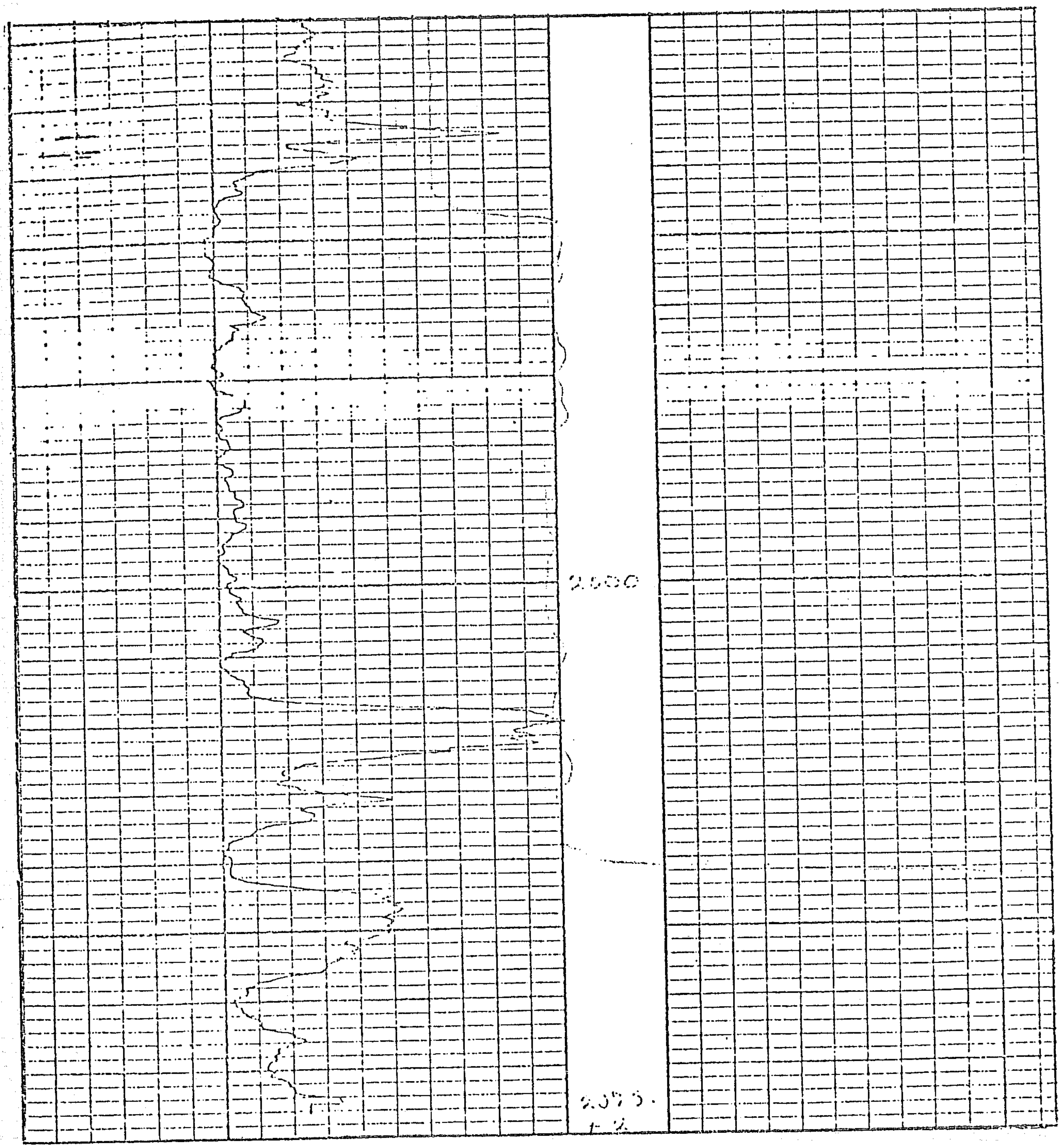
E. LEWIS NO. 18
Reconditioned Back-up Water Injection Well

GAMMA RAY
API Units

0 42 84 126 168 210

CALIPER
Inches

2 4 6 8 10 12 14



E. LEWIS NO. 27
New Back-up Water Injection Well

GAMMA RAY
API Units
20 100 200

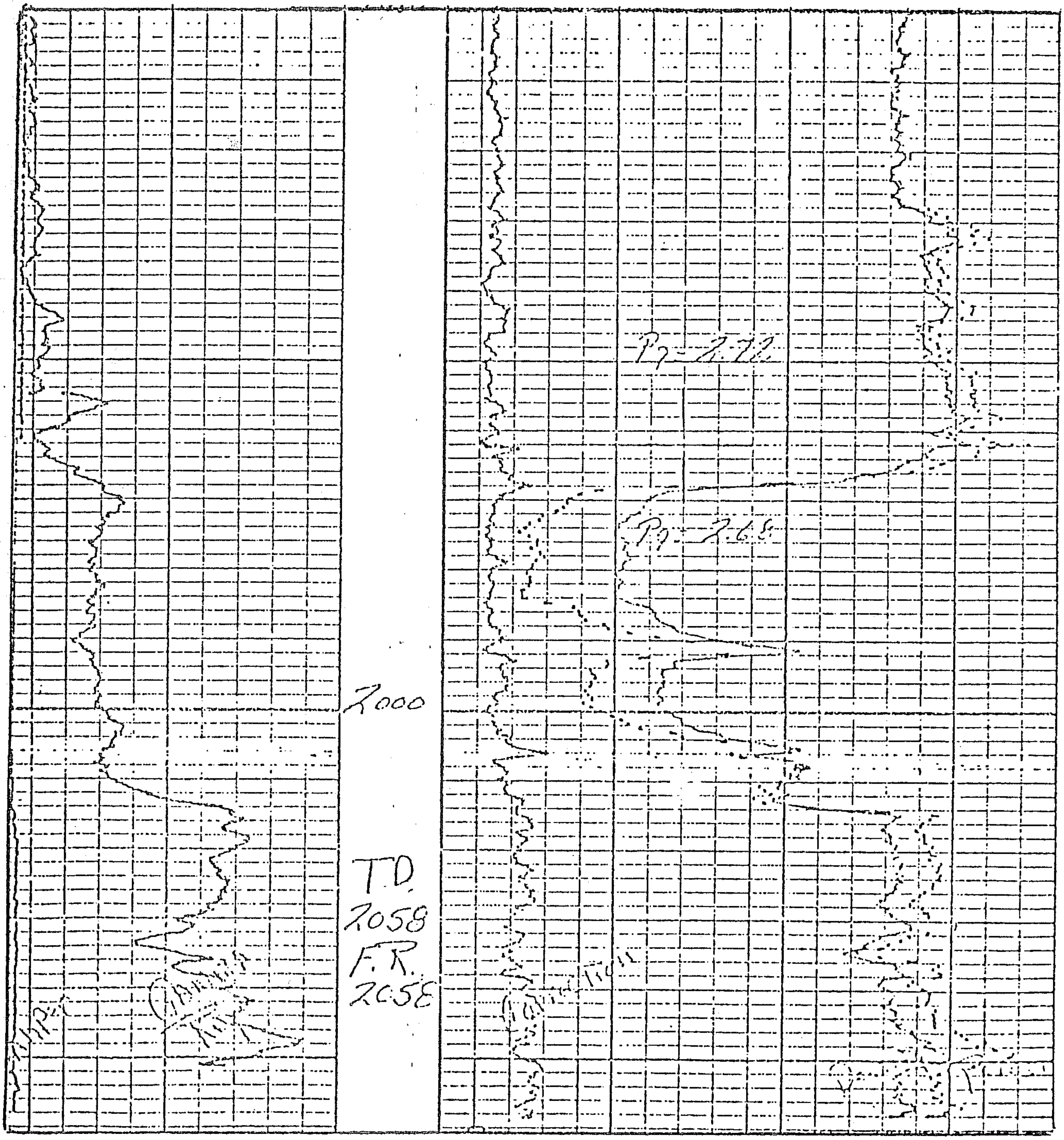
CALIPER
Inches
7 11 16

-30 2.00 0

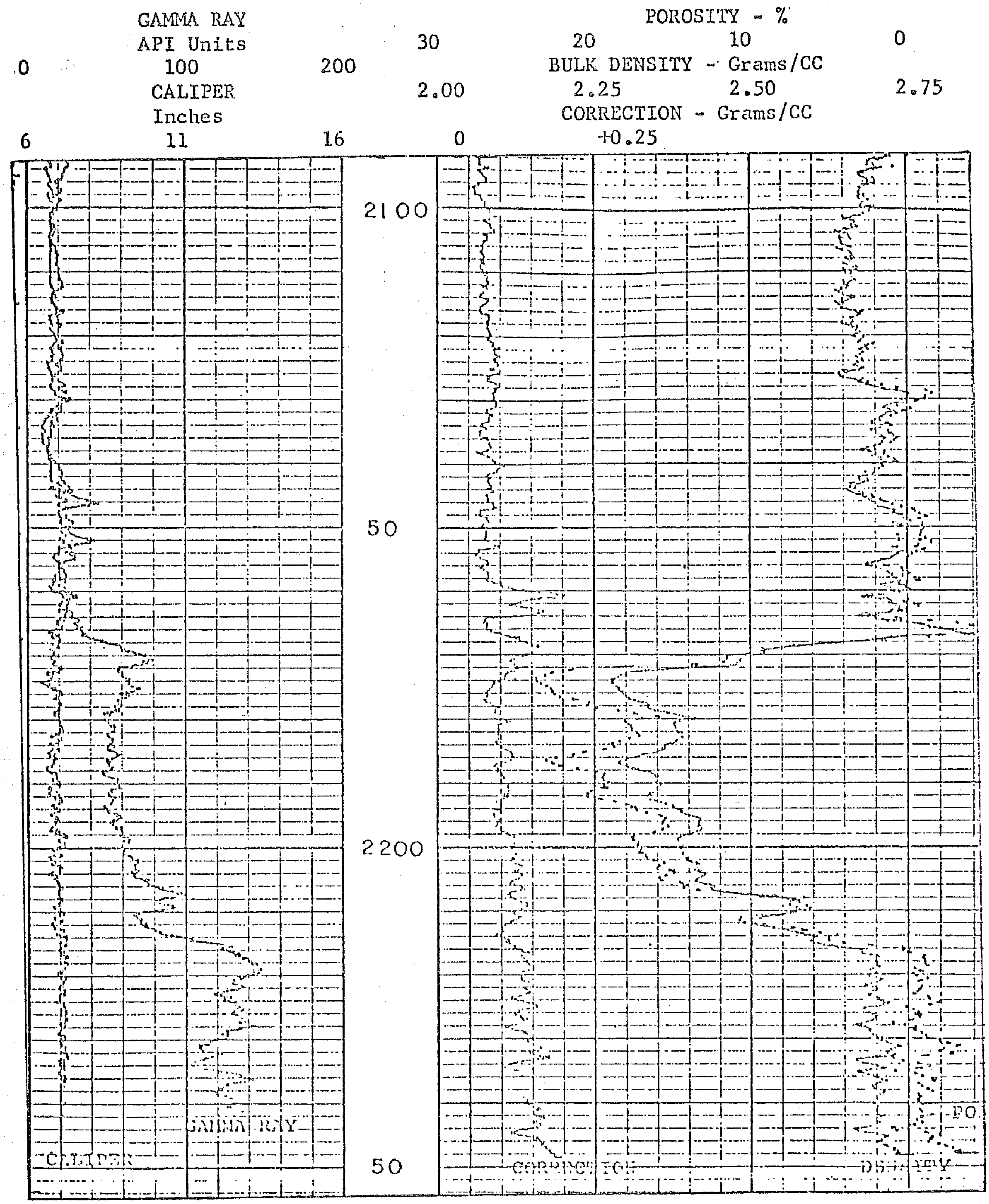
POROSITY - %
20 10 0

BULK DENSITY - Grams/CC
2.25 2.50 2.75

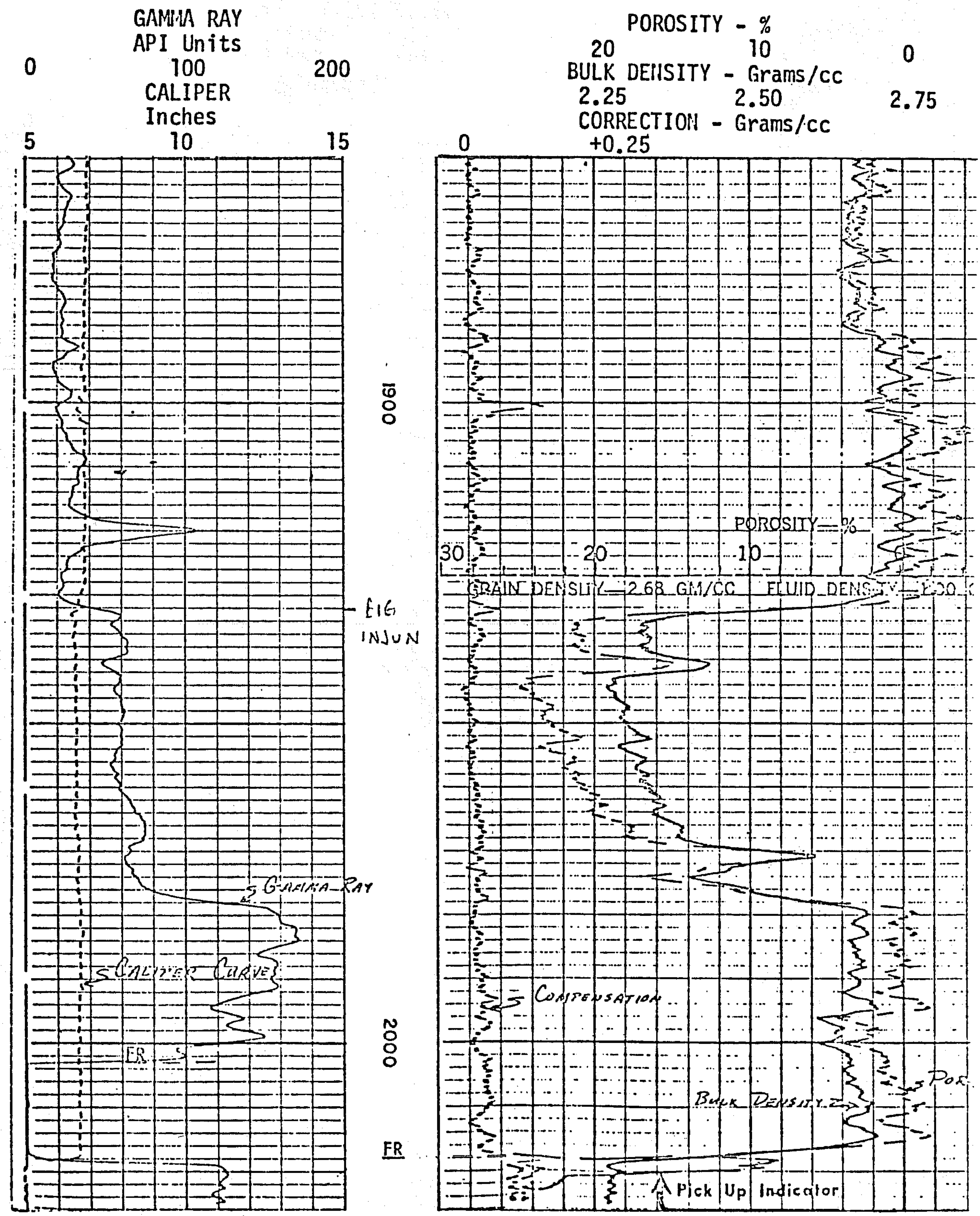
CORRECTION - Grams/CC
+0.25



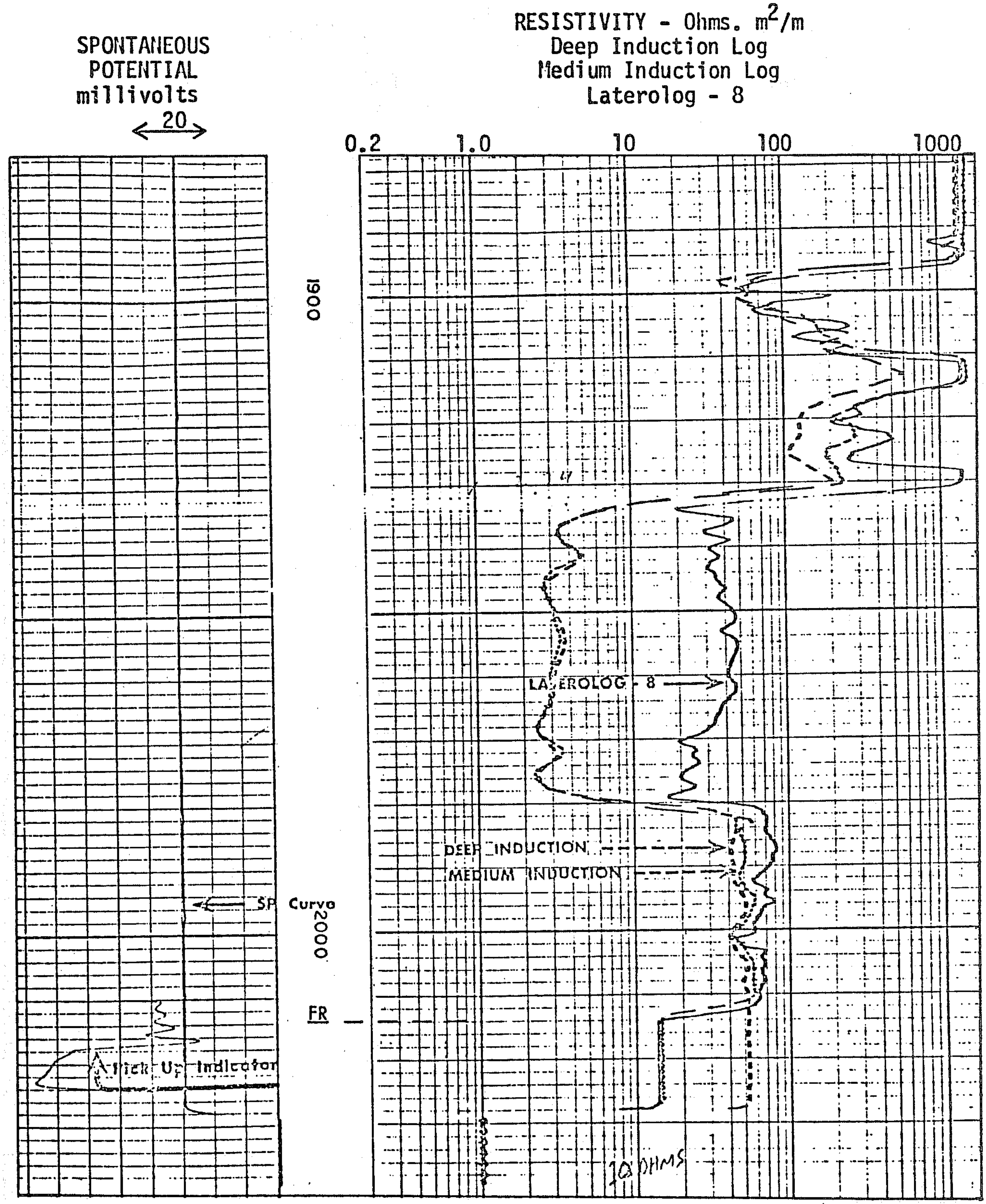
E. LEWIS NO. 28
New Back-up Water Injection Well



