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OIL RECOVERY BY CARBON DIOXIDE INJECTION

Annual Report, July 1978—June 1979

Date Publised—February 1980

Prepared for the Department of Energy
Under Contract DE-AC21-76 MC05301

Pennzoil Company
Vienna, West Virginia

U. S. DEPARTMENT OF ENERGY

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OIL RECOVERY BY CARBON DIOXIDE INJECTION

Annual Report
for the Period
July 1978–June 1979

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INTRODUCTION

This report is the forty-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.

The pilot consists of two contiguous five-spot patterns encompassing a total of 19.65 acres. These dual five spots are surrounded by thirteen back-up injection wells drilled as or converted to water injection wells with the sole purpose of containing the injected carbon dioxide (see Figure No. 2). The total effective volume of liquid carbon dioxide to be injected approximately equals 25% of the hydrocarbon pore volume in the pilot area. Prior to initiating carbon dioxide injection, the reservoir pressure was increased to over 1000 psia from the reservoir pressure of 91 psia at the start of the project. This pressure increase was accomplished by water injection.

Once miscible reservoir conditions were obtained and certain

mechanical difficulties resolved, carbon dioxide injection began. Upon completion of the carbon dioxide injection, a water slug will be injected as long as necessary to evaluate the full recovery of the process.

A detailed description of the reservoir lithology, laboratory tests, process design, and project design was presented in the first annual report for this project and published in Volume No. 1 of the 1977 ERDA Symposium Proceedings entitled "Development of a Pilot Carbon Dioxide Flood in the Rock Creek Big Injun Field, Roane County, West Virginia."

SUMMARY

After one year of response, the increase in production due to waterflooding ended by December, 1978. The total production credited to the waterflood process was 10,403 barrels or 529 barrels per acre. This short, sharp production response indicated a thin oil bank and was similar to previous waterflood attempts in the Rock Creek area. As of July 1, 1979, the total pilot production was 11,155 BO, 40,344 BW, and 5.4775 MMCF.

On February 20, 1979, limited carbon dioxide injection began. This was approximately five months behind the revised schedule of the preceeding annual report. Less than a month after injection

began, a high carbon dioxide content was found in the produced gas at Shaffer No. 1. Apparently, this carbon dioxide production is a result of channeling through the Big Lime thief zone. In April, the carbon dioxide injection rate was reduced to a total of 90 tons per day in an attempt to increase the effective injection from 26.7% to the designed 50%. The net carbon dioxide injection was 10,595.50 tons on July 1, 1979. This is 42.3% of the total to be injected.

Water injection into the back-up injection wells was initiated on October 16, 1976 and water injection into the six pattern injection wells commenced on April 22, 1977. After several attempts, the problem of communication from the back-up injection wells through the Big Lime thief zone has apparently been resolved. As of July 1, 1979, total water injection was 1,791,878 barrels.

In February, April, and again in June, compensated neutron and induction logs were run in L. W. Shaffer OB-1. These logs showed an increasing resistivity over a four foot section of the Big Injun formation. To date, the relationship of this resistivity increase to CO_2 injection has not been substantiated. This increase will be studied and monitored using future logs.

The progress of the project and the corresponding cash outlay are depicted pictorially in Figure No. 1. Figure No. 2 is a map of the project area.