E. Lewis No. 29
New Back-up Water Injection Well

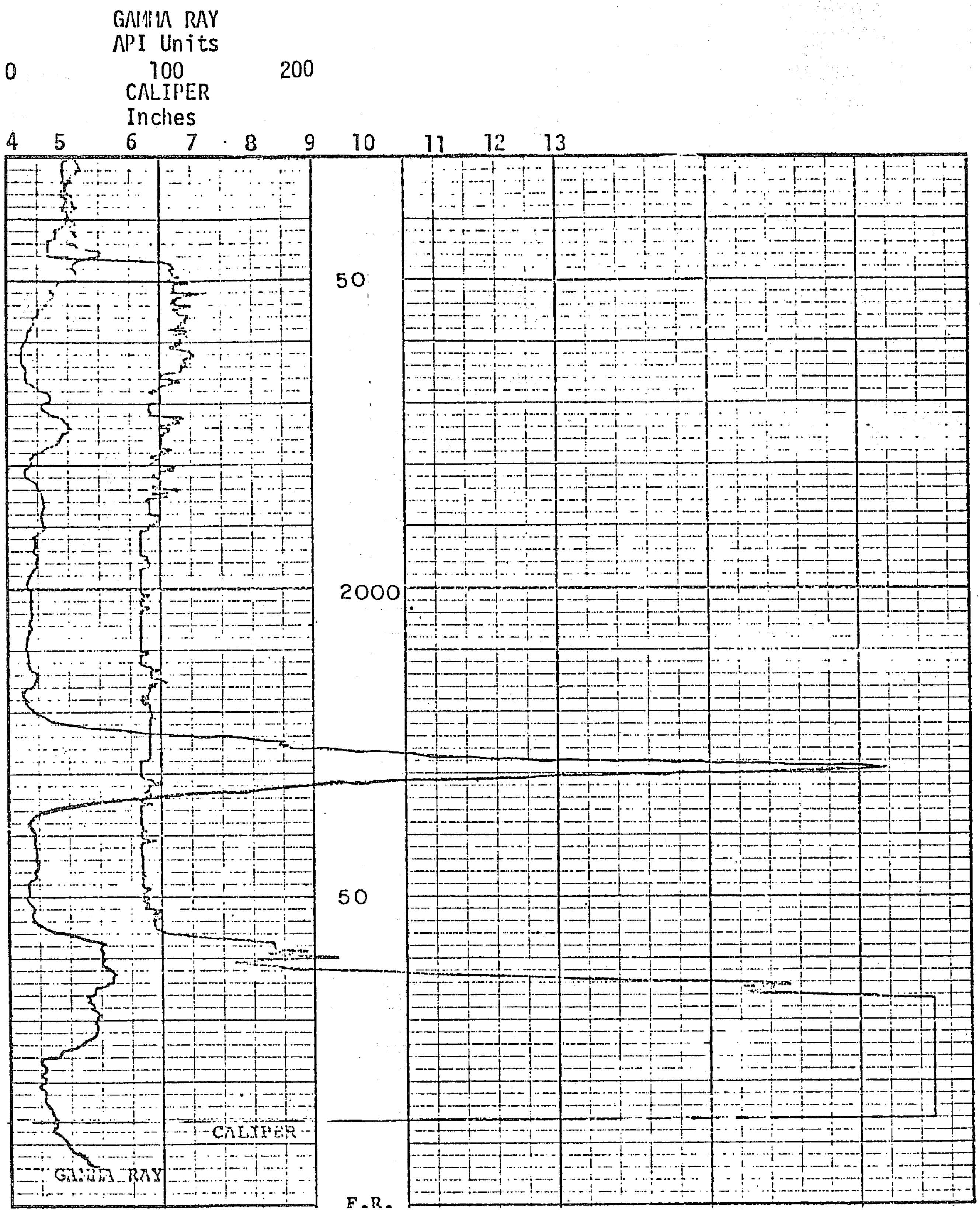


E. Lewis No. 29
New Back-up Water Injection Well

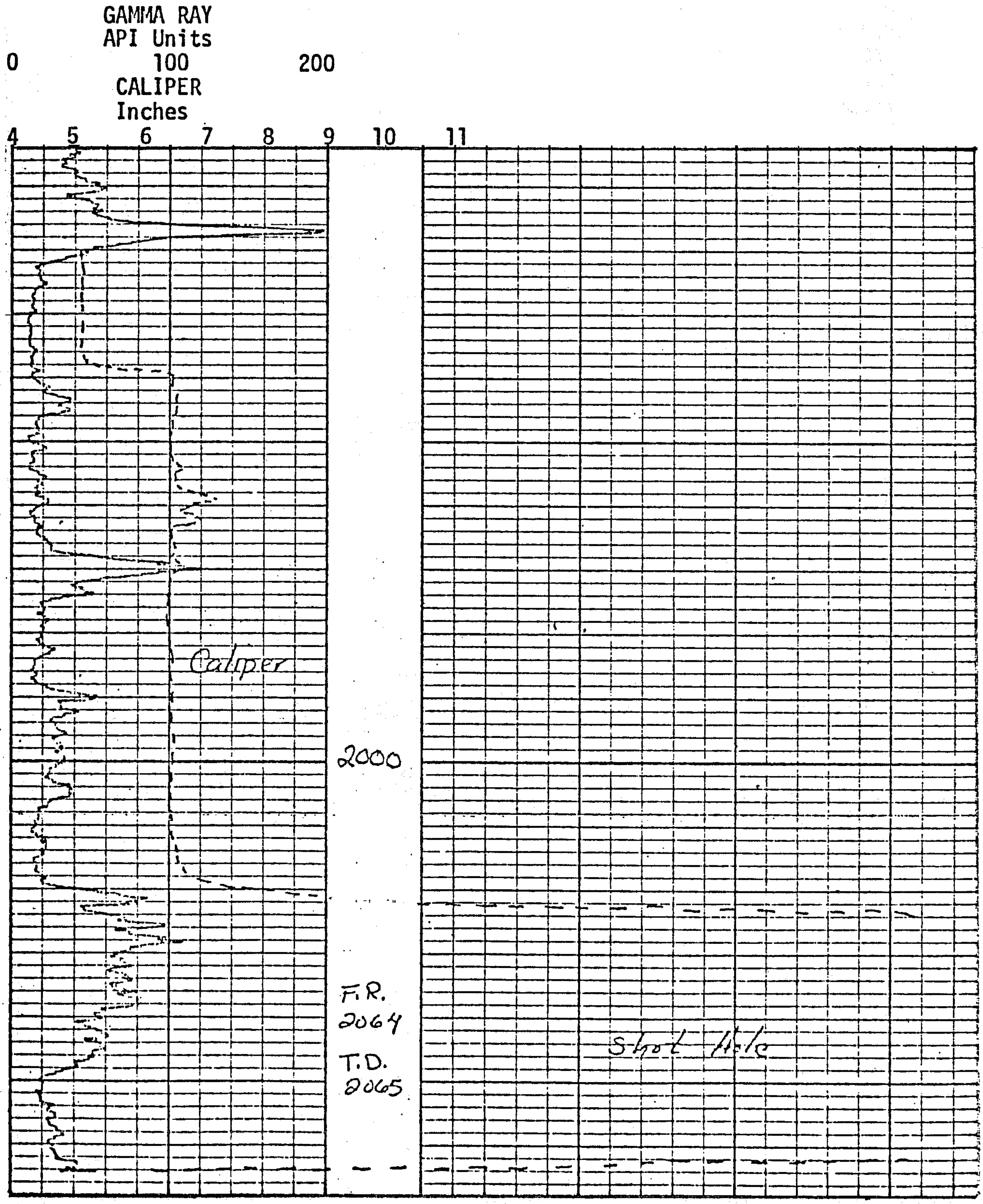


L. W. Shaffer No. 2

Reconditioned Back-up Water Injection Well



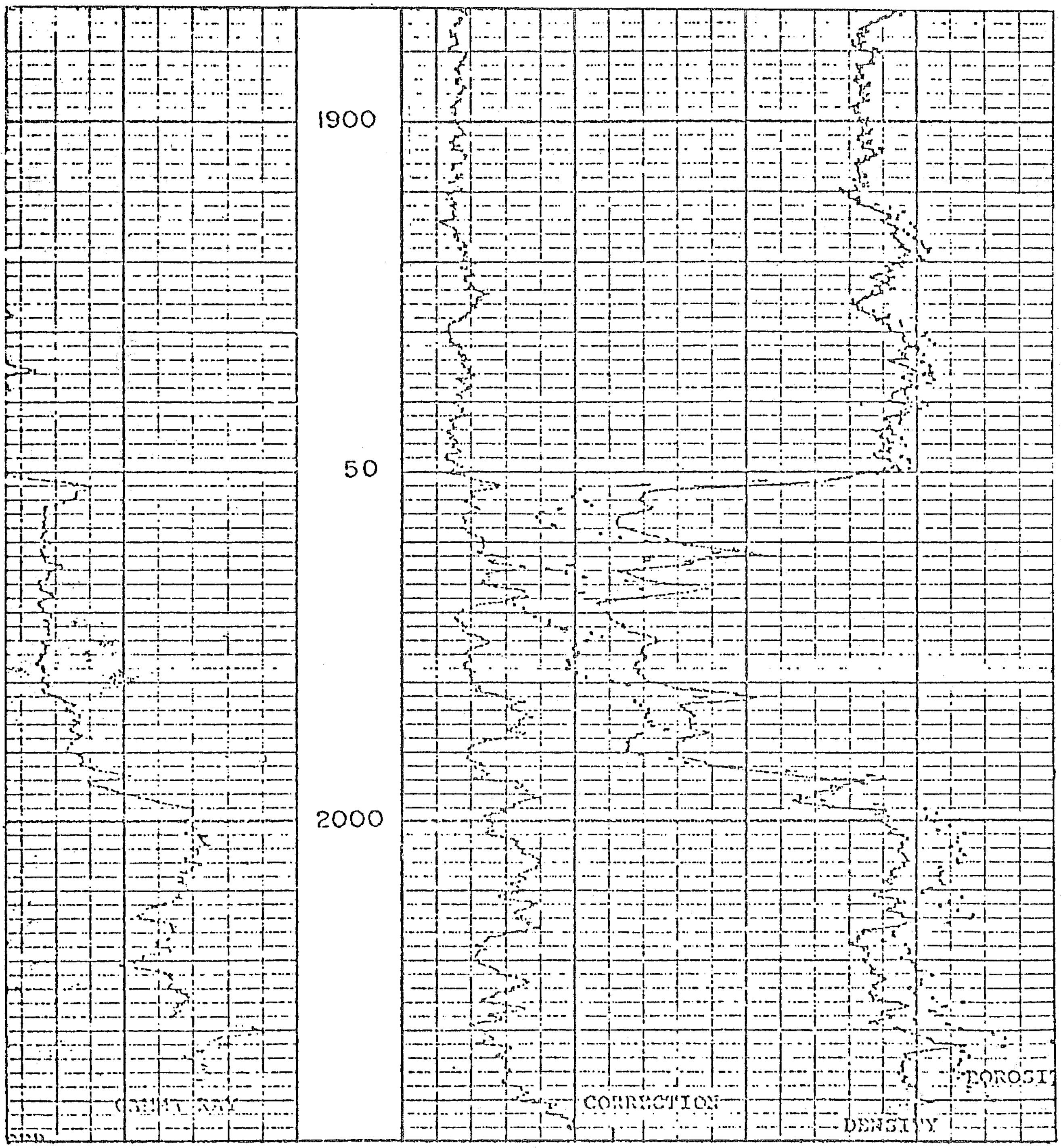
L. W. Shaffer No. 8
Reconditioned Back-up Water Injection Well



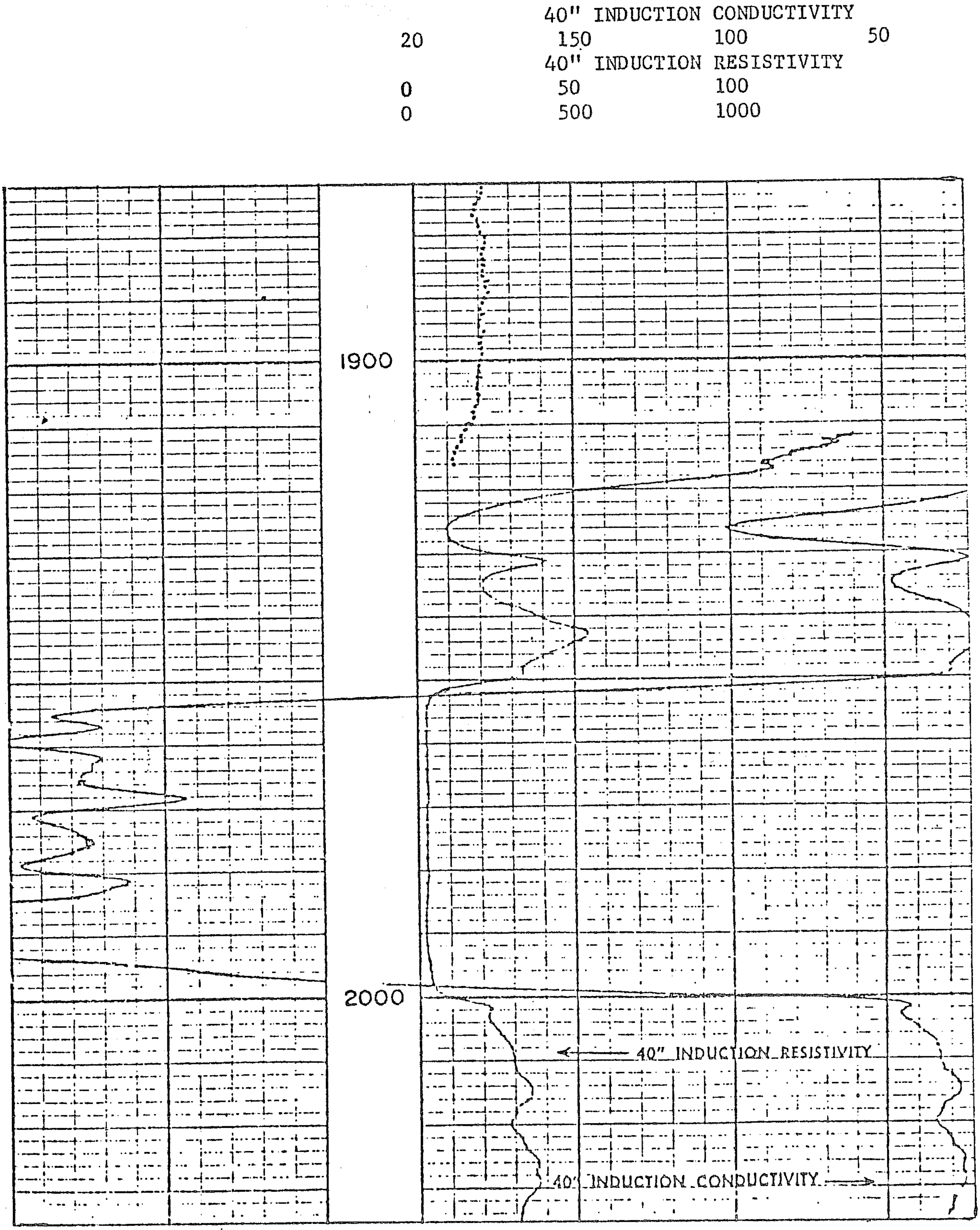
L. W. SHAFFER NO. 10
New Back-up Water Injection Well

GAMMA RAY
API Units
40 100 200
CALIPER
Inches
8 11 16

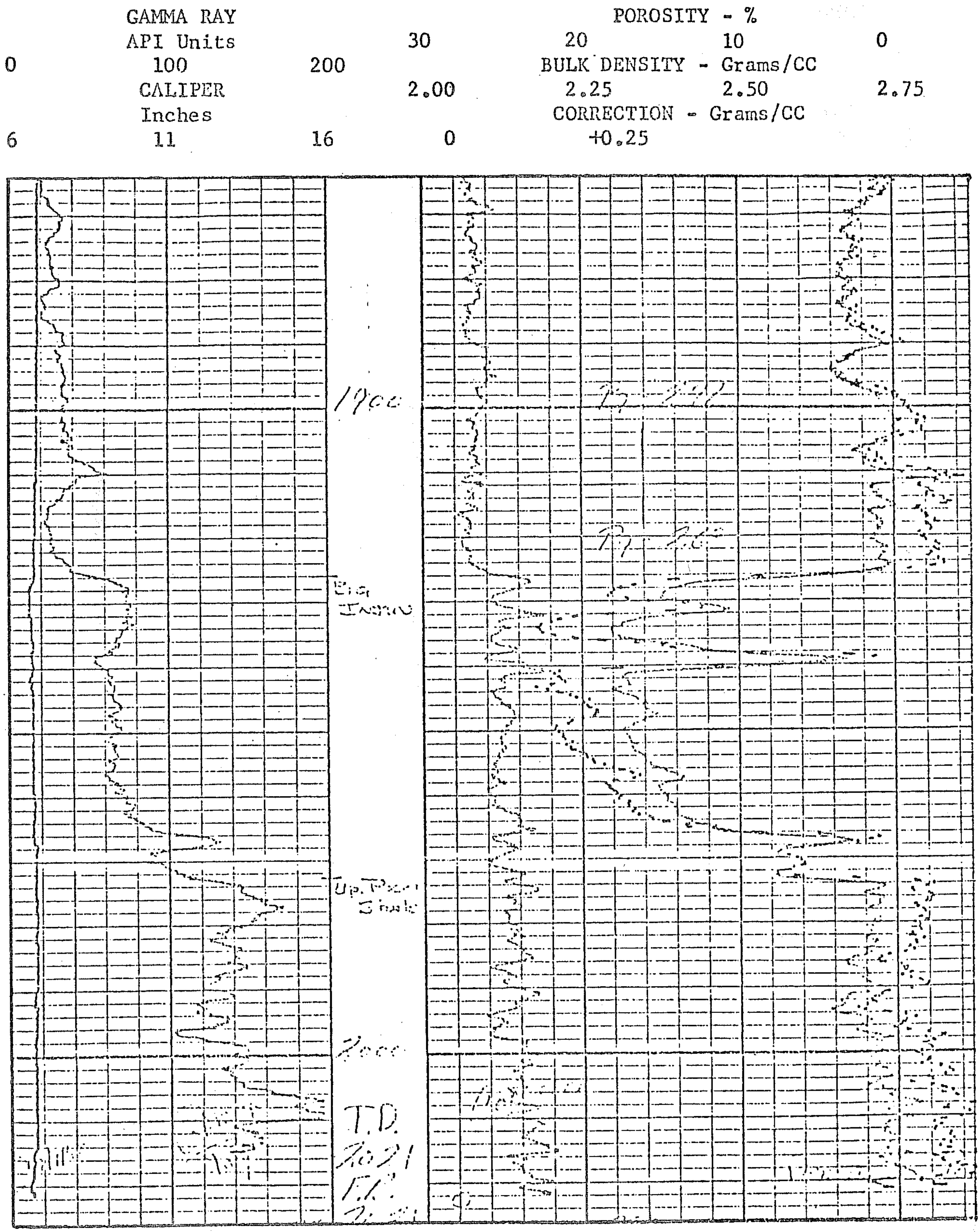
POROSITY - %
30 20 10 0
BULK DENSITY - Grams/CC
2.00 2.25 2.50 2.75
CORRECTION - Grams/CC
0 +0.25



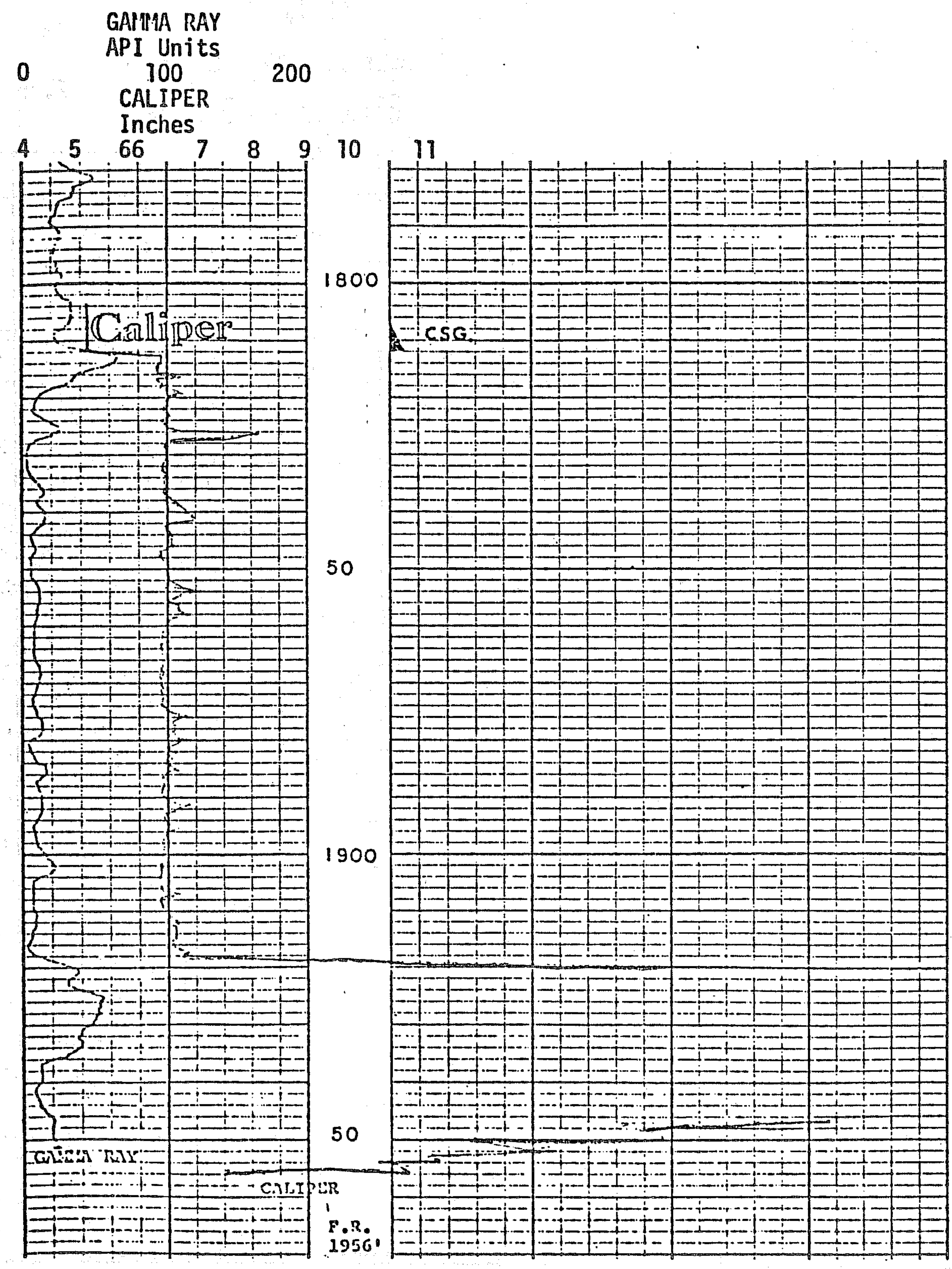
L. W. SHAFFER NO. 10
New Back-up Water Injection Well



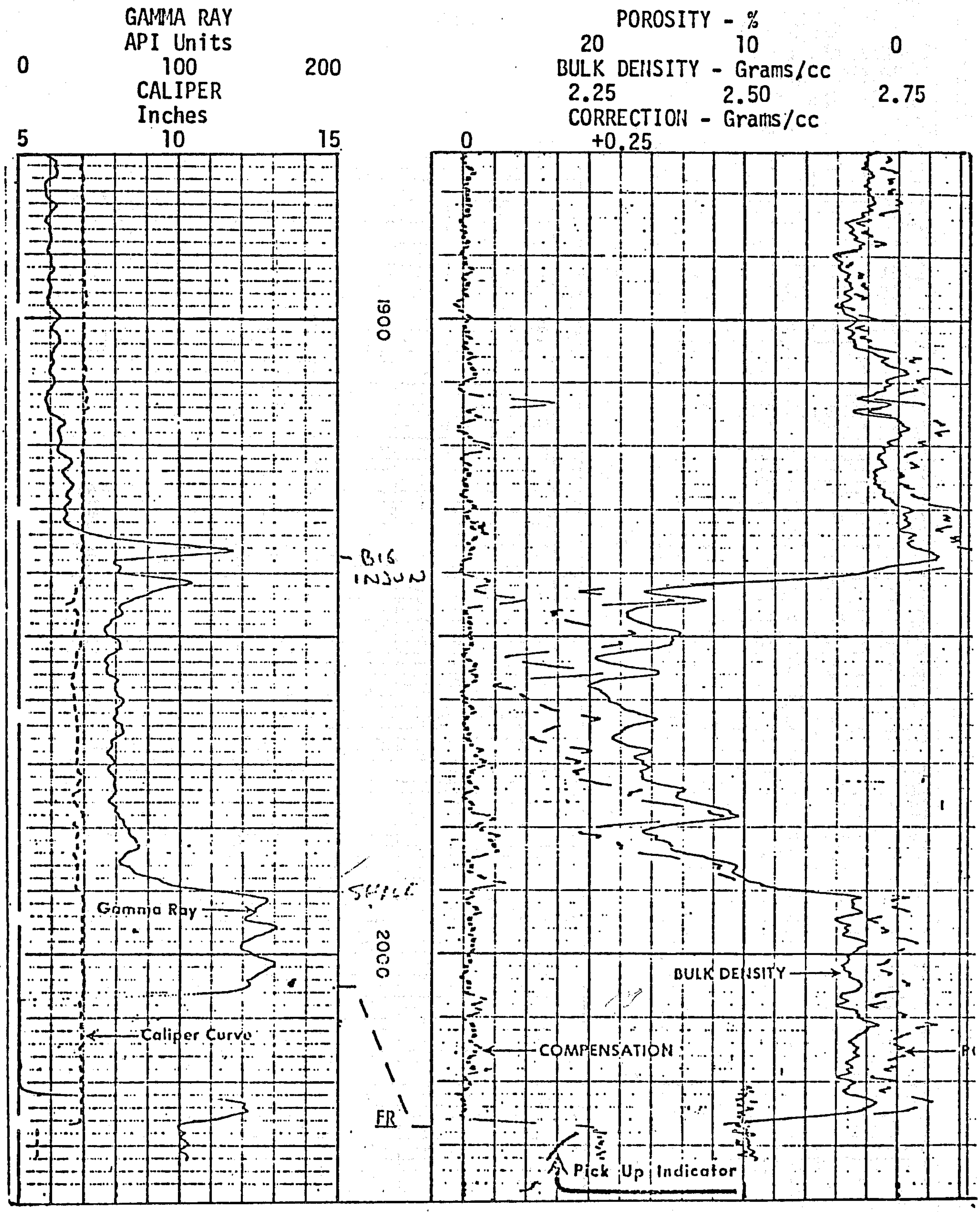
L. W. SHAFFER NO. 11
New Back-up Water Injection Well



J. H. Looney No. 1
Reconditioned Back-up Water Injection Well



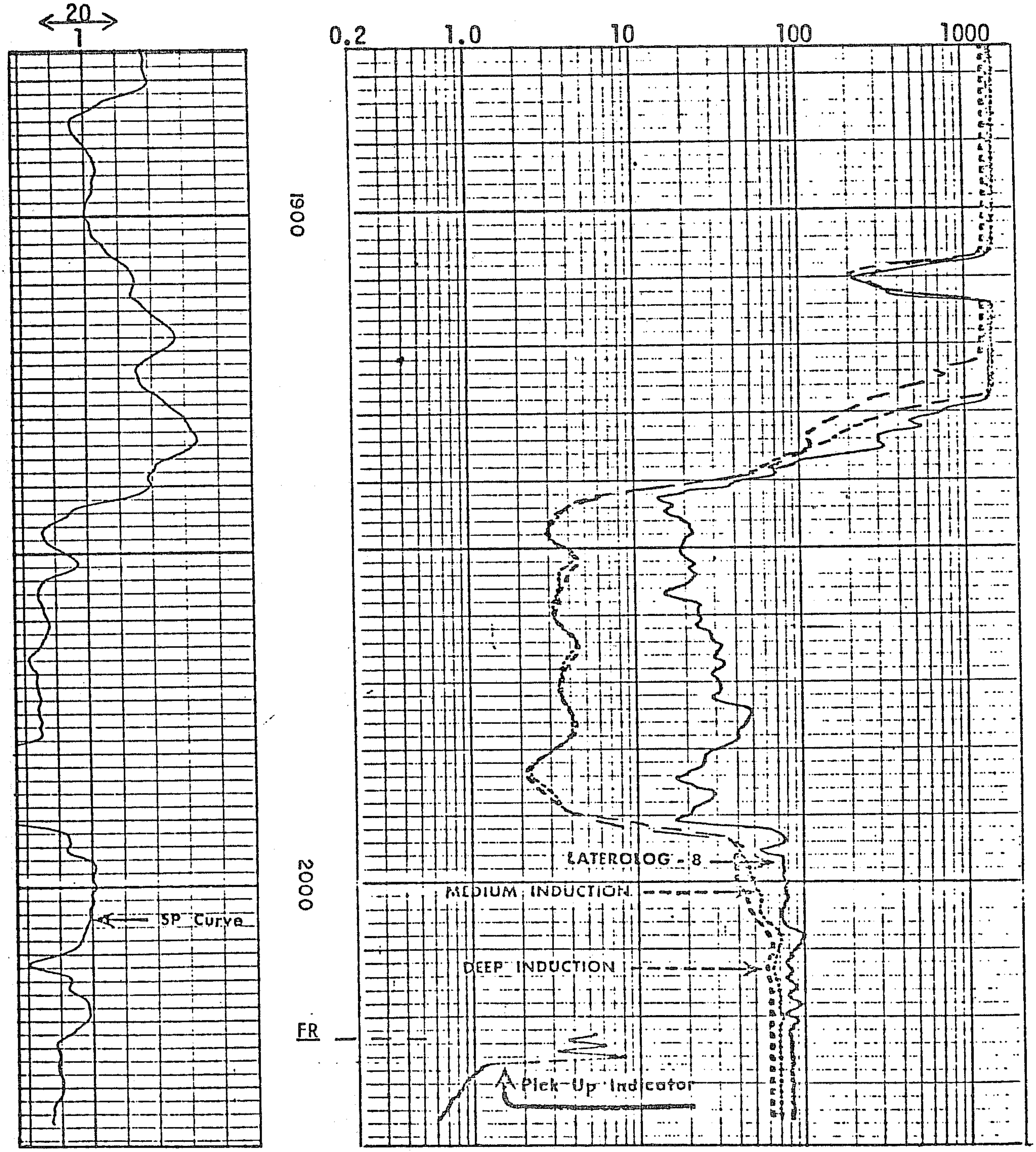
J. H. Looney No. 5
New Back-up Water Injection Well



J. H. Looney No. 5
New Back-up Water Injection Well

SPONTANEOUS
POTENTIAL
millivolts

RESISTIVITY - Ohms. m^2/m
Deep Induction Log
Medium Induction Log
Laterolog - 8

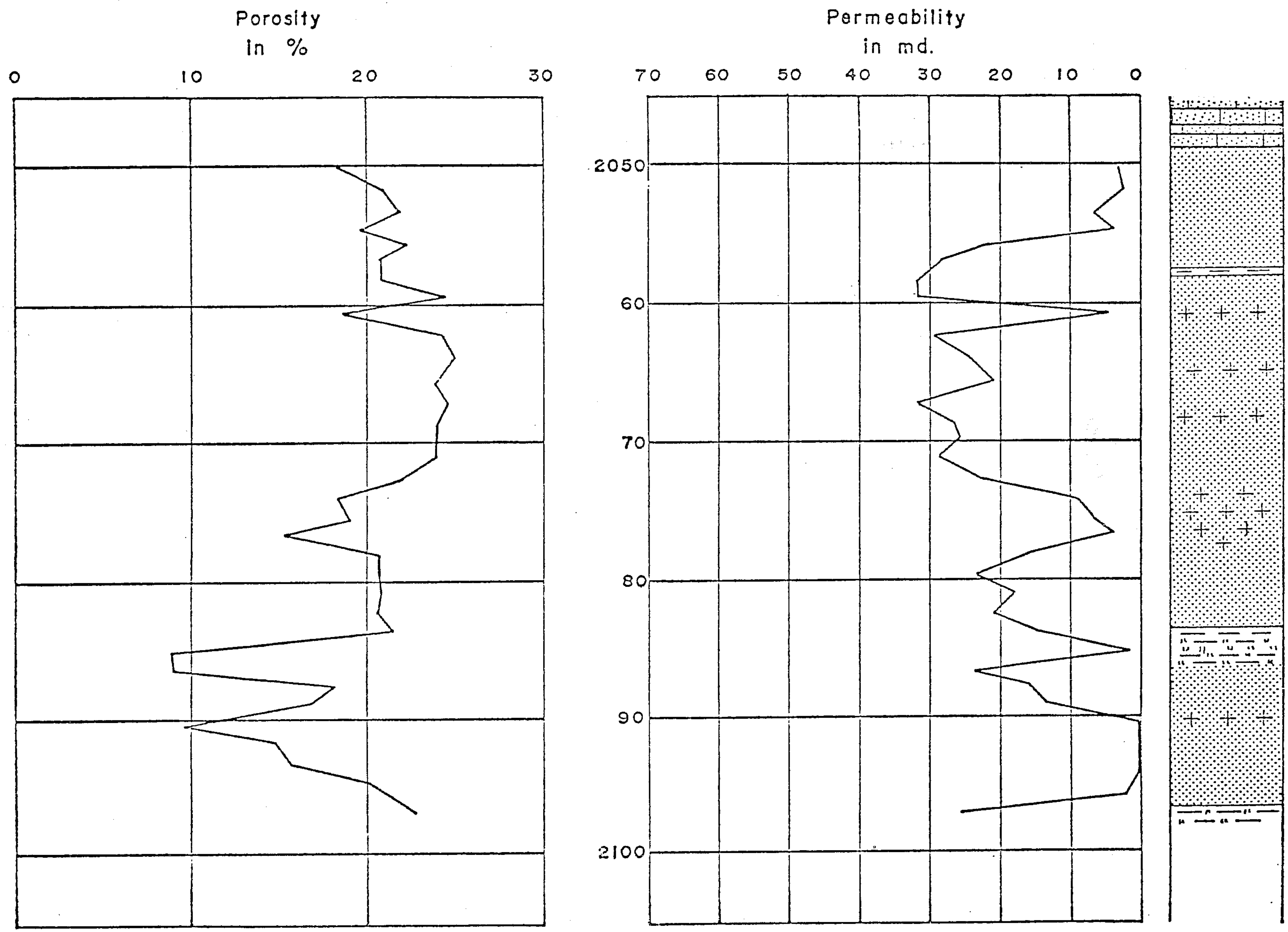


APPENDIX D

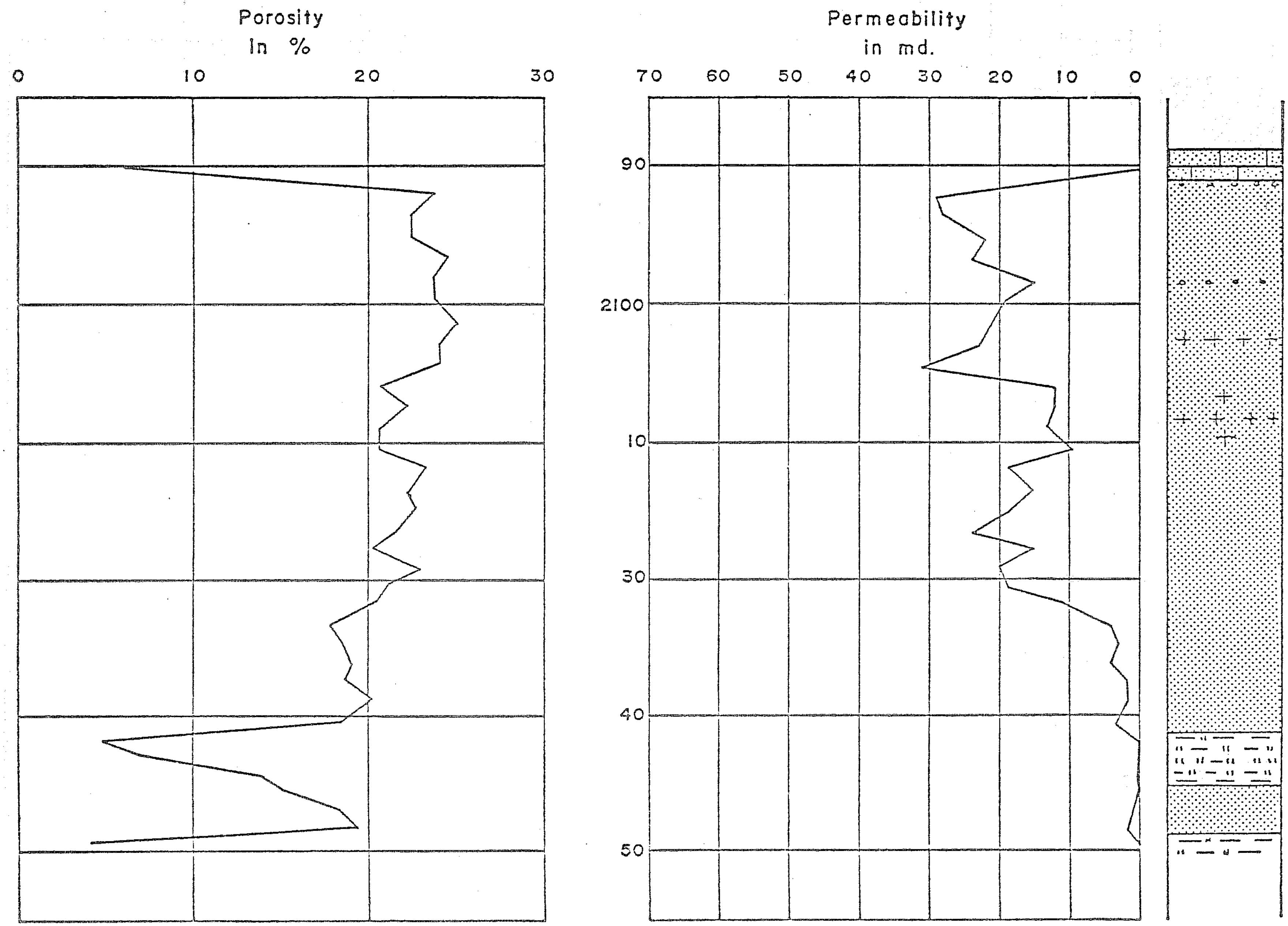
Carbon Dioxide Injection Wells

Porosity, Permeability and Lithological Profiles

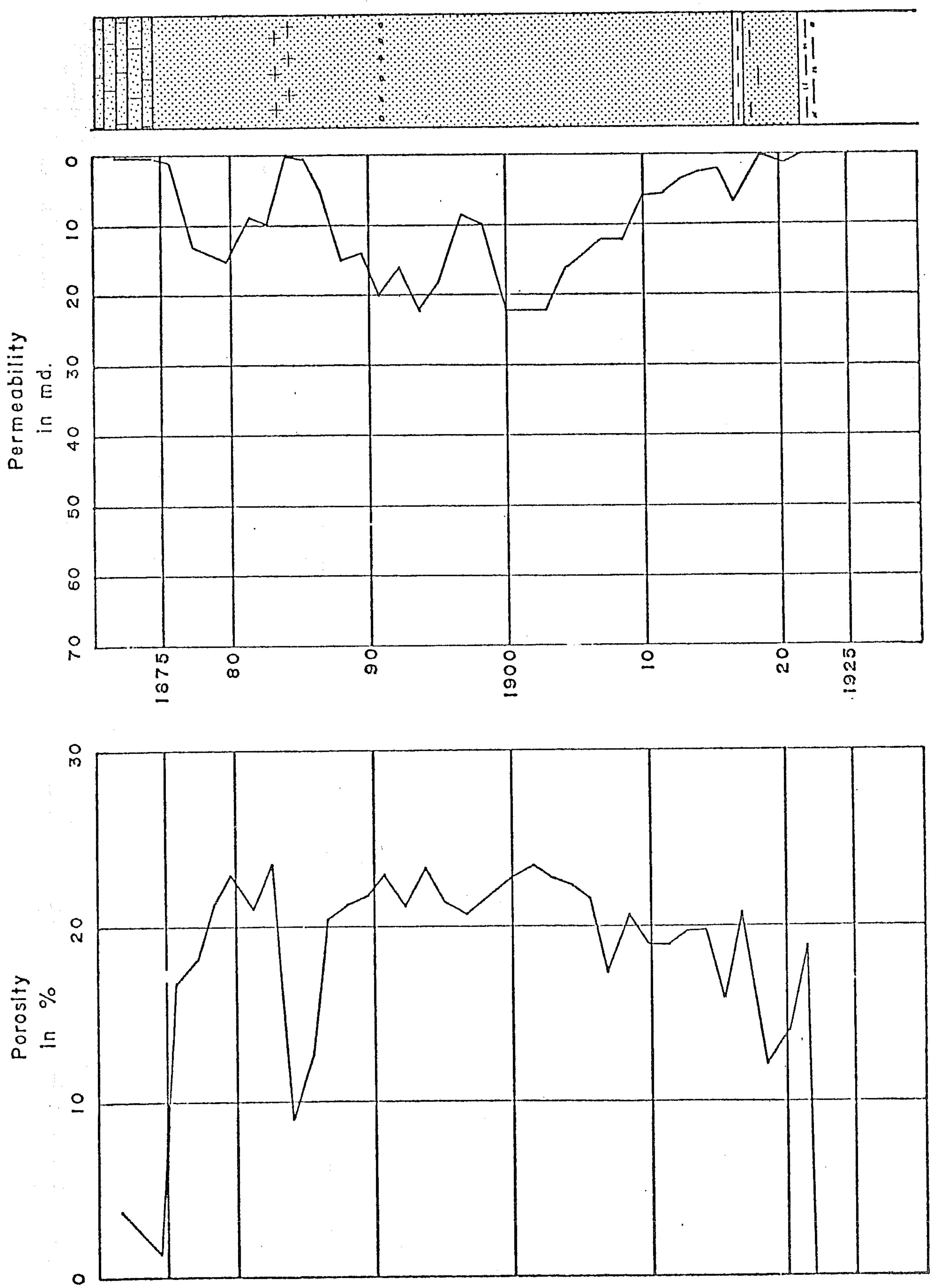
E. LEWIS P.I. #1


Porosity
In %
0
10
20
30
Permeability
in md.
70
60
50
40
30
20
10
0
2050
60
70
80
90
2100