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

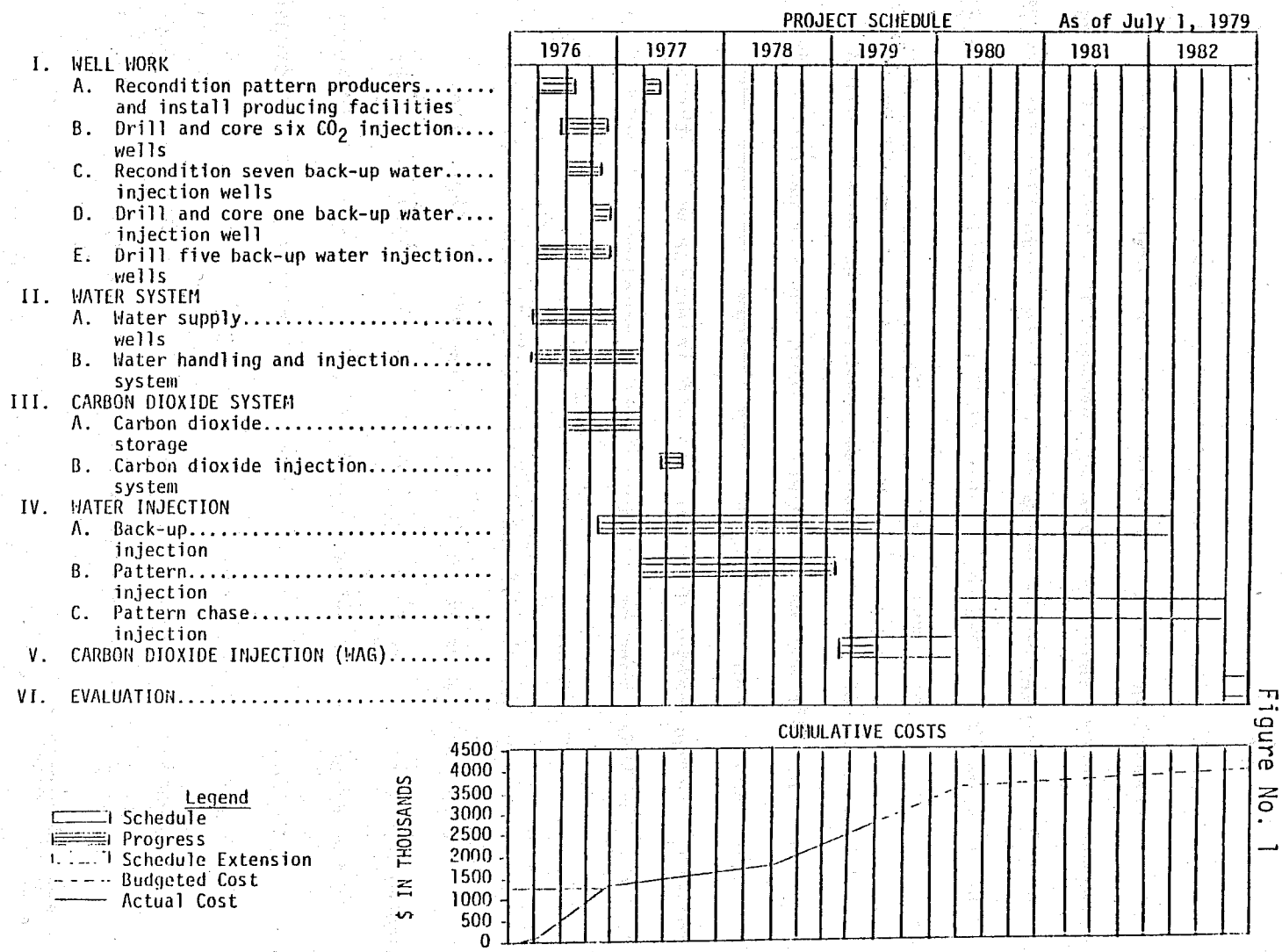
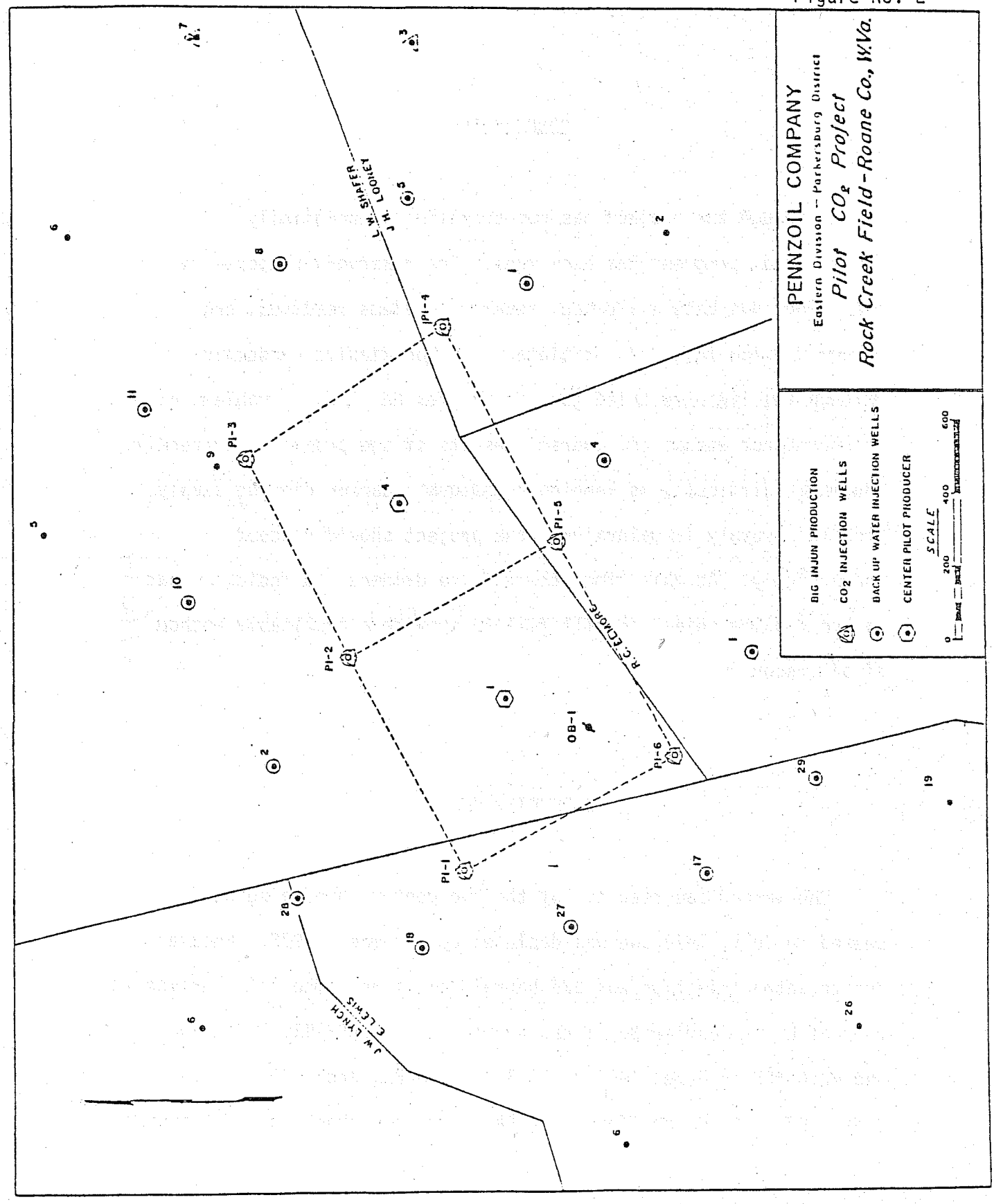


Figure No. 1

Figure No. 2


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

CONCLUSION

Although the project has not proceeded as originally anticipated, progress has been made. The reservoir response to waterflood has been evaluated, several problems resolved, and carbon dioxide injection initiated. Carbon dioxide production through the Big Lime thief zone in Shaffer No. 1 is a problem, but it should not affect the overall results of the project. Currently, the major difficulty is keeping an adequate carbon dioxide supply. When this supply is maintained, the project should proceed successfully. At this time, there is no evidence to indicate that carbon dioxide injection will fail to provide a profitable method of oil recovery.

PRODUCING WELLS

The waterflood response of the two central producing wells peaked in July, 1978 and was depleted by December, 1978. Recovery due to water injection was 529 barrels per acre. The total production rate of L. W. Shaffer No. 1 has increased from 688 BO, 1,082 BW, and 42.0 MCF in June, 1978 to 10 BO, 2,646 BW, and 1,282 MCF in June, 1979. L. W. Shaffer No. 4 has increased from a total producing

rate of 235 BO, 4 BW, and 153.2 MCF in June, 1978 to 0 BO, 3,088 BW, and 1.2 MCF in June, 1979. A major reason for these fluid production increases was stimulation treatments performed on the center producers throughout the year. Fracture treatments, performed on L. W. Shaffer No. 4 in January and L. W. Shaffer No. 1 in February were successful in increasing the productivity of both wells. A list of the work done on L. W. Shaffer Nos. 1 and 4 from July, 1978 to July, 1979 is located in Appendix A. The production history of these two wells is tabulated in Appendix B and graphically presented in Appendix C.

Table I shows the effective water injection volumes and rates in comparison with fluid withdrawals from each pattern as of July 1, 1979. Effective injection is defined as the amount of fluid that would enter the pattern area based on a radial flow pattern with no interference by the outside injection wells. Also, it is assumed that no water injected into the back-up wells enters the pattern area.

TABLE I

	Shaffer No. 1 Pattern 10.01 Acres	Shaffer No. 4 Pattern 9.64 Acres	Project 19.65 Acres
Cum. Eff. W.I.-7/1/79, Res. Bbls.	69,544	61,914	131,458
Cum. Eff. CO_2 Inj.,-7/1/79, Res. Bbls.	12,590	13,229	25,819
Cum. Eff. Inj.-7/1/79, Res. Bbls.	82 134	75,143	157,277
Cum. Eff. Inj./B.F. Produced	3.18	2.92	3.05
Cum. Eff. Inj./BO Produced	15.27	13.01	14.10
Cum. Recovery, STBOPA	537.36	599.17	567.68

The considerable decrease in these ratios from last year is most likely due to waterflood response.