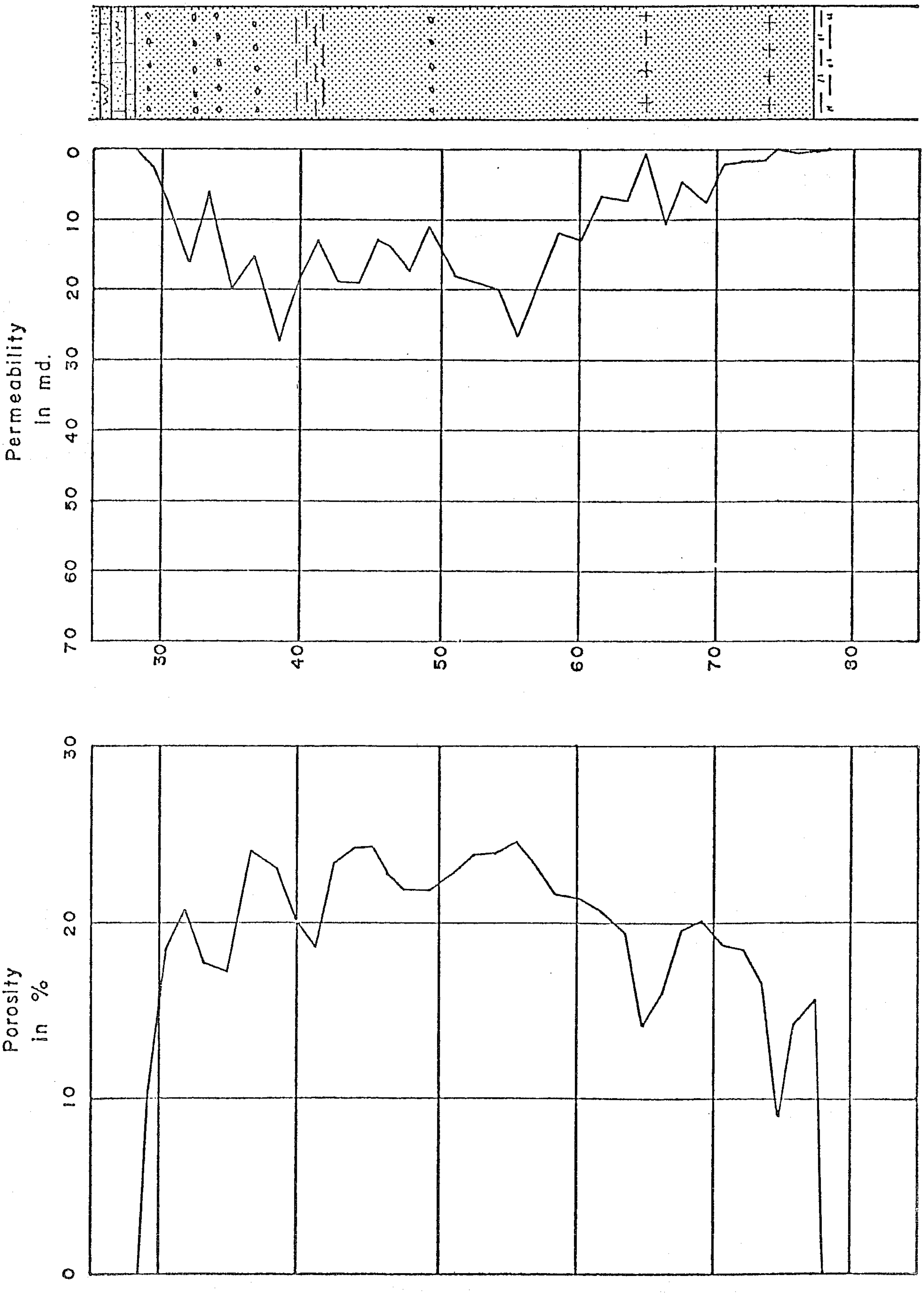
L.W. SHAFFER P.I. # 2



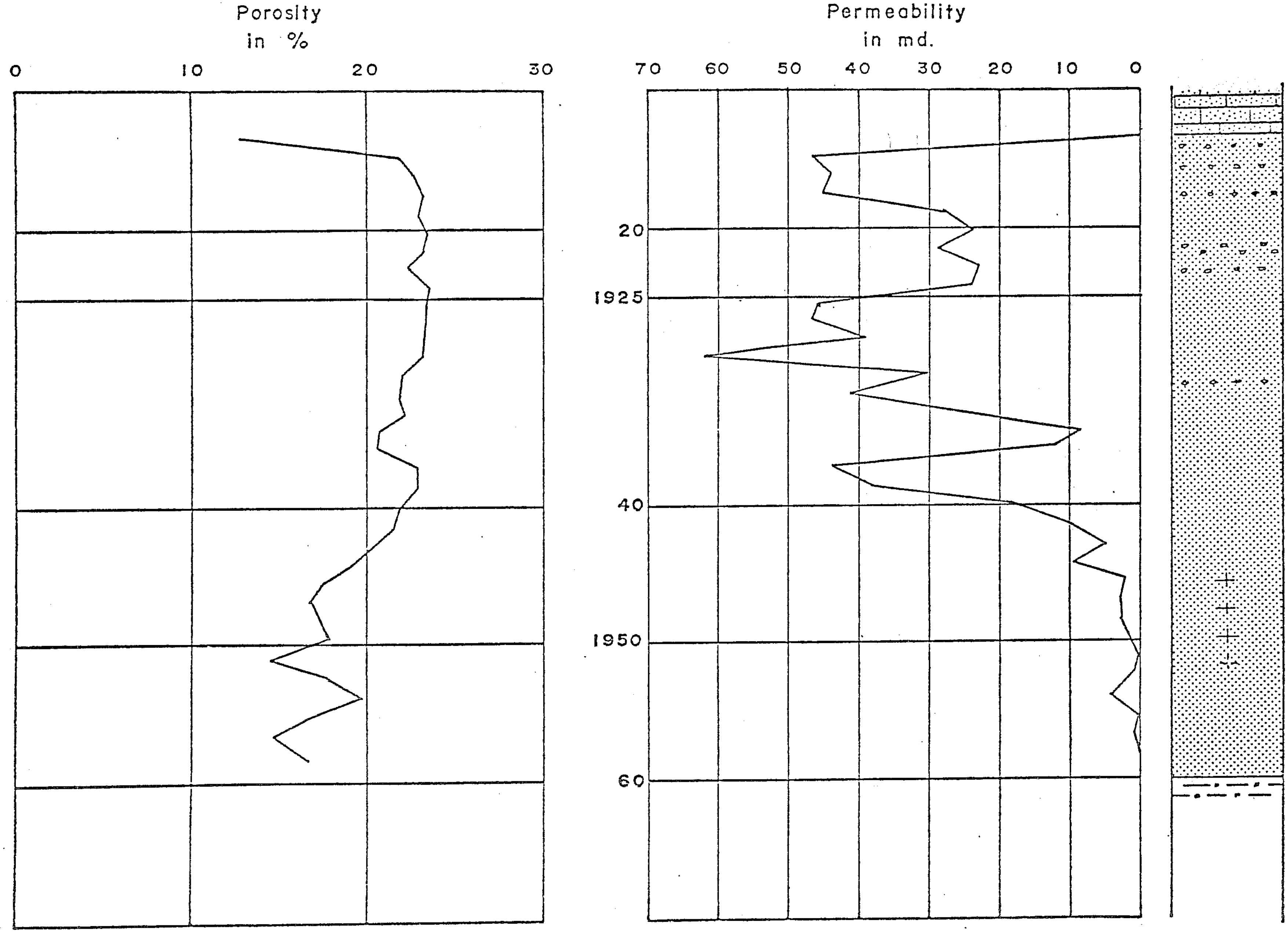
L.W. SHAFFER P.I.#3



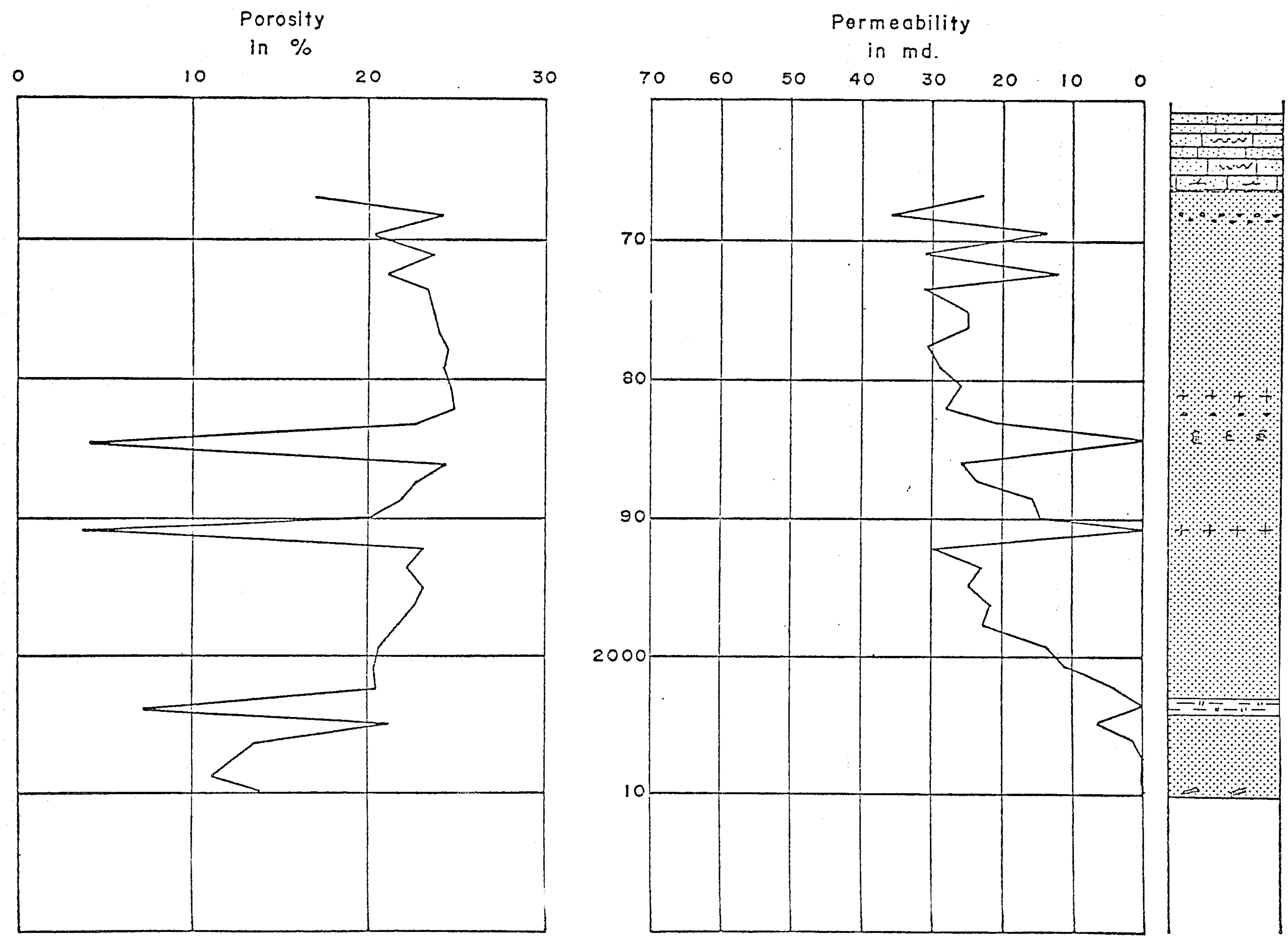
J.H. LOONEY P.I. #4



R.C. ELMORE P.I.#5



L.W. SHAFFER P.I.#6



APPENDIX E

Sand Grain Densities

SAND GRAIN DENSITIES

L. W. Shaffer P.I. No. 2
Rock Creek CO_2 Pilot Project

Depth	Sand Grain Density
2,085	2.68
2,087	2.68
2,089	2.69
2,091	2.69
2,093	2.69
2,095	2.68
2,097	2.68
2,099	2.73
2,101	2.71
2,103	2.77
2,105	2.69
2,107	2.67
2,109	2.69
2,111	2.70
2,113	2.68
2,115	2.69
2,117	2.70*
2,119	2.69*
2,121	2.70*
2,123	2.69*
2,125	2.74*
2,127	2.75*
2,129	2.77*
2,131	2.69*
Average	2.70
Average	2.70*

*Permeability less than 5.0 md. not included in average.

SAND GRAIN DENSITIES

R. C. Elmore P.I. No. 5
Rock Creek CO_2 Pilot Project

Depth	Sand Grain Density
1,912.5	2.69
1,914.0	2.68
1,915.5	2.71
1,917.8	2.67
1,918.8	2.73
1,920.5	2.76
1,921.8	2.70
1,923.3	2.68
1,924.5	2.71
1,926.0	2.72
1,927.0	2.66
1,928.0	2.74
1,929.0	2.72
1,931.0	2.69
1,932.2	2.69
1,933.2	2.68
1,935.0	2.71
1,936.0	2.74
1,937.5	2.71
1,938.5	2.71
1,939.8	2.72
1,941.0	2.68
1,942.5	2.70*
1,944.0	2.70
1,946.0	2.72*
1,947.0	2.71*
1,948.0	2.72*
1,949.5	2.73*
1,951.0	2.75*
1,953.0	2.72*
1,954.5	2.74*
1,955.6	2.74*
1,957.0	2.74*
1,958.0	2.73*
Average	2.71
Average	2.70*

*Permeability less than 5.0 md. not included in average.

SAND GRAIN DENSITIES

E. Lewis WIW No. 29
Rock Creek CO_2 Pilot Project

Depth	Sand Grain Density	Depth	Sand Grain Density
1,930.0	2.67*	1,955.0	2.69
1,931.0	2.62*	1,956.0	2.64
1,932.0	2.67	1,957.0	2.66
1,933.0	2.66	1,958.0	2.67
1,934.0	2.66	1,959.0	2.66
1,935.0	2.66	1,960.0	2.68
1,936.0	2.66	1,961.0	2.69
1,937.0	2.69*	1,962.0	2.69*
1,938.0	2.73*	1,963.0	2.67*
1,939.0	2.75*	1,964.0	2.66*
1,940.0	2.66	1,965.0	2.63*
1,941.0	2.66	1,966.0	2.62*
1,942.0	2.68	1,967.0	2.65*
1,943.0	2.65	1,968.0	2.64*
1,944.0	2.67	1,969.0	2.76*
1,945.0	2.66	1,970.0	2.73*
1,946.0	2.68	1,971.0	2.67*
1,946.0	2.67	1,972.0	2.48*
1,948.0	2.66	1,973.0	2.66*
1,949.0	2.67	1,974.5	2.58*
1,950.0	2.68	1,975.0	2.68*
1,951.0	2.66		
1,952.0	2.67	Average	2.67
1,953.0	2.68		
1,954.0	2.67	Average	2.67*

*Permeability less than 5.0 md. not included in average.

APPENDIX F

X-Ray Diffraction and Petrographic Analysis

CHEMICAL RESEARCH AND DEVELOPMENT DEPARTMENT

HALLIBURTON SERVICES
DUNCAN, OKLAHOMA

LABORATORY REPORT

No. F11-T095-76

To Mr. John Gaydos
Halliburton Services
Elkview, West Virginia

Date July 27, 1976

This report is the property of Halliburton Services, a Division of Halliburton Company, and neither this report nor any part hereof may be disclosed to any third party without the express written approval of Halliburton Services.

We give below results of our examination of formation core sample.

Submitted by Pennzoil Company

Marked Well: L. W. Shaffer P.I. 2
Formation: Big Injun
Depth: 2104.5 feet

Purpose

One core sample from the above well was submitted for x-ray diffraction and petrographic analyses, scanning electron microscope examination, acid solubility and fluid flow tests.

Discussion

The x-ray diffraction data indicates the presence of small to moderate amounts of chlorite clays. Petrographic and SEM analyses show the chlorite clay existing as a film coating the sand grains with microporosity between the clay platelets. Also the chlorite is a iron rich variety.

Immersion and fluid flow tests indicate that a potassium chloride treated water would be a satisfactory stimulation fluid. All fluid flow tests show higher permeabilities for the 24 hour reverse flow with respect to the initial flows. The 7 1/2% HCl flow tests indicate a dramatic permeability increase due to acid reaction with the small amount of calcite present in the pore space.

Data

Immersion Tests

No.	Depth (Feet)	Fresh Water	10% NaCl	2% KCl	2% Clay-Fix	7 1/2% MCA	6% HF	Kerosene
1	2104.5	V-SAF	V-SAF	NFR	NFR	V-SAF	V-SAF	NFR

NFR = No fines released.
V-SAF = Very small amount fines.

Qualitative X-Ray Diffraction And Acid Solubility Analyses

Core Number	1
Depth (Feet)	2104.5
Acid Solubility*	6.2
Quartz	Major
Feldspar	Small
Calcite	Trace
Dolomite	-----
Kaolinite	-----
Illite	Small
Montmorillonite	-----
Mixed Layer Clay	Small
Chlorite	Small-Moderate

Reported Amount	Approximate Percentage Range
Trace	0.1 to 1.0
Very Small	1.0 to 3.0
Small	3.0 to 10.0
Moderate	10.0 to 20.0
Large	15.0 to 40.0
Major	40.0 to 100.0

*This is percent solubility in dilute hydrochloric acid as calcium carbonate only.

Petrographic Analysis

Sample No.	Description
1	SANDSTONE, poorly sorted, very fine to medium grained quartz, feldspar, mica and rock fragments forming framework, small amount of quartz overgrowth, predominant clay is chlorite present as a coating on pore walls, small amount of calcite observed as pore fill. Good visible porosity with chlorite lining.

APPENDIX G

Summation of Individual Well Core Analyses

Summation of Individual
Well Core Analyses

E. Lewis P.I. No. 1
Rock Creek CO_2 Pilot Project

Depth, Ft.	Int. Thk. h	Permeability k Max.	Permeability k 90°	Permeability k Vertical	Permeability Capacity Max. kh	Permeability Capacity 90° kh	Porosity ø	Porosity Feet øh
2,049.7-2,051.2	1.5	3.3	2.8	2.9				
2,051.2-2,052.7	1.5	2.8	2.4	2.6				
2,052.7-2,054.0	1.3	6.8	6.1	5.3	8.84	7.93	21.9	28.47
2,054.0-2,055.3	1.3	4.0	3.3	5.3				
2,055.3-2,056.3	1.0	22.0	20.0	20.0	22.0	20.0	22.4	22.40
2,056.3-2,057.3	1.0	28.0	28.0	39.0	28.0	28.0	20.9	20.90
2,057.8-2,058.8	1.0	32.0	28.0	46.0	32.0	28.0	20.9	20.90
2,058.8-2,059.9	1.1	32.0	32.0	49.0	35.2	35.2	24.5	26.95
2,059.9-2,061.3	1.4	4.2	1.7	1.1				
2,061.3-2,062.9	1.6	30.0	26.0	33.0	48.0	41.6	24.4	39.04
2,062.9-2,064.8	1.9	25.0	25.0	23.0	47.5	47.5	25.0	47.50
2,064.8-2,066.4	1.6	21.0	20.0	23.0	33.6	32.0	24.0	38.40
2,066.4-2,067.8	1.4	32.0	29.0	33.0	44.8	40.6	24.5	34.30
2,067.8-2,068.9	1.1	27.0	23.0	24.0	29.7	25.3	24.0	26.40
2,068.9-2,070.2	1.3	26.0	24.0	28.0	33.8	31.2	24.0	31.20
2,070.2-2,071.8	1.6	29.0	24.0	25.0	46.4	38.4	23.9	38.24
2,071.8-2,073.4	1.6	23.0	23.0	30.0	36.8	36.8	22.0	35.20
2,073.4-2,074.6	1.2	9.7	9.7	12.0	11.64	11.64	18.2	21.84
2,074.6-2,075.9	1.3	7.5	7.5	6.3	9.75	9.75	19.0	24.70
2,075.9-2,077.3	1.4	4.2	4.2	3.9				
2,077.3-2,078.8	1.5	16.0	16.0	13.0	24.0	24.0	20.7	31.05
2,078.8-2,080.2	1.4	24.0	22.0	20.0	33.6	30.8	20.7	28.98
2,080.2-2,081.7	1.5	18.0	18.0	19.0	27.0	27.0	20.8	31.20
2,081.7-2,082.9	1.2	21.0	19.0	16.0	25.2	22.8	20.7	24.84
2,082.9-2,084.4	1.5	15.0	13.0	11.0	22.5	19.5	21.5	32.25
2,084.4-2,085.8	1.4	1.9	1.7	0.79				
2,085.8-2,087.0	1.2	24.0	14.0	0.59	28.8	16.8	8.8	10.56
2,087.0-2,088.2	1.2	16.0	13.0	6.5	19.2	15.6	18.2	21.84
2,088.2-2,089.6	1.4	14.0	14.0	7.2	19.6	19.6	17.0	23.80
2,089.6-2,090.9	1.3	0.20	0.16	0.54				
2,090.9-2,092.5	1.6	0.24	0.24	0.32				
2,092.5-2,093.9	1.4	0.34	0.33	0.72				
2,093.9-2,095.3	1.4	0.73	0.63	0.36				
2,095.3-2,096.4	1.1	2.5	1.9	2.3				
2,096.4-2,097.5	1.1	26.0	26.0	38.0	28.6	28.6	22.7	24.97
Total	30.9				667.93	610.02		660.96
Average					21.62	19.74		21.39

Summation of Individual
Well Core Analyses

L. W. Shaffer P.I. No. 2
Rock Creek CO_2 Pilot Project

Depth, Ft.	Int. Thk. h	Permeability k Max.	90°	Vertical	Permeability Capacity Max. kh	90° kh	Porosity ø	Porosity Feet øh
2,083.0-2,084.4	1.4	<0.10	<0.10	<0.10				
2,084.4-2,085.9	1.5	29.0	27.0	24.0	43.5	40.5	23.7	35.6
2,085.9-2,087.5	1.6	28.0	28.0	8.8	44.8	44.8	22.4	35.8
2,087.5-2,089.0	1.5	22.0	21.0	8.9	33.0	31.5	22.3	33.5
2,089.0-2,090.5	1.5	24.0	22.0	21.0	36.0	33.0	24.4	36.6
2,090.5-2,091.9	1.4	15.0	15.0	13.0	21.0	21.0	23.6	33.0
2,091.9-2,093.7	1.8	19.0	16.0	17.0	34.2	28.8	23.8	42.8
2,093.7-2,095.2	1.5	21.0	20.0	22.0	31.5	30.0	24.8	37.2
2,095.2-2,096.8	1.6	23.0	23.0	25.0	36.8	36.8	24.0	38.4
2,096.8-2,098.2	1.4	31.0	30.0	40.0	43.4	42.0	24.0	33.6
2,098.2-2,099.8	1.6	12.0	12.0	1.0	19.2	19.2	20.6	33.0
2,099.8-2,101.3	1.5	12.0	12.0	18.0	18.0	18.0	22.2	33.3
2,101.3-2,102.8	1.5	13.0	13.0	16.0	19.5	19.5	20.7	31.1
2,102.8-2,104.1	1.3	9.7	9.7	9.1	12.6	12.6	20.6	26.8
2,104.1-2,105.9	1.8	19.0	19.0	16.0	34.2	34.2	23.2	41.8
2,105.9-2,107.2	1.3	15.0	15.0	12.0	19.5	19.5	22.2	28.9
2,107.2-2,108.9	1.7	18.0	18.0	13.0	30.6	30.6	22.6	38.4
2,108.9-2,110.1	1.2	24.0	23.0	27.0	28.8	27.6	21.7	26.0
2,110.1-2,111.6	1.5	15.0	14.0	10.0	22.5	21.0	20.1	30.2
2,111.6-2,112.9	1.3	20.0	20.0	22.0	26.0	26.0	23.0	29.9
2,112.9-2,114.2	1.3	19.0	18.0	12.0	24.7	23.4	21.1	27.4
2,114.2-2,115.6	1.4	11.0	11.0	7.4	15.4	15.4	20.3	28.4
2,115.6-2,117.1	1.5	4.2	4.2	2.0				
2,117.1-2,118.4	1.3	3.2	2.8	2.5				
2,118.4-2,119.9	1.4	4.2	4.2	3.0				
2,119.9-2,121.2	1.3	2.0	1.8	2.4				
2,121.2-2,122.9	1.7	1.6	1.6	1.7				
2,122.9-2,124.5	1.6	3.3	3.3	3.3				
2,124.5-2,125.8	1.3	<0.10	<0.10	<0.10				
2,125.8-2,127.0	1.2	<0.10	<0.10	<0.10				
2,127.0-2,128.3	1.3	0.20	0.16	<0.10				
2,128.3-2,129.6	1.3	0.20	0.20	0.76				
2,129.6-2,130.8	1.2	0.95	0.86	1.1				
2,130.8-2,131.9	1.1	1.9	1.8	2.5				
2,131.9-2,133.0	1.1	<0.10	<0.10	<0.10				
Total	31.2				595.2	575.4		701.7
Average					19.1	18.4		22.5

Summation of Individual Well Core Analyses

L. W. Shaffer P.I. No. 3
Rock Creek CO_2 Pilot Project

Depth, Ft.	Int. Thk. h	Permeability k Max.	Permeability k 90°	Permeability k Vertical	Permeability Capacity Max. kh	Permeability Capacity 90° kh	Porosity Ø	Porosity Feet Øh
1,871.0-1,872.3	1.3	<0.10	<0.10	<0.10				
1,873.9-1,875.0	1.1	<0.10	<0.10	<0.10				
1,875.0-1,876.5	1.5	0.80	0.70	2.3				
1,876.5-1,877.9	1.4	13.0	13.0	8.9	18.2	18.2	19.2	26.9
1,877.9-1,879.0	1.1	14.0	14.0	15.0	15.4	15.4	21.4	23.5
1,879.0-1,880.4	1.4	15.0	15.0	14.0	21.0	21.0	23.0	32.2
1,880.4-1,882.2	1.8	8.6	7.8	16.0	15.5	14.0	21.0	37.8
1,882.2-1,883.3	1.1	9.7	9.7	13.0	10.7	10.7	23.5	25.9
1,883.3-1,884.7	1.4	<0.10	<0.10	0.11				
1,884.7-1,886.0	1.3	0.20	0.20	0.12				
1,886.0-1,887.2	1.2	5.1	5.1	1.9	6.1	6.1	20.3	24.4
1,887.2-1,888.8	1.6	15.0	14.0	14.0	24.0	22.4	21.1	33.8
1,888.8-1,889.9	1.1	14.0	14.0	23.0	15.4	15.4	21.8	24.0
1,889.9-1,891.5	1.6	20.0	19.0	34.0	32.0	30.4	22.9	36.6
1,891.5-1,892.8	1.3	16.0	14.0	27.0	20.8	18.2	21.1	27.4
1,892.8-1,894.4	1.6	22.0	22.0	28.0	35.2	35.2	23.3	37.3
1,894.4-1,895.6	1.2	18.0	15.0	25.0	21.6	18.0	21.4	25.7
1,895.6-1,897.4	1.8	8.6	8.4	6.5	15.5	15.1	20.7	37.3
1,897.4-1,899.0	1.6	10.0	10.0	11.0	16.0	16.0	21.8	34.9
1,899.0-1,900.8	1.8	22.0	18.0	24.0	39.6	32.4	22.8	41.0
1,900.8-1,902.2	1.4	22.0	21.0	31.0	30.8	29.4	23.5	32.9
1,902.2-1,903.4	1.2	22.0	22.0	18.0	26.4	26.4	22.8	27.4
1,903.4-1,904.9	1.5	16.0	12.0	20.0	24.0	18.0	22.4	33.6
1,904.9-1,906.2	1.3	14.0	13.0	17.0	18.2	16.9	21.6	28.1
1,906.2-1,907.6	1.4	12.0	11.0	13.0	16.8	15.4	17.2	24.1
1,907.6-1,909.1	1.5	12.0	12.0	7.7	18.0	18.0	20.6	30.9
1,909.1-1,910.7	1.6	6.1	6.1	4.4	9.8	9.8	19.0	30.4
1,910.7-1,912.0	1.3	5.4	5.4	4.0	7.0	7.0	18.9	24.6
1,912.0-1,913.4	1.4	3.8	3.2	2.7				
1,913.4-1,914.8	1.4	2.2	2.2	2.9				
1,914.8-1,916.1	1.3	1.9	1.9	1.7				
1,916.1-1,917.2	1.1	6.8	6.4	4.6			20.6	
1,917.9-1,919.3	1.4	<0.10	<0.10	<0.10				
1,919.3-1,920.9	1.6	1.0	0.93	0.35				
1,920.9-1,922.1	1.2	<0.10	<0.10	<0.10				
Total	32.8				458.0	429.4		700.7
Average					13.96	13.09		21.3