Since the beginning of the project, gas samples have been taken periodically from the two center producing wells. From June, 1978 to August, 1979 gas gravities have increased from 1.2025 to 1.5202 and 1.0525 to 1.3974 in L. W. Shaffer Nos. 1 and 4 respectively. These analyses are presented in Appendix D. The carbon dioxide produced through the thief zone has greatly affected the gas analyses of L. W. Shaffer No. 1. L. W. Shaffer No. 4 is beginning to show an increase in the carbon dioxide percentage of the produced gas as of July, 1979.

INJECTION WELLS

Carbon Dioxide Injection Wells

From July 1, 1978 to February 20, 1979, the six pattern injection wells continued to inject water. During this time, the injection rate averaged 80 BWPD at an average wellhead pressure of 1063 psig. Total water injected into these wells has been 391,679 barrels.

The initial carbon dioxide injection was delayed when a supplier in Charleston, West Virginia, shut down their ammonia plant due to the high price of natural gas. Another source was

located and limited carbon dioxide injection began on February 20, 1979. Cumulative carbon dioxide injection as of July, 1979 totaled 10,820.10 tons. Of this volume, 224.60 tons have been produced from L. W. Shaffer No. 1 as a result of the Big Lime thief zone. Therefore, the net volume of carbon dioxide injection to date has been 10,595.50 tons. This net volume of carbon dioxide equates to 75,016 barrels at a reservoir pressure of 1400 psia and is 42.3% of the total designed carbon dioxide volume of 25,000 tons. As of July 1, total production from the center wells since the start of carbon dioxide injection was 24,132 barrels. Therefore, by material balance it is estimated that 32.2% of the carbon dioxide injection has entered the pattern area. The injection rate of carbon dioxide averaged 90 tons or 637.20 reservoir barrels per day during April and May. In June, the injection rate was lowered to 60.1 tons or 426 reservoir barrels per day due to a short supply of carbon dioxide in the summer months. The carbon dioxide injection history is listed in Appendix E and presented graphically in Appendix F.

Back-up Water Injection Wells

Injection into the thirteen back-up wells totaled 1,400,199 barrels of water as of July 1, 1979. The average injection rate for the active wells during June, 1979 was 68 BPDPW at an average wellhead pressure of 1085 psig. In comparison, the average rate in June, 1978 was 125 BPDPW at an average wellhead pressure of

955 psig. This decrease in injectivity and increase in injection pressure is indicative of pressure build-up in the reservoir. Also, remedial treatment of injection wells shown to be in communication with the Big Lime thief zone has decreased the injection rate. During the year, E. Lewis Nos. 17 and 18 and L. W. Shaffer No. 2 were squeezed to eliminate the thief zone problem.

The injection history for these wells is tabulated in Appendix G and presented graphically in Appendix H.

OBSERVATION WELL

L. W. Shaffer OB-1 was completed in February, 1979. The purpose of this well is to monitor reservoir pressure and fluid movement inside the pattern area. Fiberglass casing was hung over the reservoir interval to enable the use of induction logs throughout the project life.

Since completion of OB-1, dual induction and compensated neutron logs have been run three times. These logs have shown an increase in resistivity over a four foot section of the Big Injun reservoir. This resistivity increase, which is currently being studied, may be related to carbon dioxide injection. Copies of these logs were included in the appropriate monthly reports.

APPENDIX A

Rock Creek Pilot CO_2 Project
Rock Creek Field - Walton District
Roane County, West Virginia

STIMULATION TREATMENTS

L. W. SHAFFER NO. 1

January 22, 1979	-	Open hole squeeze - Appeared to be successful in eliminating fluid entry from the thief zone.
February 24, 1979	-	Fracture treatment - Used 180 barrels of treated water and 3,600 lbs. of 20/40 sand.
May 31, 1979	-	Acidized - Used 1,000 gallons of 7-1/2% HCl acid with a sequestering agent; had little effect on production.

L. W. SHAFFER NO. 4

November, 1978	-	Treated for paraffin damage; had no significant results.
December 13, 1978	-	Acidized - Increased fluid withdrawal from 21 to 50 BFPD.
January 15, 1979	-	Fracture treatment - Used 500 gallons of 15% F.E. acid, 150 barrels of treated water, and 3,000 lbs. of 20/40 sand. Productivity increased to over 100 BFPD.
May 24, 1979	-	Acidized - Used 1,000 gallons of 7-1/2% HCl acid with a sequestering agent; had little effect on production.

APPENDIX B

History of Production

ROCK CREEK PILOT CARBON DIOXIDE PROJECT
HISTORY OF PRODUCTION

	L. W. Shaffer No. 1				L. W. Shaffer No. 4			
	Oil, Bbls.	Water, Bbls.	Gas, MMCF	Hrs.	Oil, Bbls.	Water, Bbls.	Gas, MMCF	Hrs.
1976								
October	48	0	0.0744	47	3	69	0.0620	48
November	44	0	0.0720	59	0	47	0.0600	60
December	51	0	0.0744	64	0	26	0.0620	64
1977								
January	40	0	0.0576	37	0	15	0.0420	34
February	39	0	0.0672	46	0	16	0.0560	38
March	53	0	0.1635	62	22	10	0.1268	62
April	60	0	0.1723	66	28	5	0.1168	60
May	49	0	0.1527	58	24	17	0.1744	54
June	56	12	0.0950	65	34	19	0.1949	60
July	56	78	0.1224	88	43	7	0.2083	70
August	33	56	0.1929	93	43	3	0.2239	62
September	30	10	0.1650	93	36	2	0.2100	62
October	35	62	0.1009	100	37	2	0.1653	67
November	31	34	0.1305	87	34	4	0.1204	66
December	20	86	0.1023	80	39	5	0.1178	66
1978								
January	4	43	0.0495	33	32	1	0.0570	57
February	0	0	0	0	41	0	0.1104	70
March	2	313	0.0194	147	43	3	0.1178	67
April	14	1,116	0.0435	404	34	11	0.1133	64
May	195	681	0.0434	254	40	8	0.1178	60
June	688	1,082	0.0420	616	235	4	0.1532	162
Cumulative Production	1,548	3,573	1.9409		768	274	2.6101	

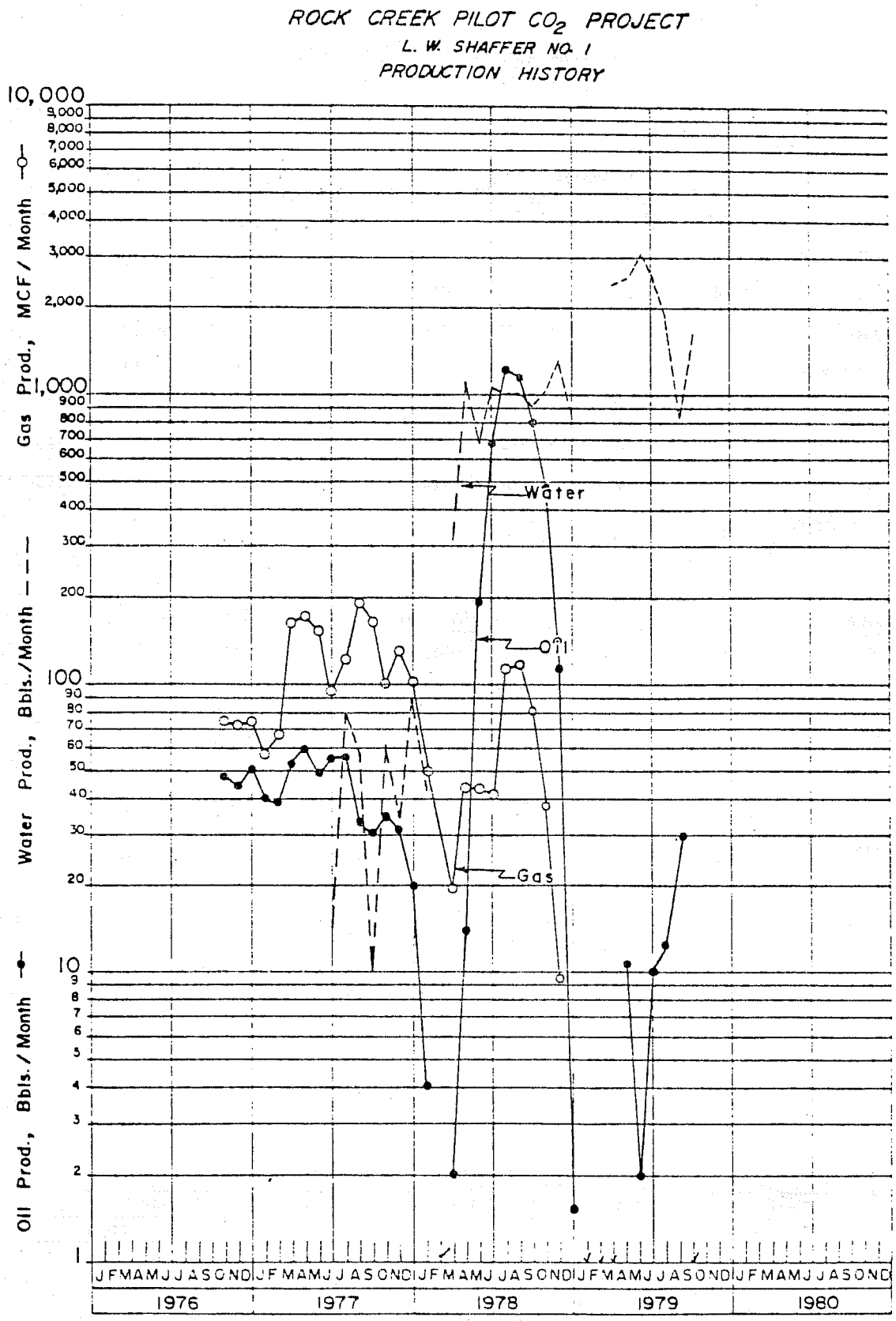
ROCK CREEK PILOT CARBON DIOXIDE PROJECT
HISTORY OF PRODUCTION
Continued