Summation of Individual
Well Core Analyses

J. H. Looney P.I. No. 4
Rock Creek CO_2 Pilot Project

Depth, Ft.	Int. Thk. h	Permeability k Max.	90°	Vertical	Permeability Capacity Max. kh	90° kh	Porosity Ø	Porosity Feet Øh
1,928.5-1,929.8	1.3	2.0	1.9	2.6				
1,929.8-1,931.2	1.4	7.4	6.7	11.0	10.4	9.4	18.5	25.9
1,931.2-1,932.8	1.6	16.0	15.0	19.0	25.6	24.0	20.8	33.3
1,932.8-1,934.3	1.5	6.0	6.0	2.5	9.0	9.0	17.8	26.7
1,934.3-1,935.8	1.5	20.0	19.0	18.0	30.0	28.5	17.3	26.0
1,935.8-1,937.8	2.0	15.0	13.0	8.4	30.0	26.0	24.2	48.4
1,937.8-1,939.2	1.4	27.0	23.0	14.0	37.8	32.2	23.3	32.6
1,939.2-1,940.5	1.3	19.0	18.0	2.8	24.7	23.4	20.2	26.3
1,940.5-1,942.0	1.5	13.0	12.0	2.3	19.5	18.0	18.8	28.2
1,942.0-1,943.5	1.5	19.0	17.0	6.3	28.5	25.5	23.5	35.2
1,943.5-1,944.9	1.4	19.0	17.0	33.0	26.6	23.8	24.4	34.2
1,944.9-1,946.0	1.1	13.0	12.0	30.0	14.3	13.2	24.4	26.8
1,946.0-1,947.1	1.1	14.0	14.0	17.0	15.4	15.4	22.8	25.1
1,947.1-1,948.5	1.4	17.0	17.0	18.0	23.8	23.8	22.0	30.8
1,948.5-1,950.0	1.5	11.0	10.0	12.0	16.5	15.0	21.9	32.8
1,950.0-1,951.9	1.9	18.0	18.0	27.0	34.2	34.2	22.9	43.5
1,951.9-1,953.4	1.5	19.0	18.0	28.0	28.5	27.0	24.0	36.0
1,953.4-1,954.8	1.4	20.0	20.0	24.0	28.0	28.0	24.1	33.7
1,954.8-1,956.2	1.4	27.0	23.0	28.0	37.8	32.2	24.7	34.6
1,956.2-1,957.8	1.6	19.0	19.0	21.0	30.4	30.4	23.4	37.4
1,957.8-1,959.3	1.5	12.0	12.0	13.0	18.0	18.0	21.8	32.7
1,959.3-1,960.9	1.6	13.0	13.0	14.0	20.8	20.8	21.5	34.4
1,960.9-1,962.5	1.6	6.7	6.0	10.0	10.7	9.6	20.8	33.3
1,962.5-1,964.2	1.7	7.5	7.1	8.7	12.8	12.1	19.5	33.2
1,964.2-1,965.5	1.3	0.47	0.42	0.79				
1,965.5-1,967.0	1.5	11.0	11.0	16.0	16.5	16.5	18.4	27.6
1,967.0-1,968.4	1.4	4.7	4.2	3.5				
1,968.4-1,969.8	1.4	7.5	6.7	6.0	10.5	9.4	20.1	28.1
1,969.8-1,971.6	1.8	2.2	2.0	2.3				
1,971.6-1,973.0	1.4	1.7	1.6	1.5				
1,973.0-1,974.2	1.2	1.5	1.5	1.1				
1,974.2-1,975.3	1.1	<0.10	<0.10	<0.10				
1,975.3-1,976.8	1.5	0.40	0.28	<0.10				
1,976.8-1,978.0	1.2	0.34	0.29	<0.10				
Total	37.3				560.3	525.4		806.8
Average					15.0	14.1		21.6

Summation of Individual
Well Core Analyses

R. C. Elmore P.I. No. 5
Rock Creek CO_2 Pilot Project

Depth, Ft.	Int. Thk. h	Permeability k Max.	* 90°	Vertical	Permeability Capacity Max. kh	90° kh	Porosity Ø	Porosity Feet Øh
1,912.9-1,914.1	1.2	<0.10		<0.10			12.6	
1,914.1-1,915.4	1.3	47.0		20.0	61.1		21.7	28.2
1,915.4-1,916.8	1.4	44.0		28.0	61.6		22.7	31.8
1,916.8-1,918.1	1.3	40.0		21.0	52.0		23.1	30.0
1,918.1-1,919.4	1.3	28.0		21.0	36.4		22.9	29.8
1,919.4-1,920.8	1.4	24.0		15.0	33.6		23.3	32.6
1,920.8-1,922.1	1.3	29.0		32.0	37.7		23.1	30.0
1,922.1-1,923.5	1.4	23.0		6.8	32.2		22.1	30.9
1,923.5-1,924.8	1.3	24.0		* 10.0	31.2		23.4	30.4
1,924.8-1,926.1	1.3	46.0		* 23.0	59.8		23.3	30.3
1,926.1-1,927.4	1.3	47.0		* 38.0	61.1		23.3	30.3
1,927.4-1,928.7	1.3	39.0		* 8.4	50.7		23.3	30.3
1,928.7-1,929.9	1.2	62.0		* 48.0	74.4		23.2	27.8
1,929.9-1,931.5	1.6	30.0		* 23.0	48.0		22.0	35.2
1,931.5-1,932.8	1.3	41.0		* 27.0	53.3		21.8	28.3
1,932.8-1,934.0	1.2	27.0		* 20.0	32.4		22.0	26.4
1,934.0-1,935.2	1.2	8.2		* 8.9	9.8		20.6	24.7
1,935.2-1,936.5	1.3	12.0		* 6.1	15.6		20.4	26.5
1,936.5-1,938.0	1.5	44.0		* 28.0	66.0		22.8	34.2
1,938.0-1,939.3	1.3	38.0		* 24.0	49.4		22.8	29.6
1,939.3-1,940.9	1.6	23.0		* 24.0	36.8		21.8	34.9
1,940.9-1,942.3	1.4	9.7		* 8.3	13.6		21.5	30.1
1,942.3-1,943.8	1.5	4.6		* 3.9				
1,943.8-1,945.0	1.2	9.7		* 6.3	11.6		18.9	22.7
1,945.0-1,946.3	1.3	2.0		* 1.9				
1,946.3-1,947.6	1.3	2.6		* 1.8				
1,947.6-1,949.0	1.4	2.6		* 1.5				
1,949.0-1,950.4	1.4	1.7		* 1.9				
1,950.4-1,951.8	1.4	<0.10		* <0.10				
1,951.8-1,953.3	1.5	0.66		* <0.10				
1,953.3-1,954.8	1.5	3.8		* 1.6				
1,954.8-1,956.2	1.4	<0.10		* 0.82				
1,956.2-1,957.8	1.6	0.69		* <0.10				
1,957.8-1,959.2	1.4	<0.10		* <0.10				
Total	29.4				928.3			655.0
Average					31.8			22.3

*Horizontal permeabilities - all conventional analysis.
Vertical permeabilities - all conventional analysis.

Summation of Individual
Well Core Analyses

L. W. Shaffer P.I. No. 6
Rock Creek CO_2 Pilot Project

Depth, Ft.	Int. Thk. h	Permeability k Max.	90°	Vertical	Permeability Capacity Max. kh	90° kh	Porosity Ø	Porosity Feet Øh
1,966.3-1,967.6	1.3	23.0	23.0	22.0	38.9	38.9	16.8	21.8
1,967.6-1,969.0	1.4	36.0	31.0	20.0	50.4	43.4	24.2	33.9
1,969.0-1,970.4	1.4	14.0	13.0	1.5	19.6	18.2	20.4	28.6
1,970.4-1,971.9	1.5	31.0	29.0	25.0	46.5	43.5	23.7	35.6
1,971.9-1,973.1	1.2	12.0	11.0	4.3	14.4	13.2	21.2	25.4
1,973.1-1,974.4	1.3	31.0	27.0	31.0	40.3	35.1	23.6	30.7
1,974.4-1,975.9	1.5	25.0	25.0	33.0	37.5	37.5	23.7	35.6
1,975.9-1,977.3	1.4	25.0	24.0	24.0	35.0	33.6	24.0	33.6
1,977.3-1,978.5	1.2	31.0	31.0	31.0	37.2	37.2	24.5	29.4
1,978.5-1,980.0	1.5	29.0	29.0	32.0	43.5	43.5	24.3	36.4
1,980.0-1,981.5	1.5	26.0	26.0	31.0	39.0	39.0	24.6	36.9
1,981.5-1,982.8	1.3	28.0	25.0	30.0	36.4	32.5	24.9	32.4
1,982.8-1,983.9	1.1	21.0	18.0	16.0	23.1	19.8	22.6	24.9
1,983.9-1,985.4	1.3	<0.10	<0.10	0.12				
1,985.4-1,986.8	1.4	26.0	24.0	31.0	36.4	33.6	24.4	34.2
1,986.8-1,988.1	1.3	24.0	23.0	14.0	31.2	29.9	22.7	29.5
1,988.1-1,989.5	1.4	16.0	15.0	15.0	22.4	21.0	21.8	30.5
1,989.5-1,990.5	1.0	15.0	15.0	11.0	15.0	15.0	20.2	20.2
1,990.5-1,991.6	1.1	<0.10	<0.10	<0.10				
1,991.6-1,992.9	1.3	30.0	28.0	28.0	39.0	36.4	23.2	30.2
1,992.9-1,994.3	1.4	23.0	23.0	18.0	32.2	32.2	22.2	31.1
1,994.3-1,995.7	1.4	25.0	24.0	25.0	35.0	33.6	23.0	32.2
1,995.7-1,997.1	1.4	22.0	22.0	17.0	30.8	30.8	22.6	31.6
1,997.1-1,998.7	1.6	23.0	21.0	20.0	32.2	29.4	21.7	30.4
1,998.7-2,000.1	1.4	14.0	14.0	12.0	19.6	19.6	20.6	28.8
2,000.1-2,001.8	1.7	11.0	11.0	8.2	18.7	18.7	20.2	34.3
2,001.8-2,003.3	1.5	4.2	3.2	0.41				
2,003.3-2,004.4	1.1	<0.10	<0.10	<0.10				
2,004.4-2,005.6	1.2	6.8	6.1	12.0			21.0	
2,005.6-2,006.9	1.3	1.9	1.8	1.0				
2,006.9-2,008.2	1.3	0.18	0.18	<0.10				
2,008.2-2,009.3	1.1	0.16	0.16	0.21				
2,009.3-2,010.6	1.3	<0.10	<0.10	<0.10				
Total	32.9				774.3	735.6		738.2
Average					23.5	22.4		22.4

Summation of Individual Well Core Analyses

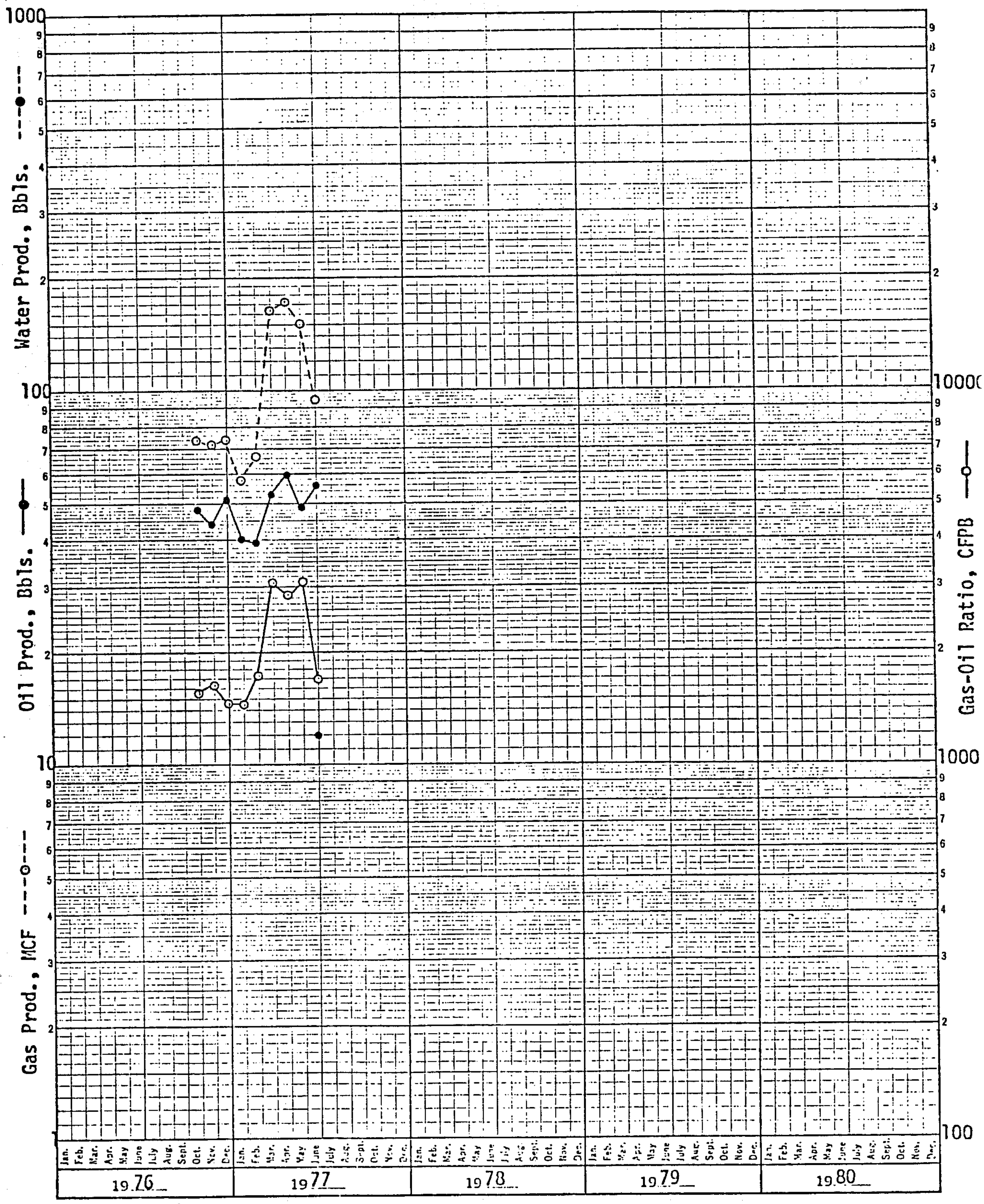
E. Lewis WIW No. 29 Rock Creek CO_2 Pilot Project

Depth, Ft.	Int. Thk. h	Permeability k Max.	90°	Vertical	Permeability Capacity Max. kh	90° kh	Porosity Ø	Porosity Feet Øh
1,930.0-1,931.0	1.0	0.3	0.1	<0.1			11.0	
1,931.0-1,932.0	1.0	1.3	1.3	<0.1			16.7	
1,932.0-1,932.5	0.5	8.9	8.4	7.3	4.5	4.2	19.8	9.9
1,933.0-1,934.0	1.0	8.8	8.4	7.4	8.8	8.4	20.0	20.0
1,934.0-1,935.0	1.0	6.2	5.1	2.7	6.2	5.1	19.7	19.7
1,935.0-1,936.0	1.0	13.0	12.0	9.4	13.0	12.0	19.5	19.5
1,936.0-1,937.0	1.0	16.0	12.0	9.5	16.0	12.0	20.9	20.9
1,937.0-1,938.0	1.0	4.1	3.2	2.9			15.3	
1,938.0-1,939.0	1.0	2.2	1.4	1.0			14.3	
1,939.0-1,940.0	1.0	3.3	2.5	0.9			15.4	
1,940.0-1,941.0	1.0	14.0	14.0	18.0	14.0	14.0	22.2	22.2
1,941.0-1,942.0	1.0	9.6	9.4	8.7	9.6	9.4	22.0	22.0
1,942.0-1,943.0	1.0	9.5	9.3	12.0	9.5	9.3	21.5	21.5
1,943.0-1,944.0	1.0	9.5	9.4	10.0	9.5	9.4	20.6	20.6
1,944.0-1,945.0	1.0	21.0	21.0	7.9	21.0	21.0	20.6	20.6
1,945.0-1,946.0	1.0	8.3	7.9	7.7	8.3	7.9	19.9	19.9
1,946.0-1,946.5	0.5	9.3	9.1	11.0	4.7	4.6	20.4	10.2
1,947.0-1,948.0	1.0	13.0	12.0	17.0	13.0	12.0	20.6	20.6
1,948.0-1,949.0	1.0	13.0	12.0	16.0	13.0	12.0	20.4	20.4
1,949.0-1,950.0	1.0	8.8	8.8	3.6	8.8	8.8	18.9	18.9
1,950.0-1,951.0	1.0	7.2	6.9	5.1	7.2	6.9	19.3	19.3
1,951.0-1,952.0	1.0	12.0	12.0	15.0	12.0	12.0	19.9	19.9
1,952.0-1,953.0	1.0	14.0	14.0	18.0	14.0	14.0	20.5	20.5
1,953.0-1,954.0	1.0	13.0	12.0	17.0	13.0	12.0	20.8	20.8
1,954.0-1,955.0	1.0	11.0	11.0	16.0	11.0	11.0	20.0	20.0
1,955.0-1,956.0	1.0	7.0	6.8	10.0	7.0	6.8	20.0	20.0
1,956.0-1,957.0	1.0	9.1	8.9	8.0	9.1	8.9	19.1	19.1
1,957.0-1,958.0	1.0	8.0	7.9	7.6	8.0	7.9	19.3	19.3
1,958.0-1,959.0	1.0	7.8	7.5	11.0	7.8	7.5	19.4	19.4
1,959.0-1,960.0	1.0	10.0	9.9	11.0	10.0	9.9	18.3	18.3
1,960.0-1,961.0	1.0	5.4	5.3	3.8	5.4	5.3	18.1	18.1
1,961.0-1,962.0	1.0	5.3	4.8	3.1	5.3	4.8	18.7	18.7
1,962.0-1,963.0	1.0	4.4	4.2	2.6			17.8	
1,963.0-1,964.0	1.0	2.3	2.3	0.5			17.3	
1,964.0-1,964.5	0.5	3.6	2.8	1.5			18.0	
1,965.0-1,966.0	1.0	0.3	0.3	<0.1			15.9	
1,966.0-1,967.0	1.0	1.0	0.8	<0.1			16.8	
1,967.0-1,968.0	1.0	<0.1	<0.1	<0.1			6.0	
1,968.0-1,969.0	1.0	<0.1	<0.1	<0.1			4.3	
1,969.0-1,970.0	1.0	0.5	0.5	<0.1			13.2	
1,970.0-1,971.0	1.0	0.6	0.2	<0.1			10.7	
1,971.0-1,972.0	1.0	1.4	1.2	0.3			17.6	
1,972.0-1,973.0	1.0	0.2	0.2	<0.1			5.8	
1,973.0-1,973.5	0.5	0.6	0.2	<0.1			5.0	
1,974.5-1,975.0	0.5	0.3	0.2	<0.1			5.6	
1,975.0-1,976.0	1.0	0.2	0.2	<0.1			12.1	
Total	26.0				269.7	257.1		520.3
Average					10.4	9.9		20.0