	L. W. Shaffer No. 1				L. W. Shaffer No. 4			
	Oil, Bbls.	Water, Bbls.	Gas, MMCF	Hrs.	Oil, Bbls.	Water, Bbls.	Gas, MMCF	Hrs.
1978 - Continued								
July	1,246	1,036	0.1170	694	2,029	15	0.2022	690
August	1,174	1,016	0.1190	726	1,662	22	0.1686	
September	804	932	0.0810	720	919	167	0.0917	720
October	474	1,031	0.0373	744	314	350	0.0262	646
November	109	1,315	0.0094	720	17	783	0.0010	605
December	1	857	0.0008	424	9	768	0.0208	503
Cumulative Production	5,356	9,760	2.3054		5,718	2,379	3.1206	
1979								
January	0	0	0	Workover	10	2,258	0.0110	685
February	0	0	0	Workover	17	2,777	0.0149	654
March	0	2,446	0.0962*	458	8	2,377	0.0036	568
April	11	2,451	0.9147*	669	17	3,473	0.0151	705
May	2	3,118	1.4950*	484	6	3,571	0.0057	672
June	10	2,646	1.2818*	607	0	3,088	0.0012	604
Cumulative Production	5,379	20,421	3.7877*		5,776	19,923	3.1721	

*CO_2 Production

APPENDIX C

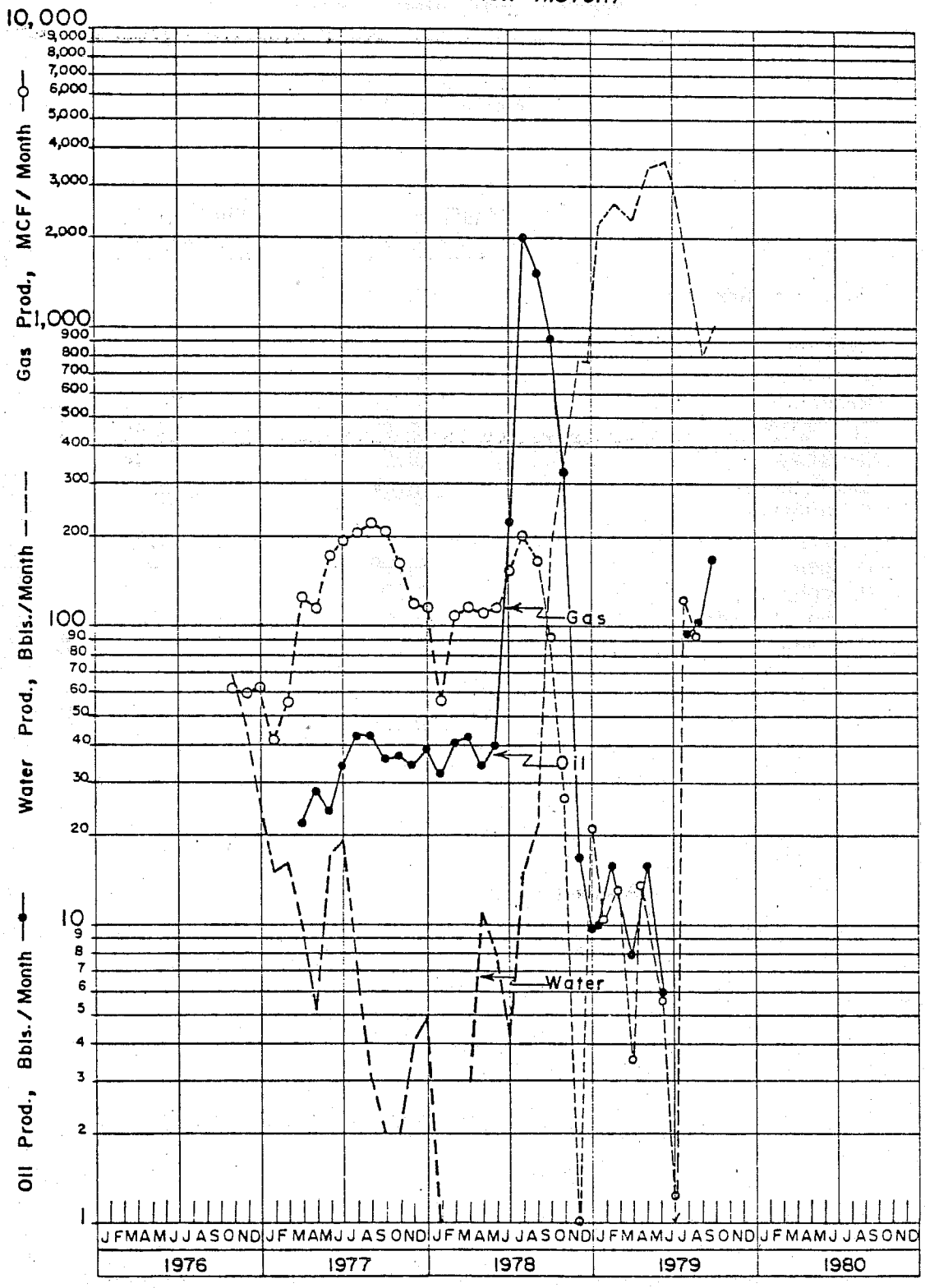
Graphical History of Production



ROCK CREEK PILOT CO_2 PROJECT

L. W. SHAFFER NO. 4

PRODUCTION HISTORY



APPENDIX D

Rock Creek Pilot CO_2 Project
Rock Creek Field - Walton District
Roane County, West Virginia

PRODUCED GAS ANALYSES
August 8, 1979

	Shaffer No. 1 Mol %	Shaffer No. 4 Mol %
Specific Gravity	1.5202	1.3974
Methane	Trace	17.67
Ethane	0.20	14.08
Propane	0.13	18.61
Iso-Butane	0.03	3.98
N-Butane	0.08	7.44
Iso-Pentane	0.03	2.05
N-Pentane	0.02	1.52
Hexane		0.97
Oxygen	0.09	-
Nitrogen	0.76	0.27
Carbon Dioxide	98.66	33.41
Hydrogen		
Total	100.00	100.00