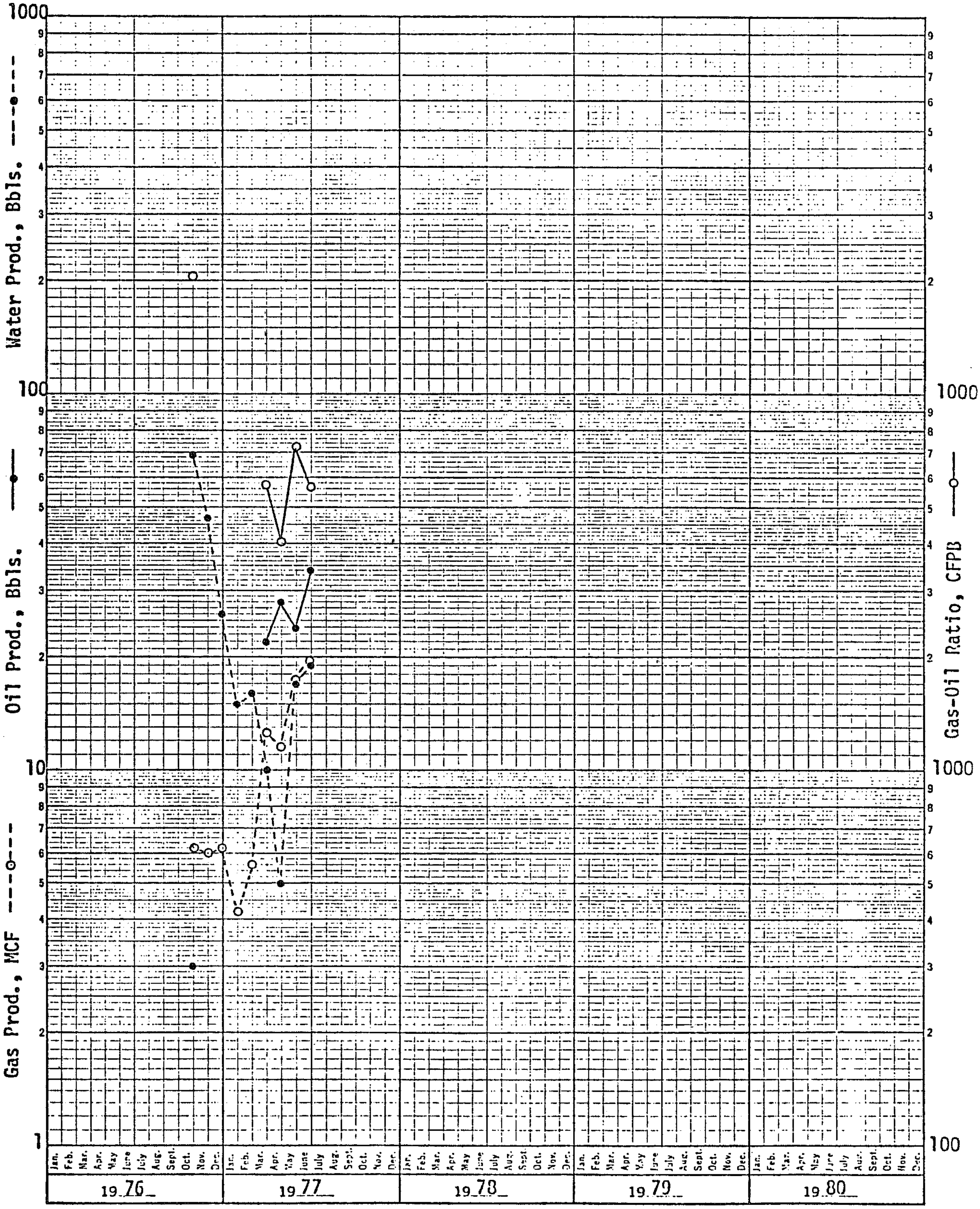
APPENDIX H

Graphical Producing Well History

L. W. Shaffer No. 1



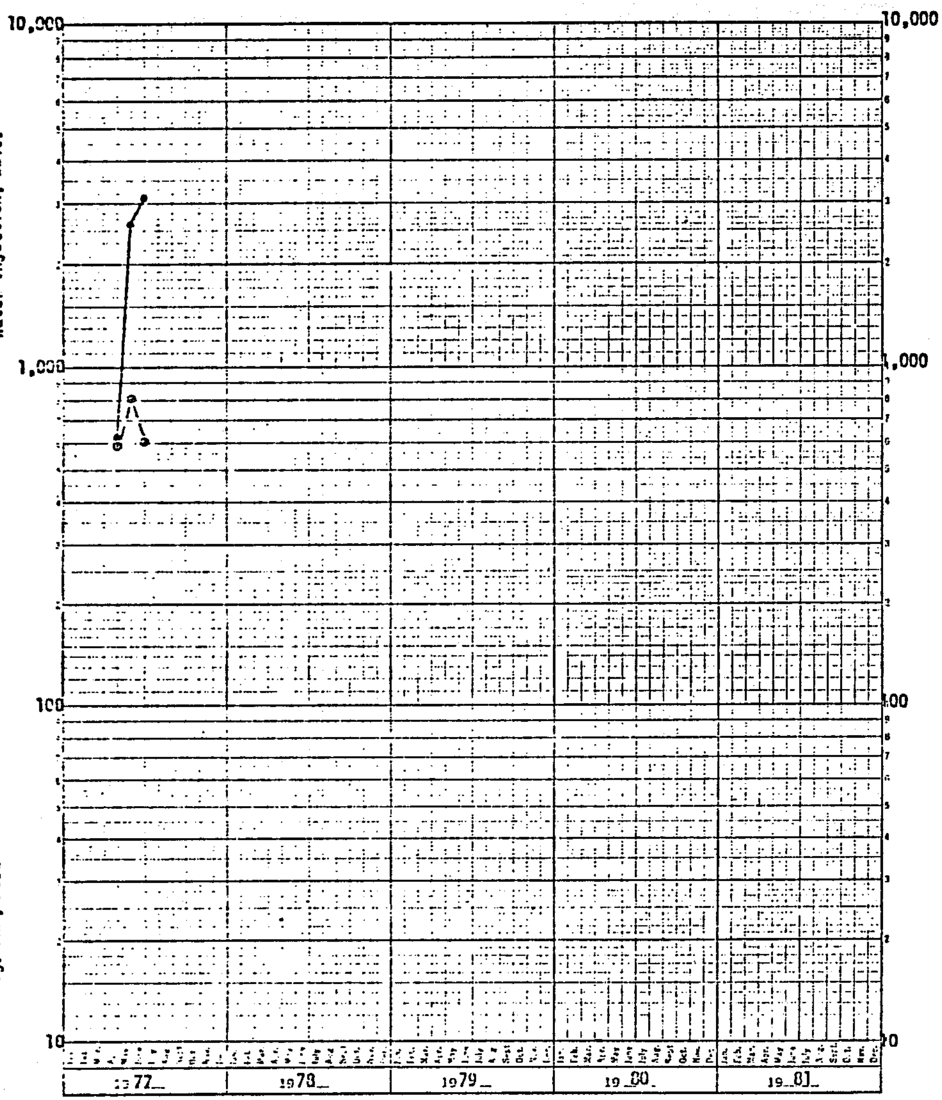
L. W. Shaffer No. 4



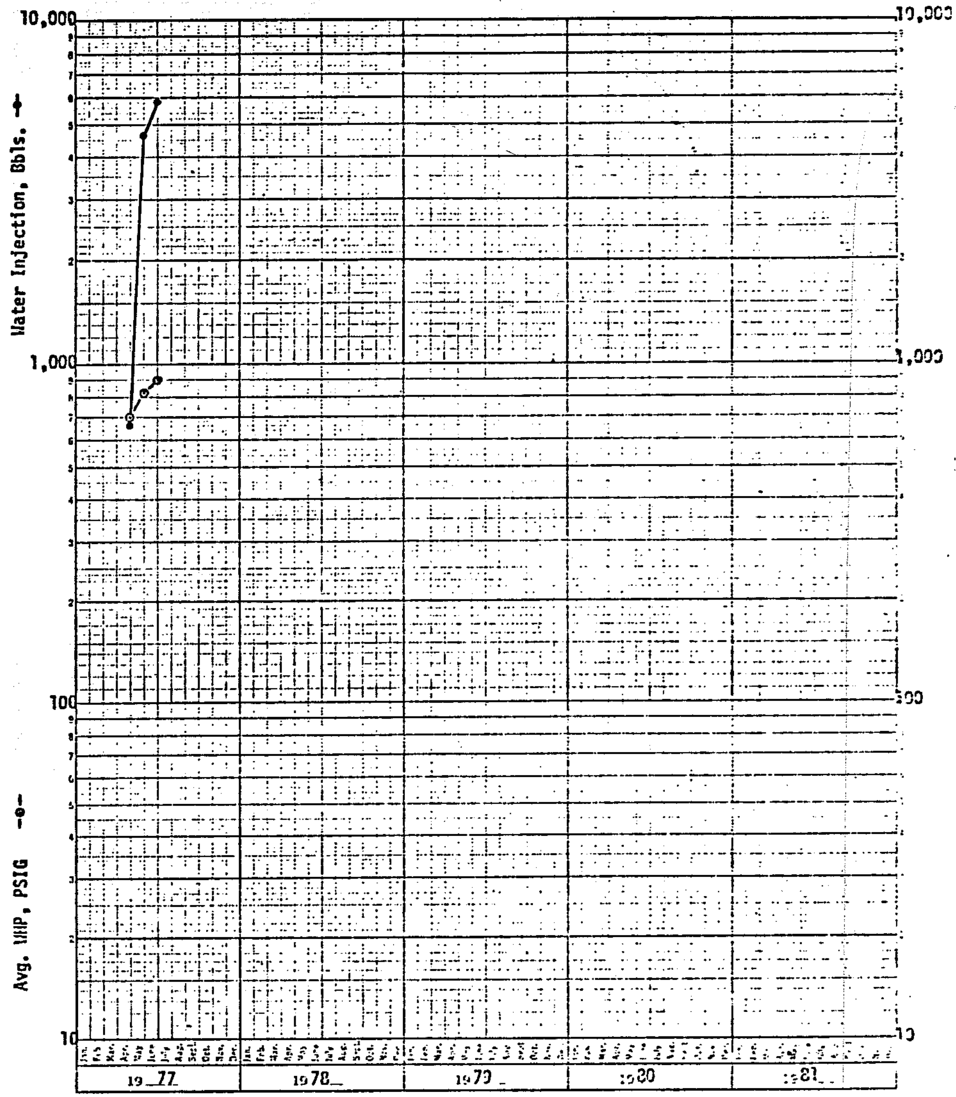
APPENDIX I

Graphical Carbon Dioxide Injection Well History

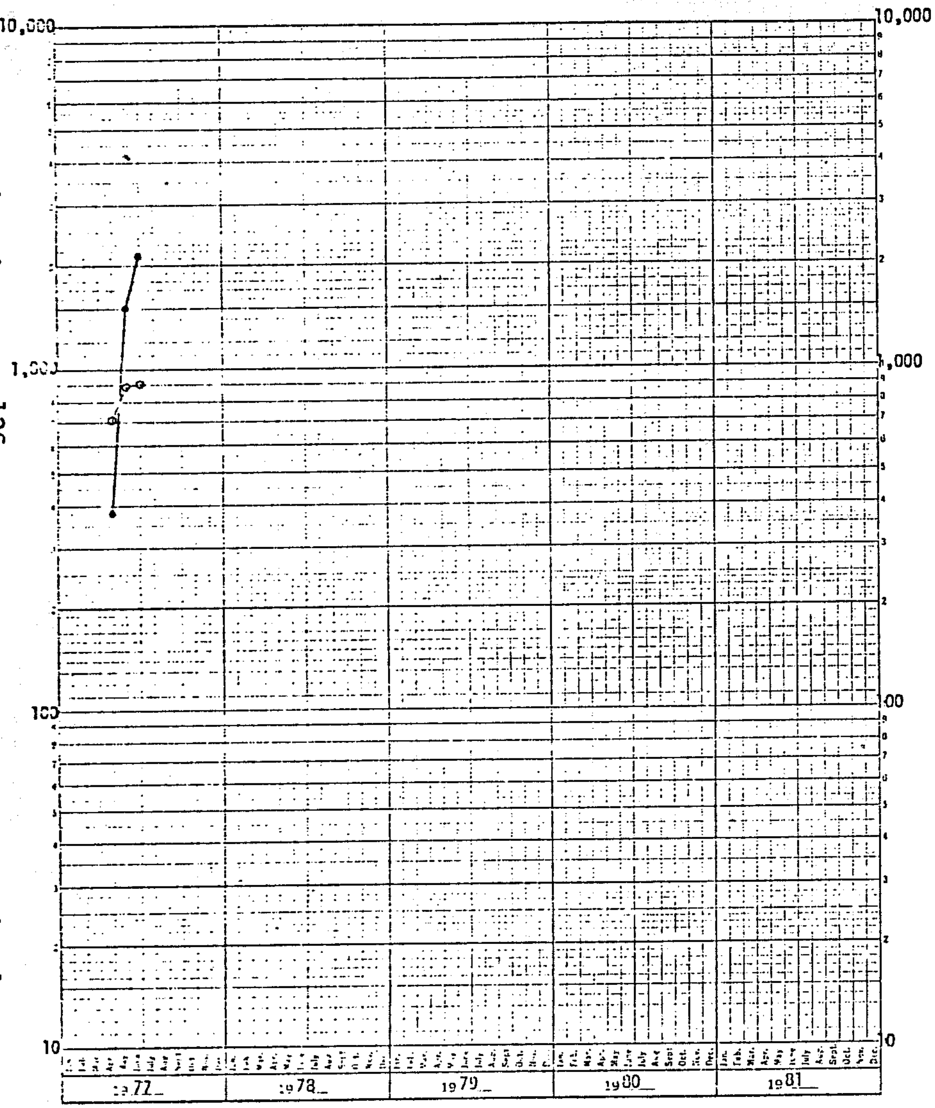
E. Lewis P.I. No. 1



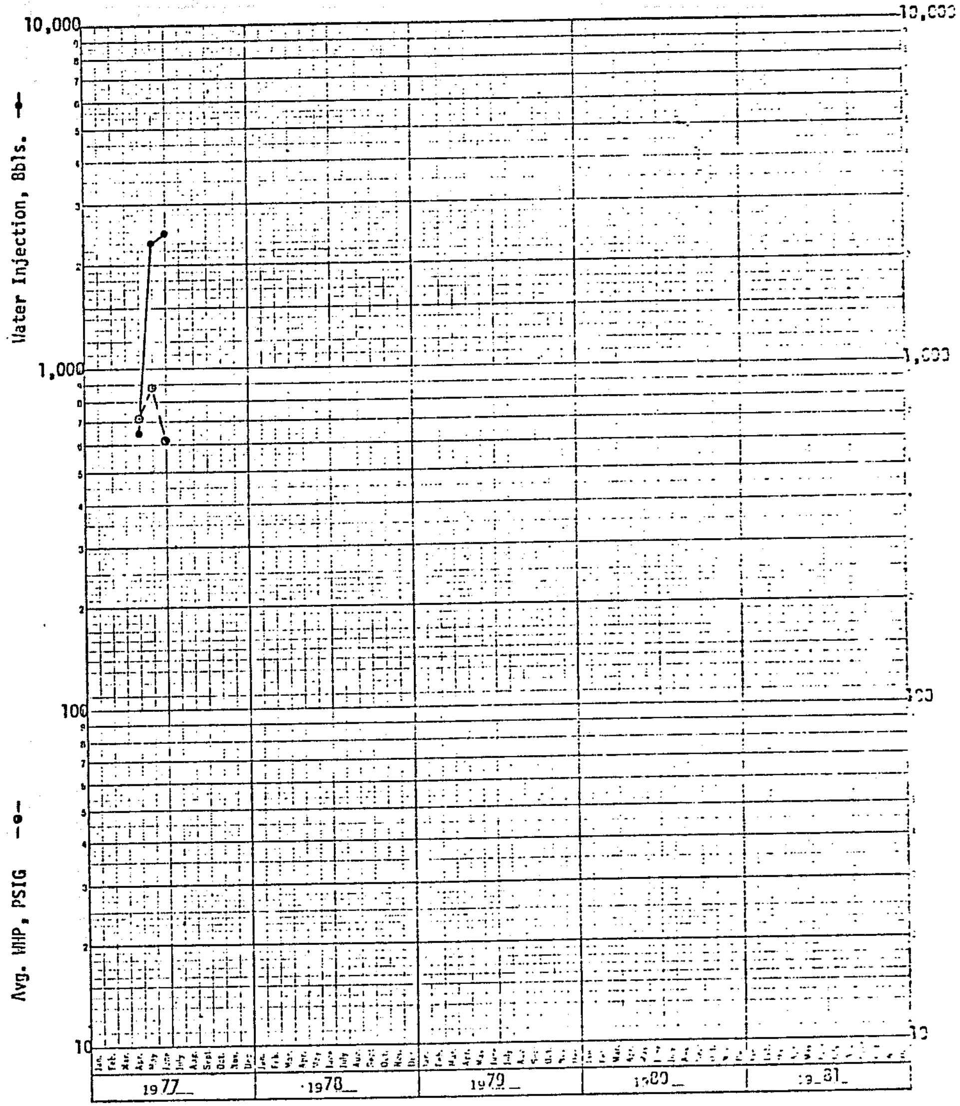
L. W. Shaffer P.I. No. 2



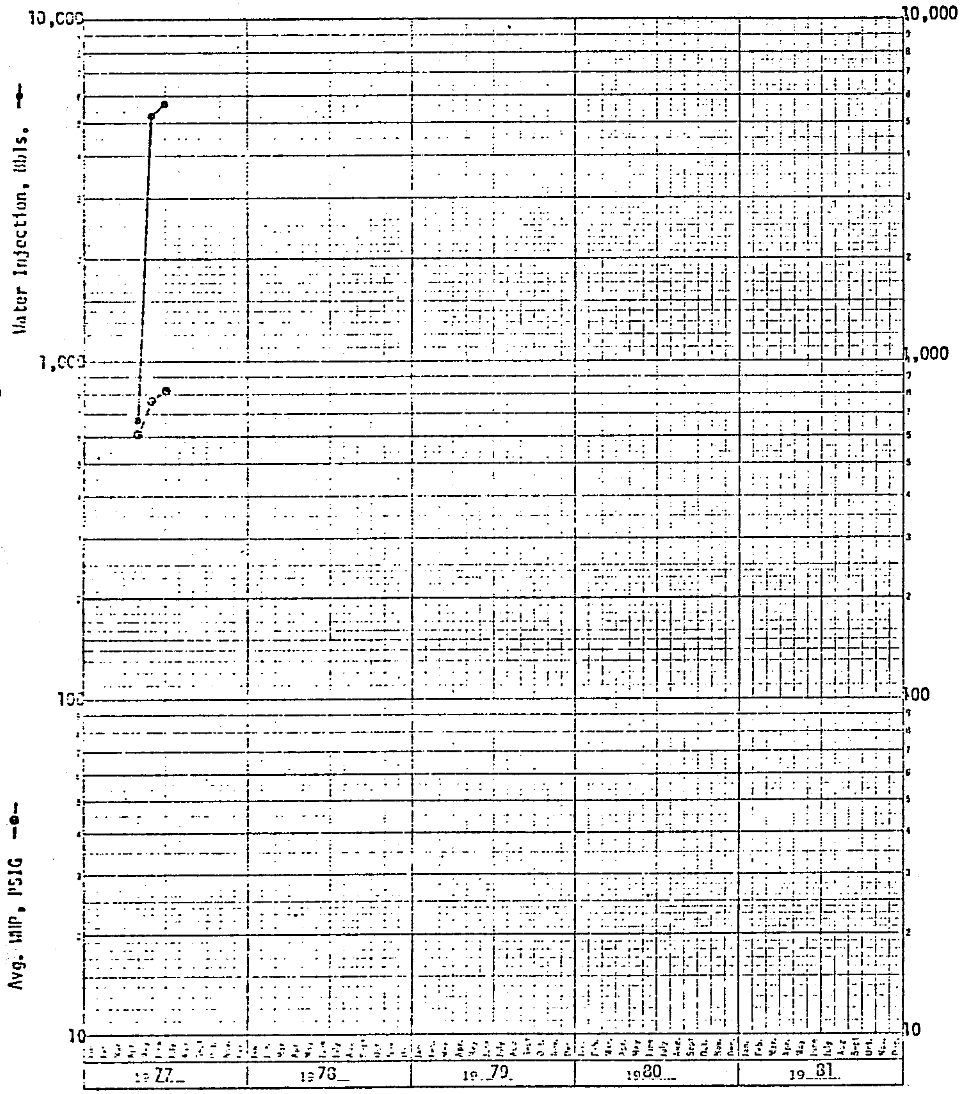
L. W. Shaffer P.I. No. 3



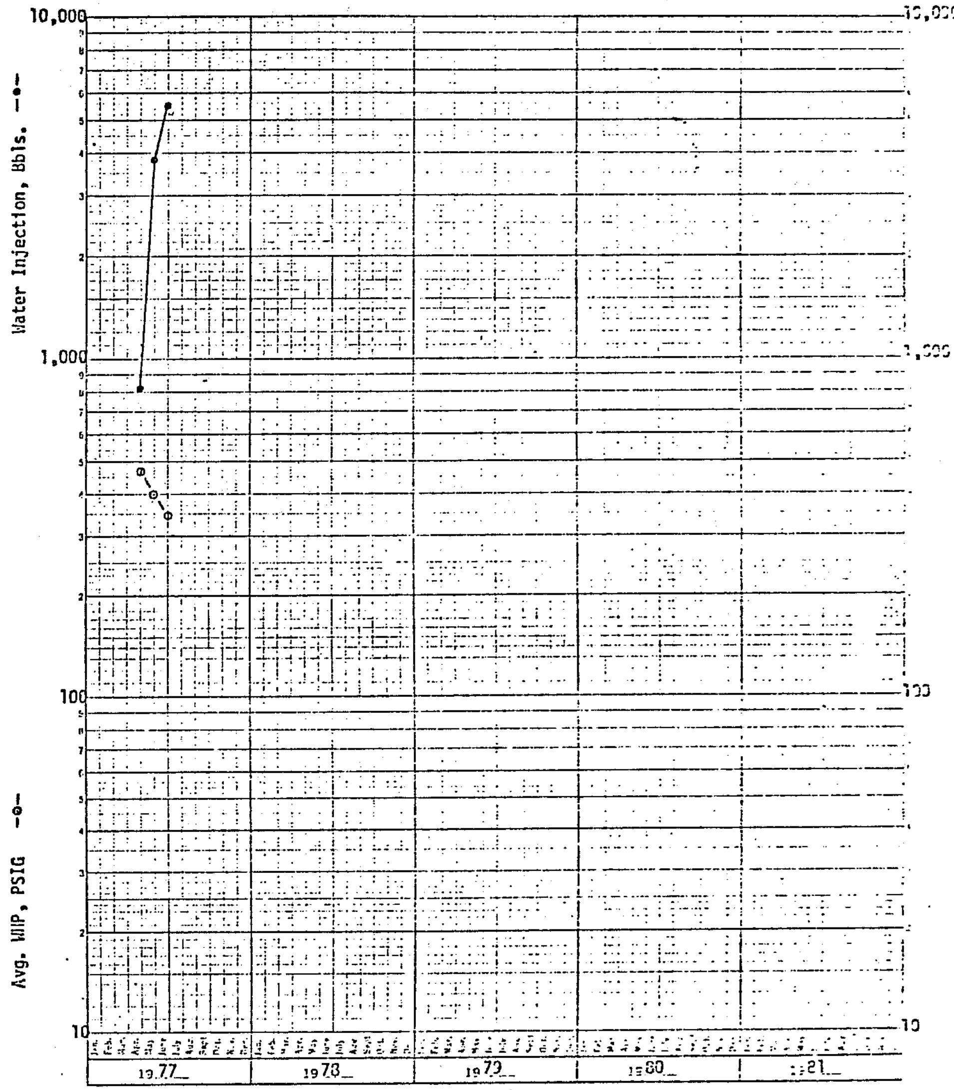
J. H. Looney P.I. No. 4



R. C. Elmore P.I. No. 5



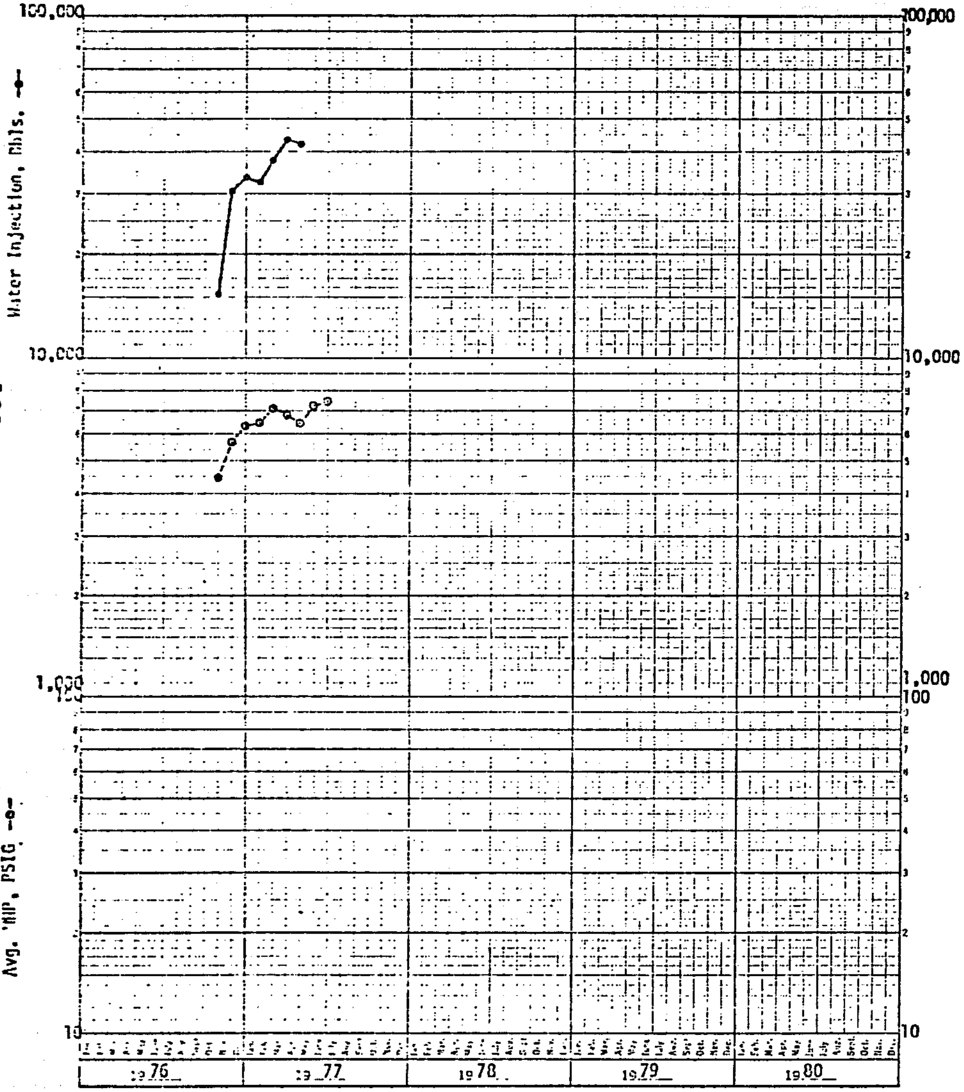
L. W. Shaffer P.I. No. 6



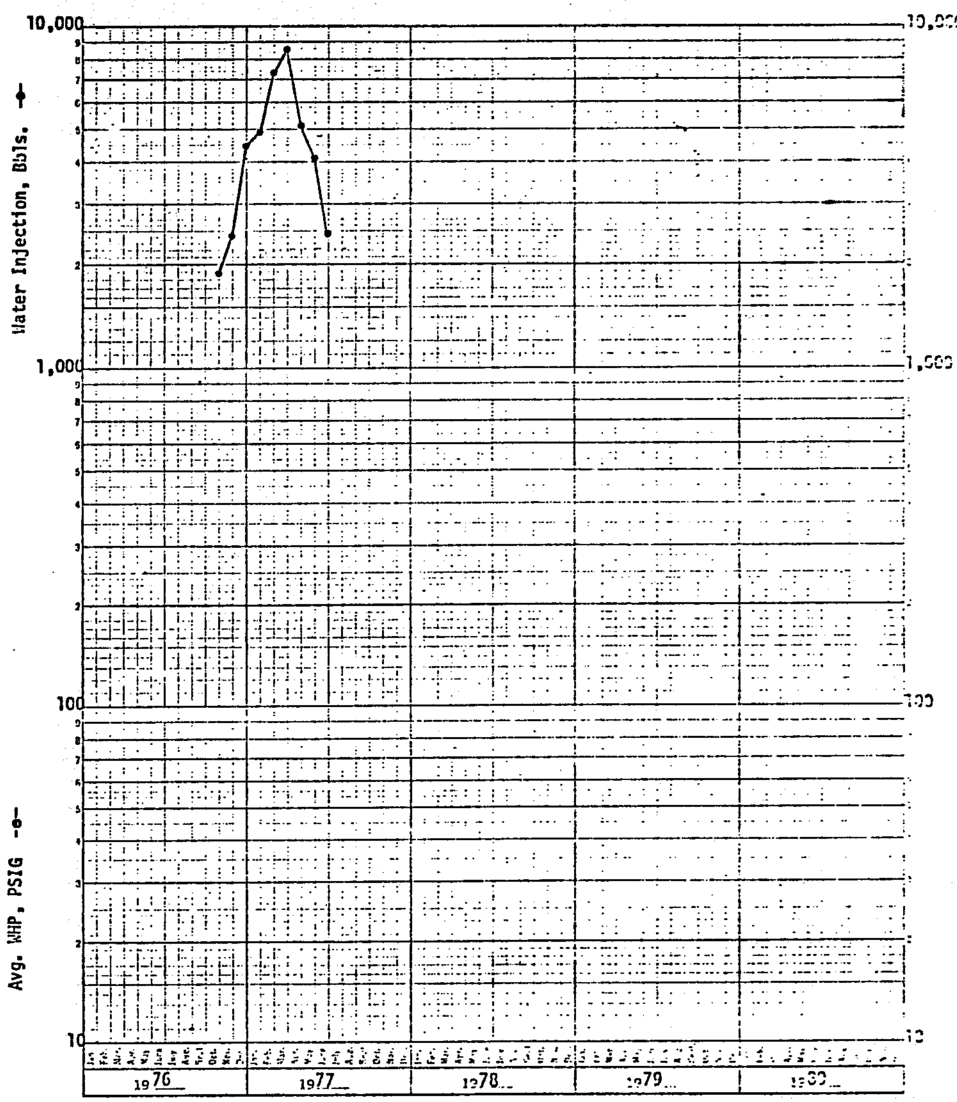
APPENDIX J

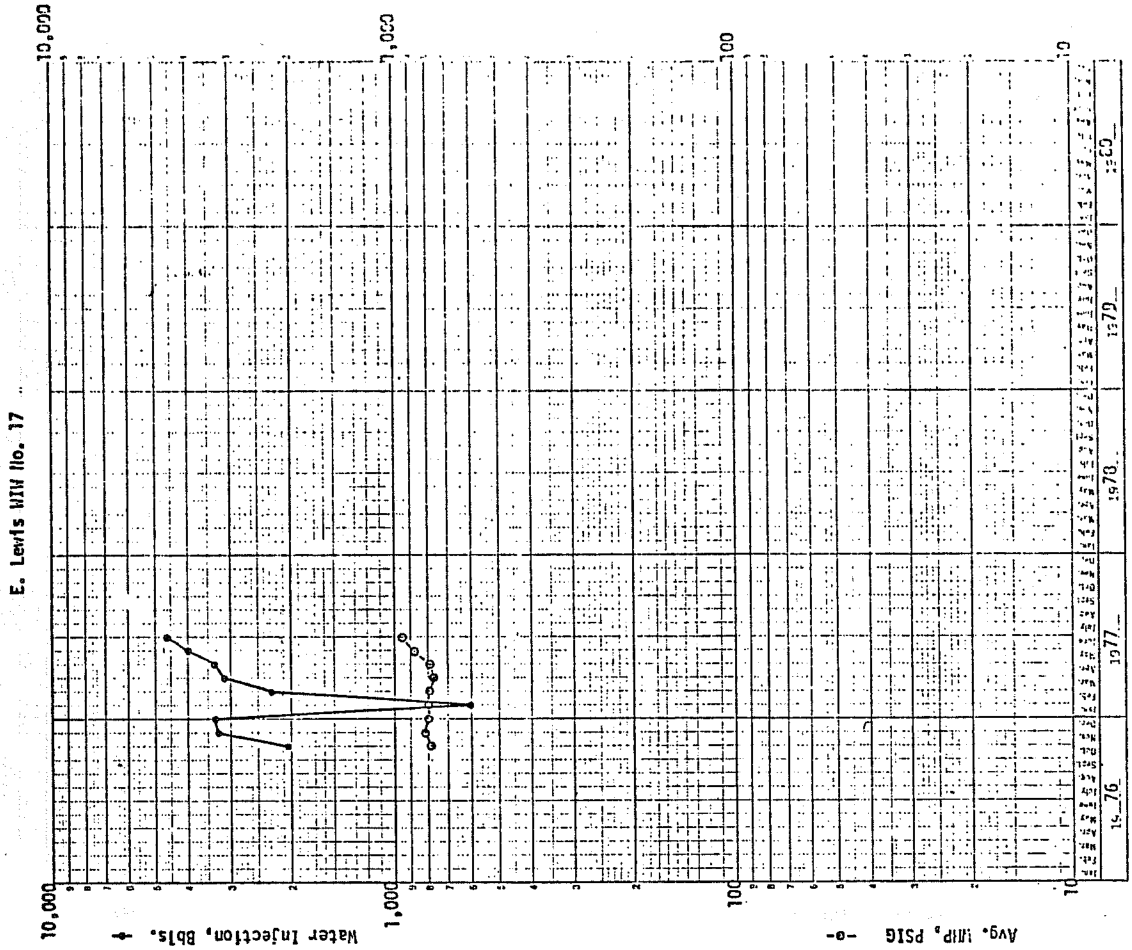
Graphical Back-up Water Injection Well History

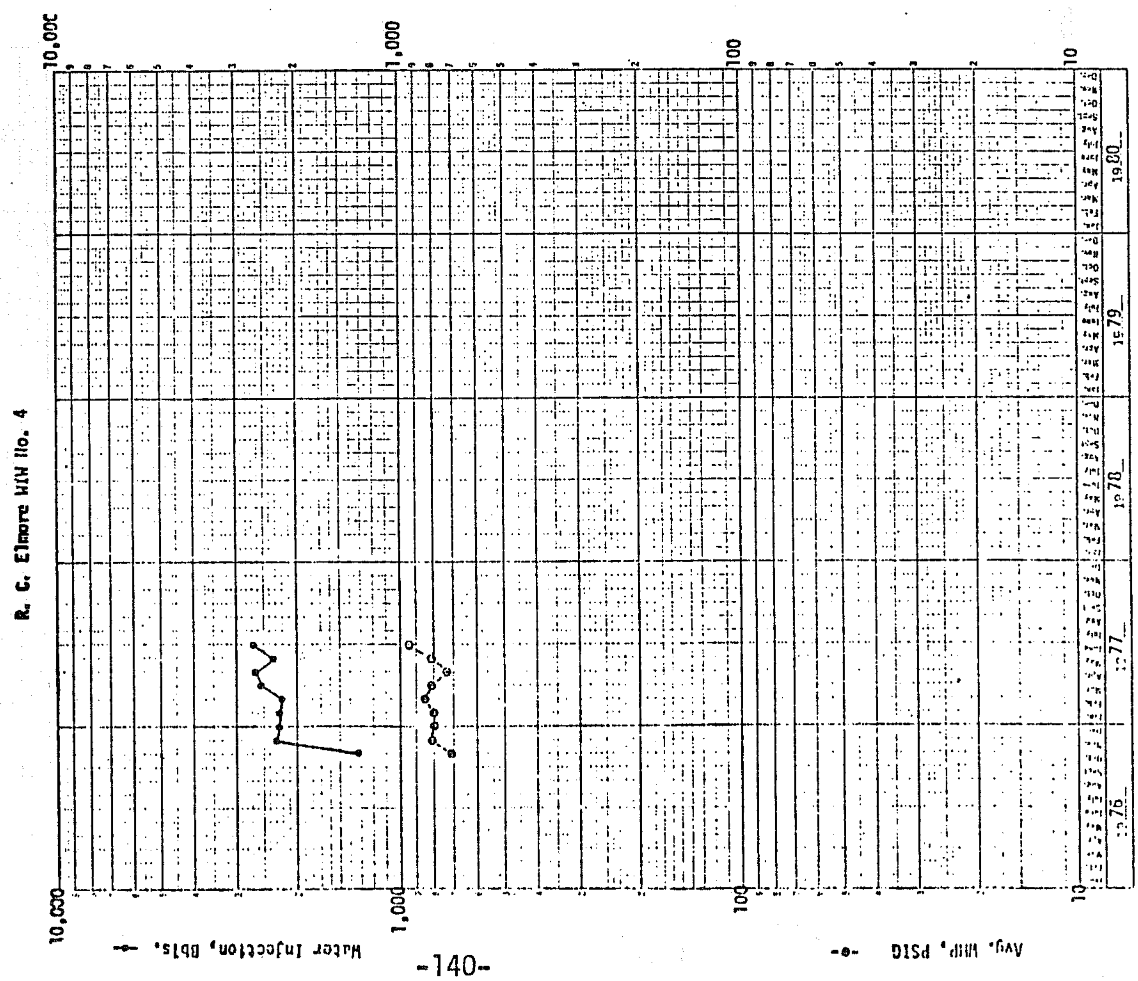
Total Water Injection



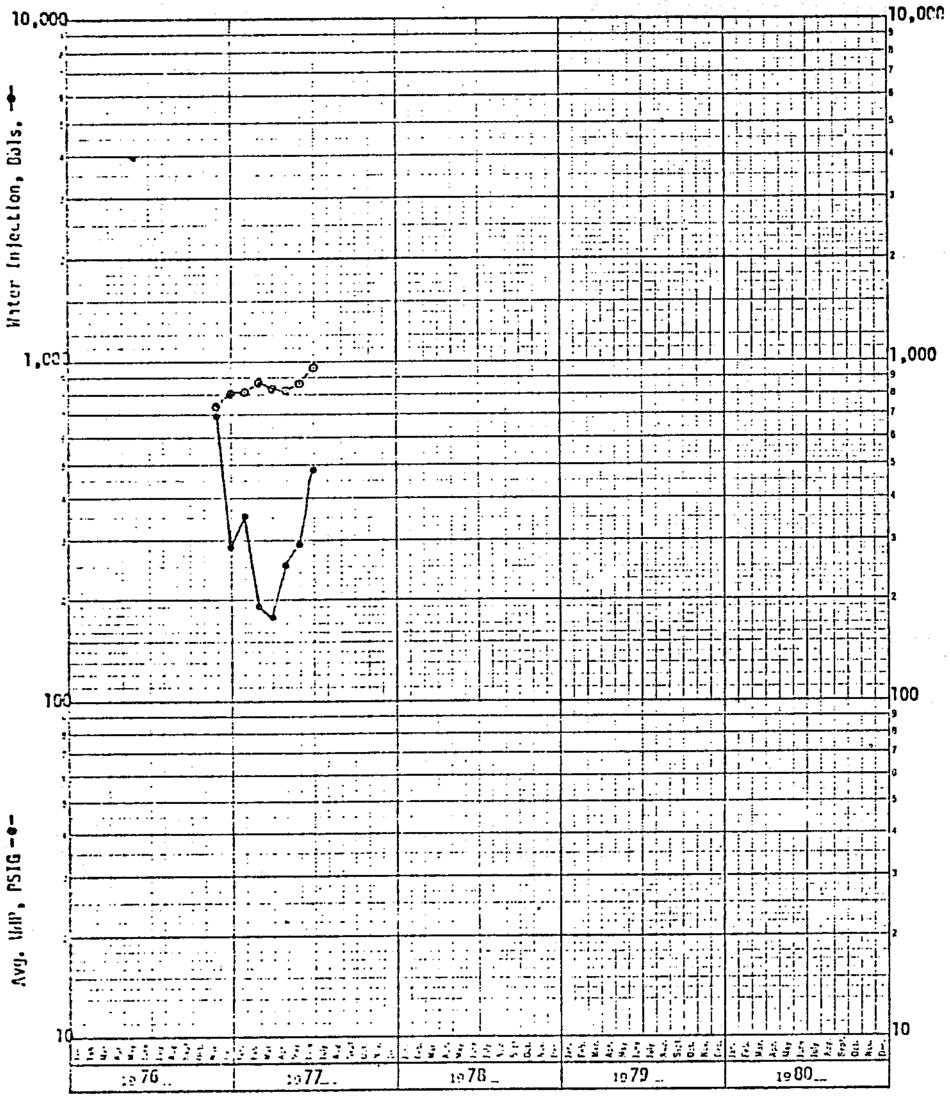
R. C. Elmore WIW No. 1



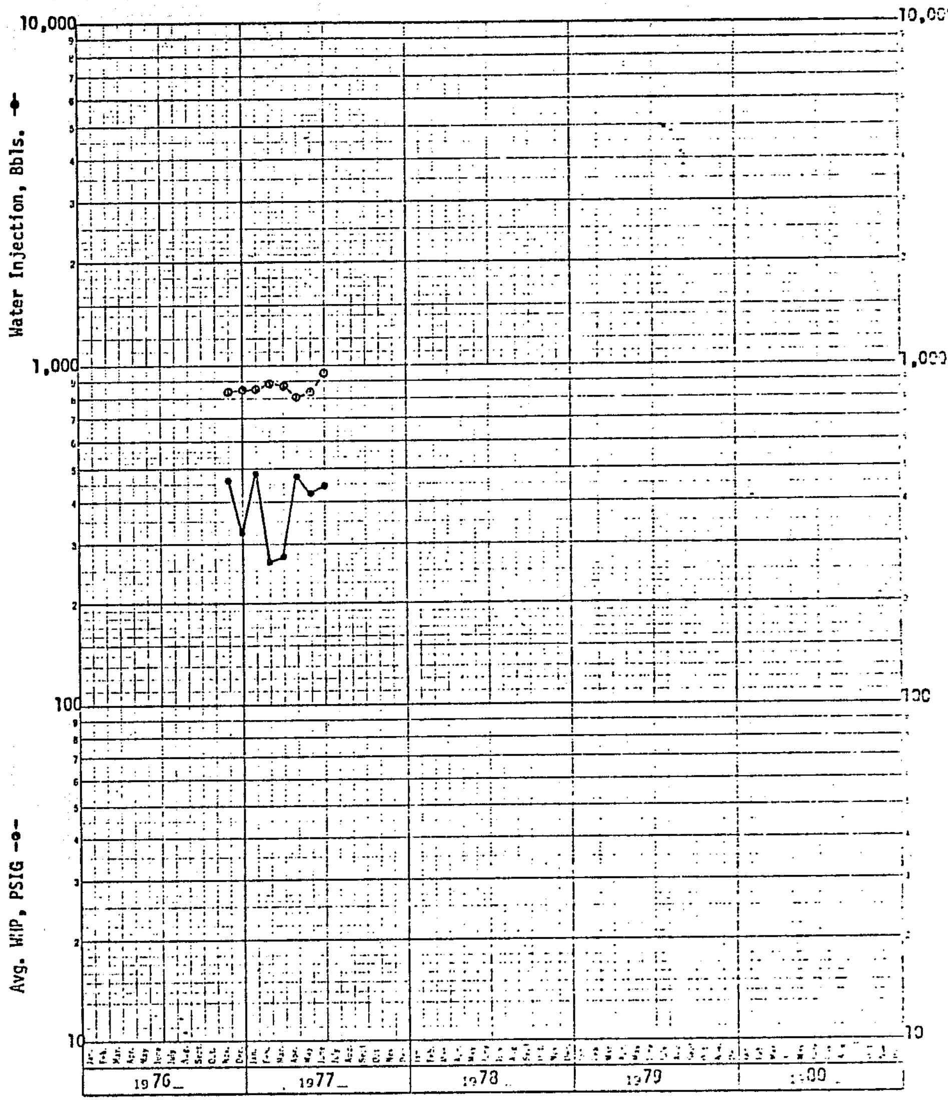

E. Lewis WIW No. 17
10,000
1,000
100
10
Water Injection, Bbls.
Avg. WHP, PSIG
19_76
1977
1978
1979
1980


R. C. Elmore WIW No. 4
10,000
1,000
100
10
Water Injection, Bbls.
Avg. WHP, PSIG
1976
1977
1978
1979
1980

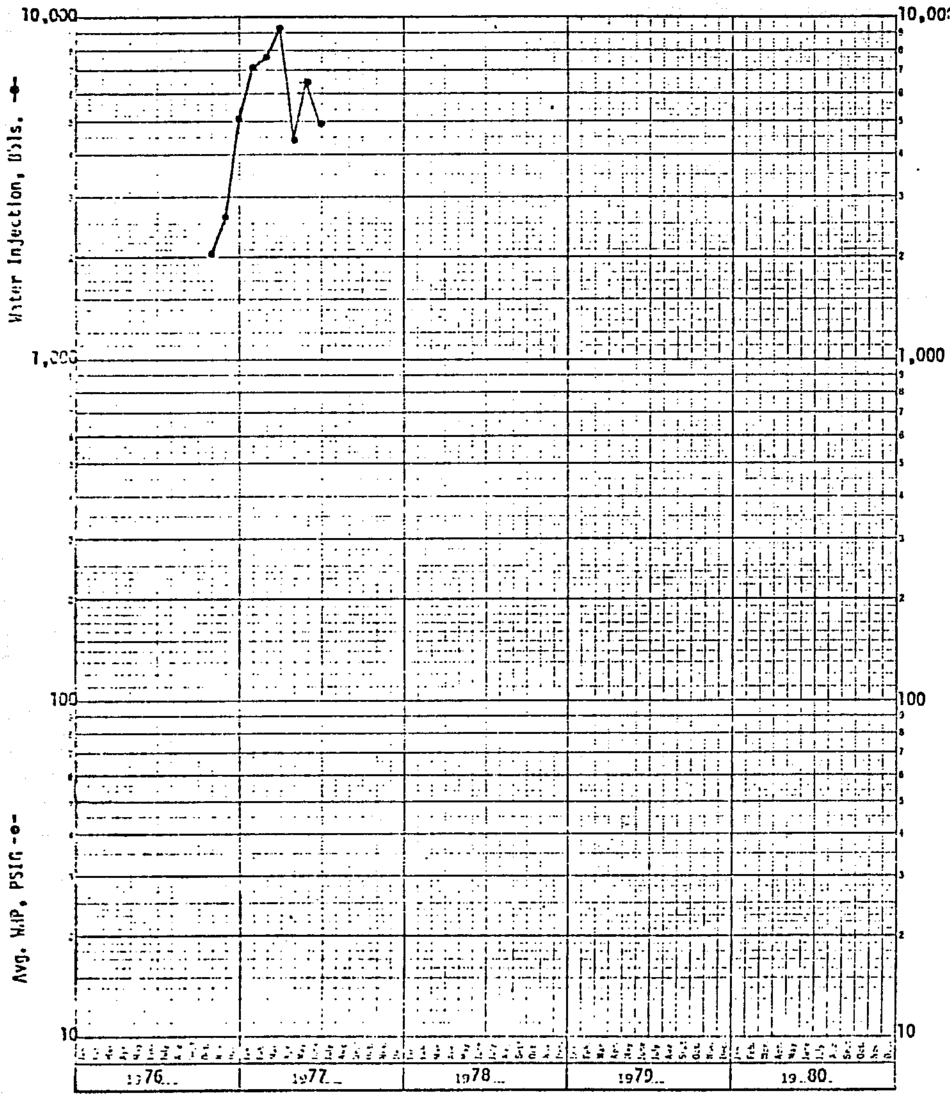
L. W. Shaffer WIW No. 10



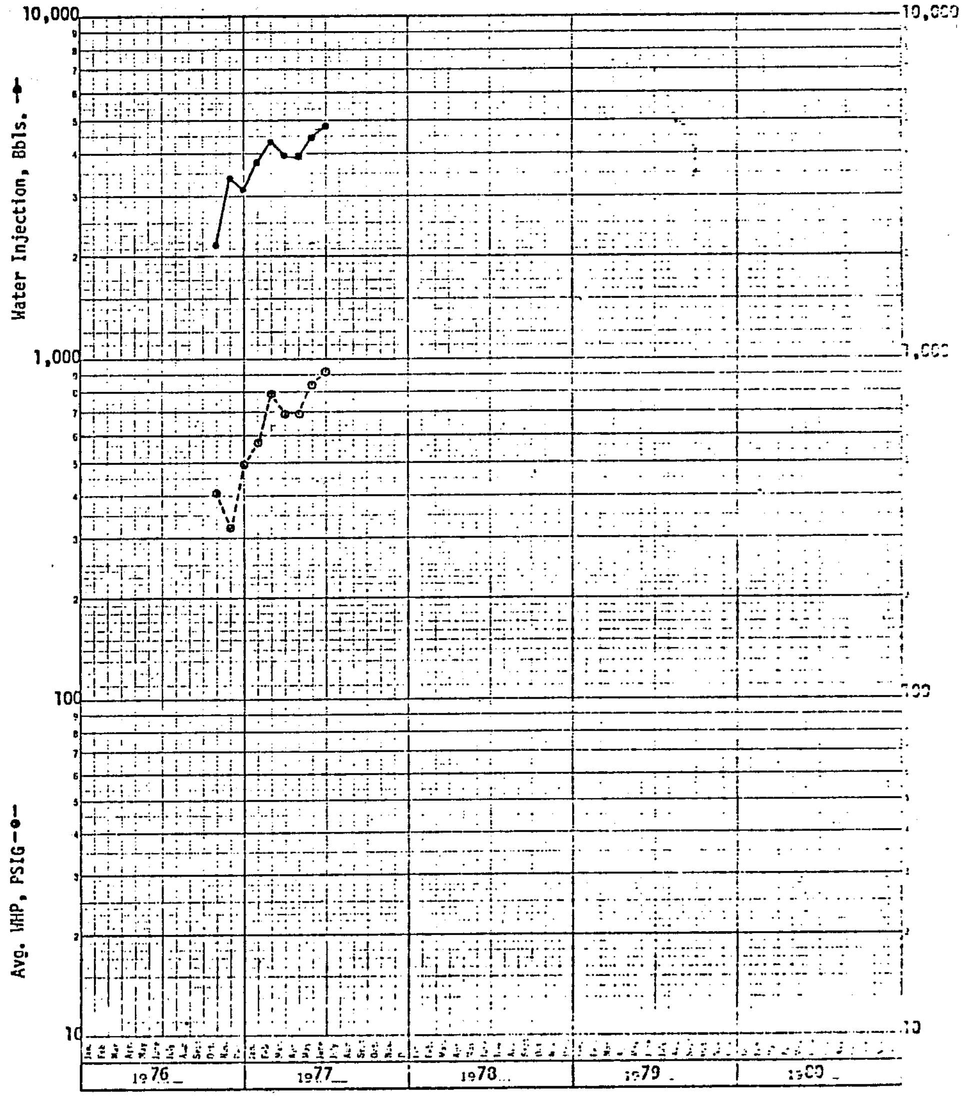
L. W. Shaffer WIW No. 11



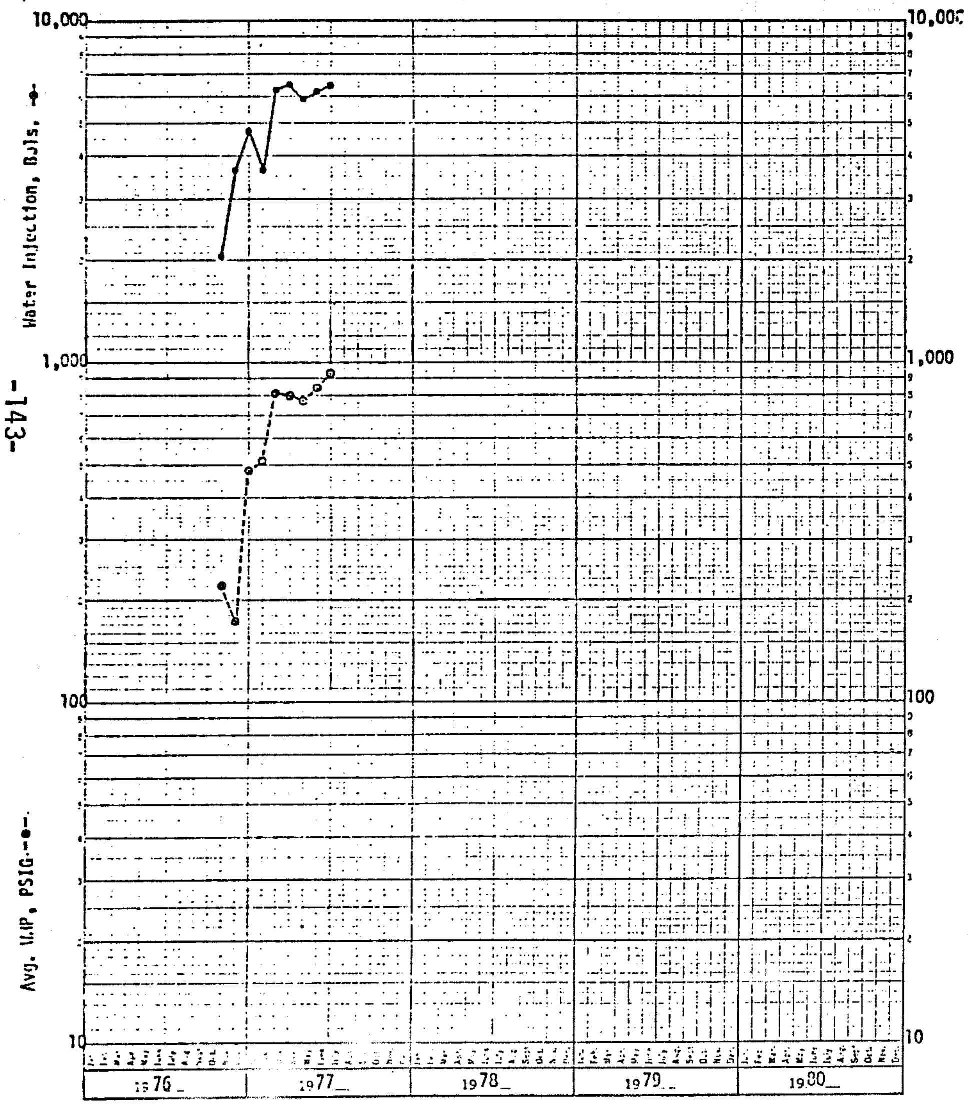
L. W. Shaffer WIW No. 2



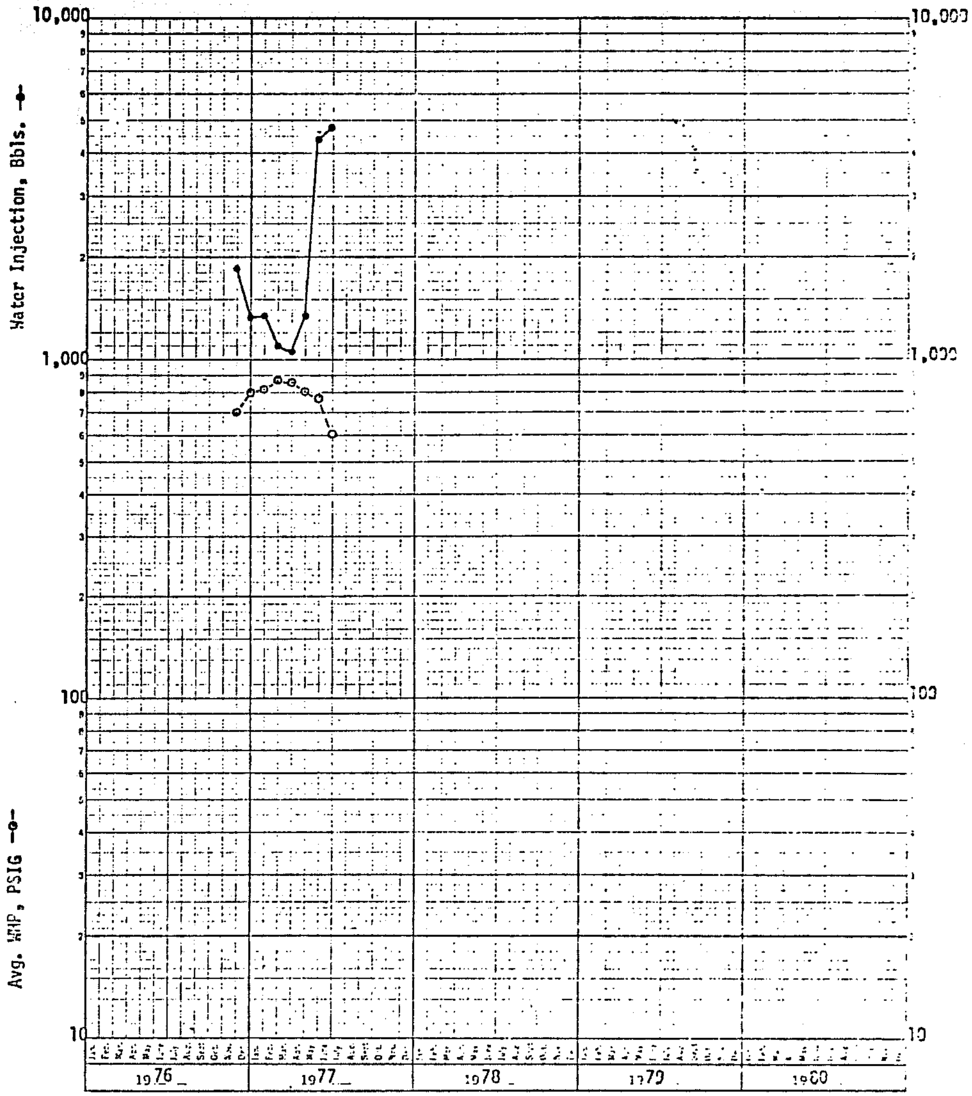
L. W. Shaffer WIW No. 8



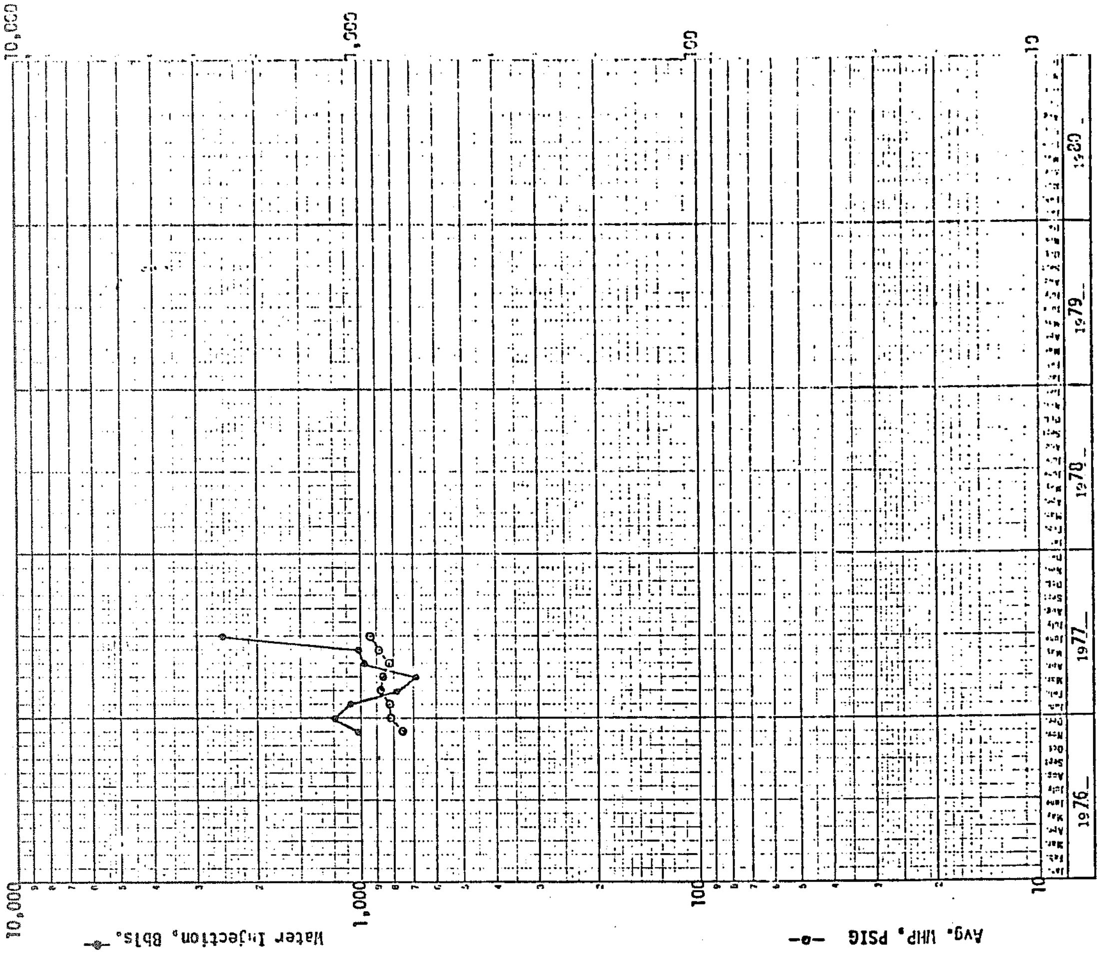
J. H. Looney WIW No. 1



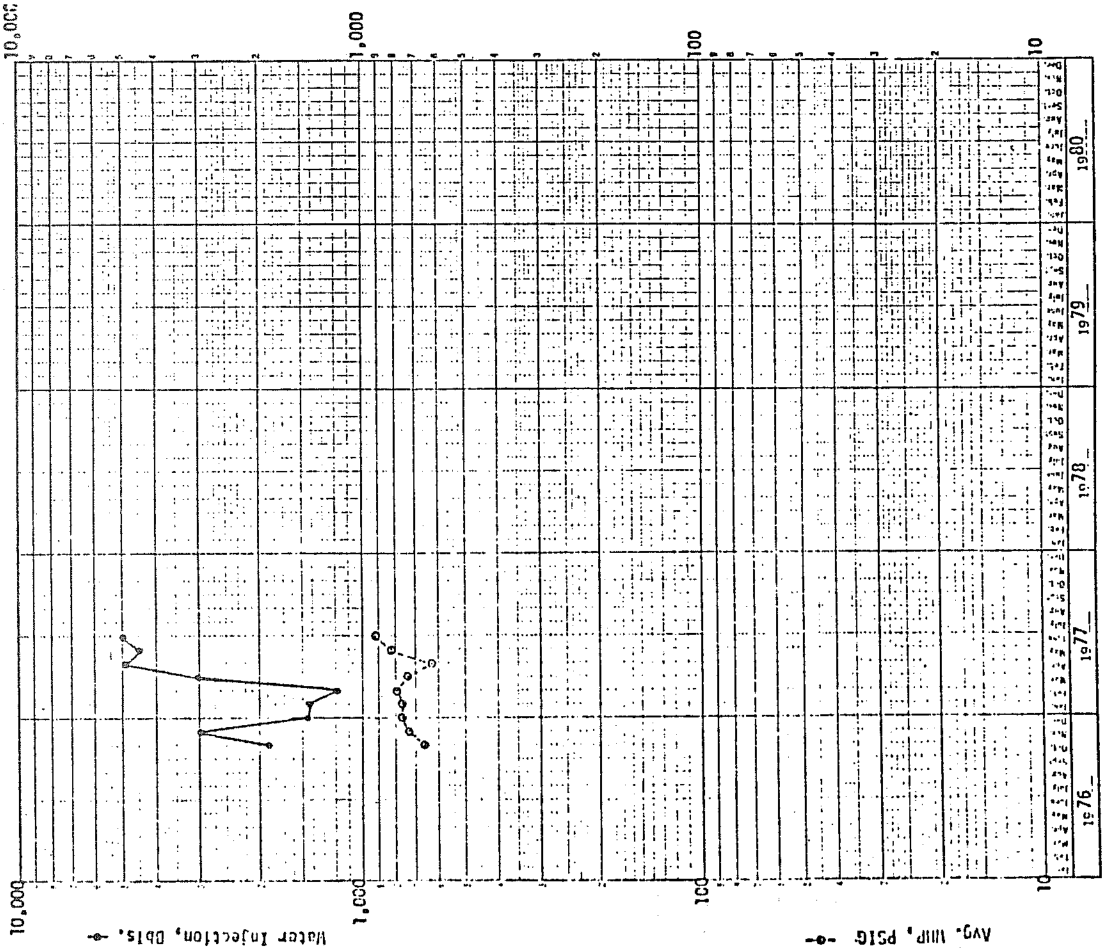
J. H. Looney WIW No. 5



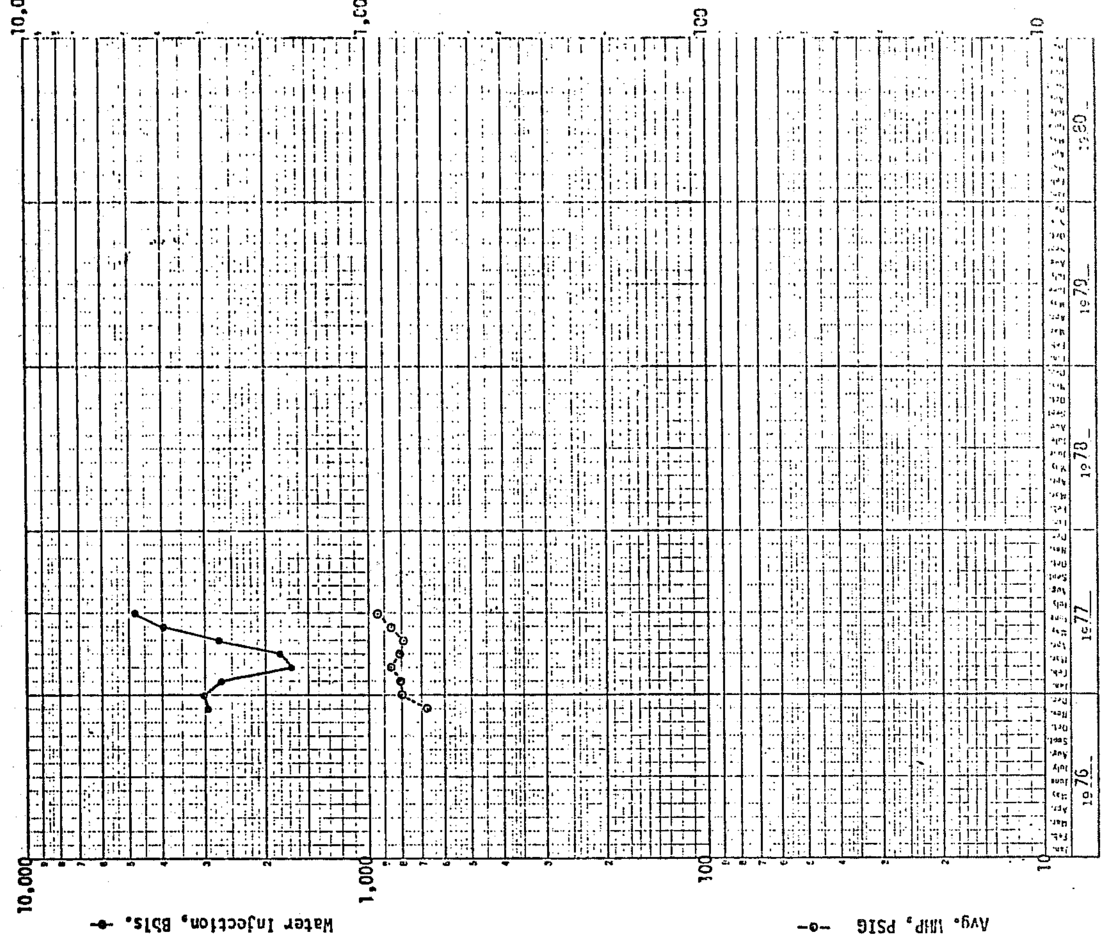
E. Lewis WIW No. 29



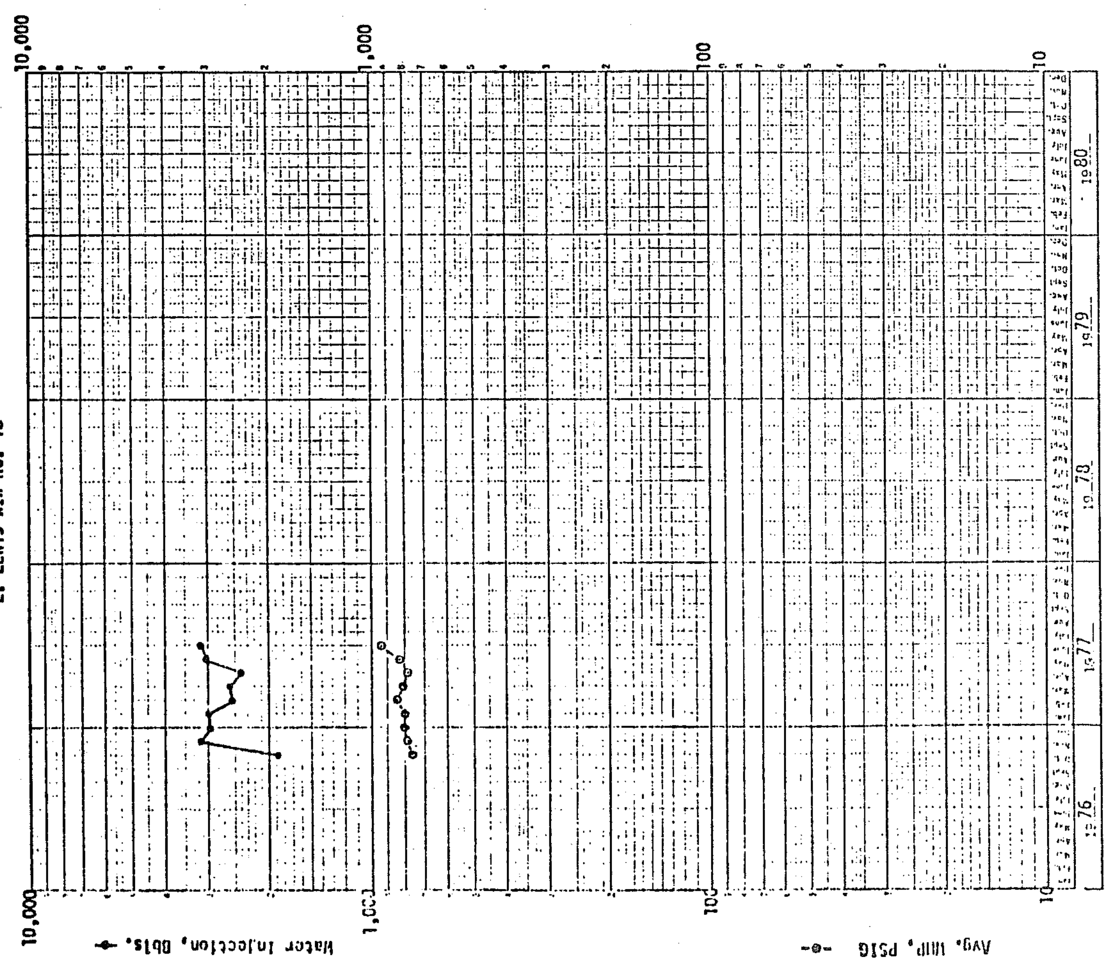
E. Lewis WIW No. 28



E. Lewis WIW No. 27



E. Lewis WIW No. 18



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