APPENDIX E

History of Carbon Dioxide Injection

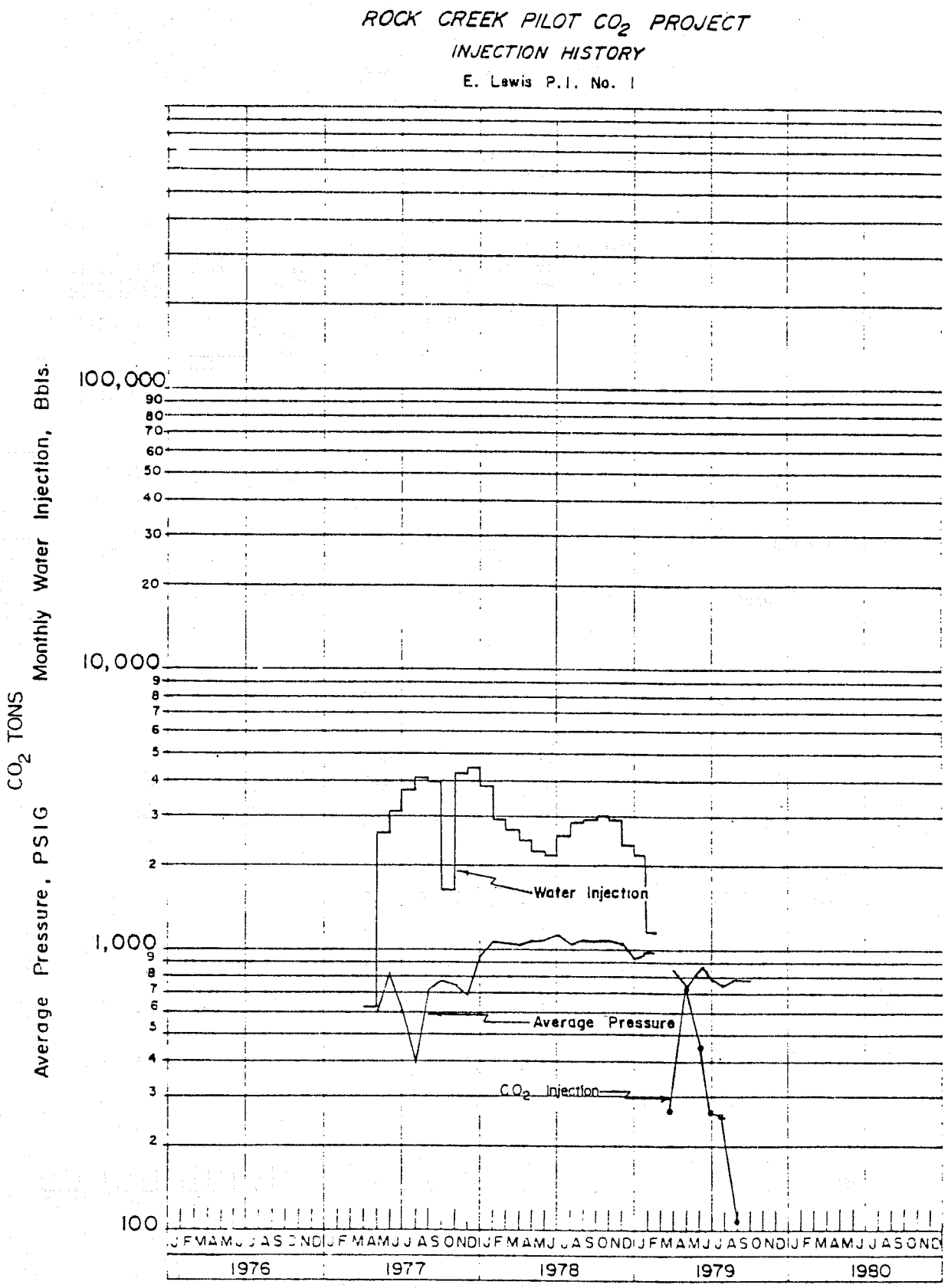
ROCK CREEK PILOT CARBON DIOXIDE PROJECT
HISTORY OF CARBON DIOXIDE INJECTION

	January, 1979		February, 1979		March, 1979		
	Inj., Tons	Avg. WHP	Inj., Tons	Avg. WHP	Inj., Tons	Avg. WHP	Res. Bbls. @1400 psia
E. Lewis P.I. No. 1	0	--	75.20	850	270.23	725	2,445.6
L. W. Shaffer P.I. No. 2	0	--	15.90	755	295.65	840	2,205.8
L. W. Shaffer P.I. No. 3	0	--	40.60	675	259.16	745	2,122.3
J. H. Looney P.I. No. 4	0	--	15.70	545	264.30	675	1,982.4
R. C. Elmore P.I. No. 5	0	--	98.30	925	335.96	755	3,074.6
L. W. Shaffer P.I. No. 6	0	--	89.40	795	223.47	620	2,215.1
Total Injection or Average Pressure	0	--	335.10	755	1,648.77	725	14,045.8
Cumulative Injection	0		335.10		1,983.87		

	April, 1979		May, 1979		June, 1979		
	Inj., Tons	Avg. WHP	Inj., Tons	Avg. WHP	Inj., Tons	Avg. WHP	Res. Bbls. @1400 psia
E. Lewis P.I. No. 1	735.25	880	449.87	780	269.28	750	12,742.8
L. W. Shaffer P.I. No. 2	707.52	1150	469.10	890	293.96	750	12,617.5
L. W. Shaffer P.I. No. 3	778.37	945	465.26	820	318.95	785	13,185.3
J. H. Looney P.I. No. 4	787.13	730	468.51	725	309.19	755	13,061.4
R. C. Elmore P.I. No. 5	772.85	955	469.85	905	308.01	800	14,053.6
L. W. Shaffer P.I. No. 6	481.10	1040	449.28	835	302.75	780	10,945.7
Total Injection or Average Pressure	4,262.22	950	2,771.87	825	1,802.14	770	76,606.3
Cumulative Injection	6,246.09		9,017.96		10,820.10		

APPENDIX F

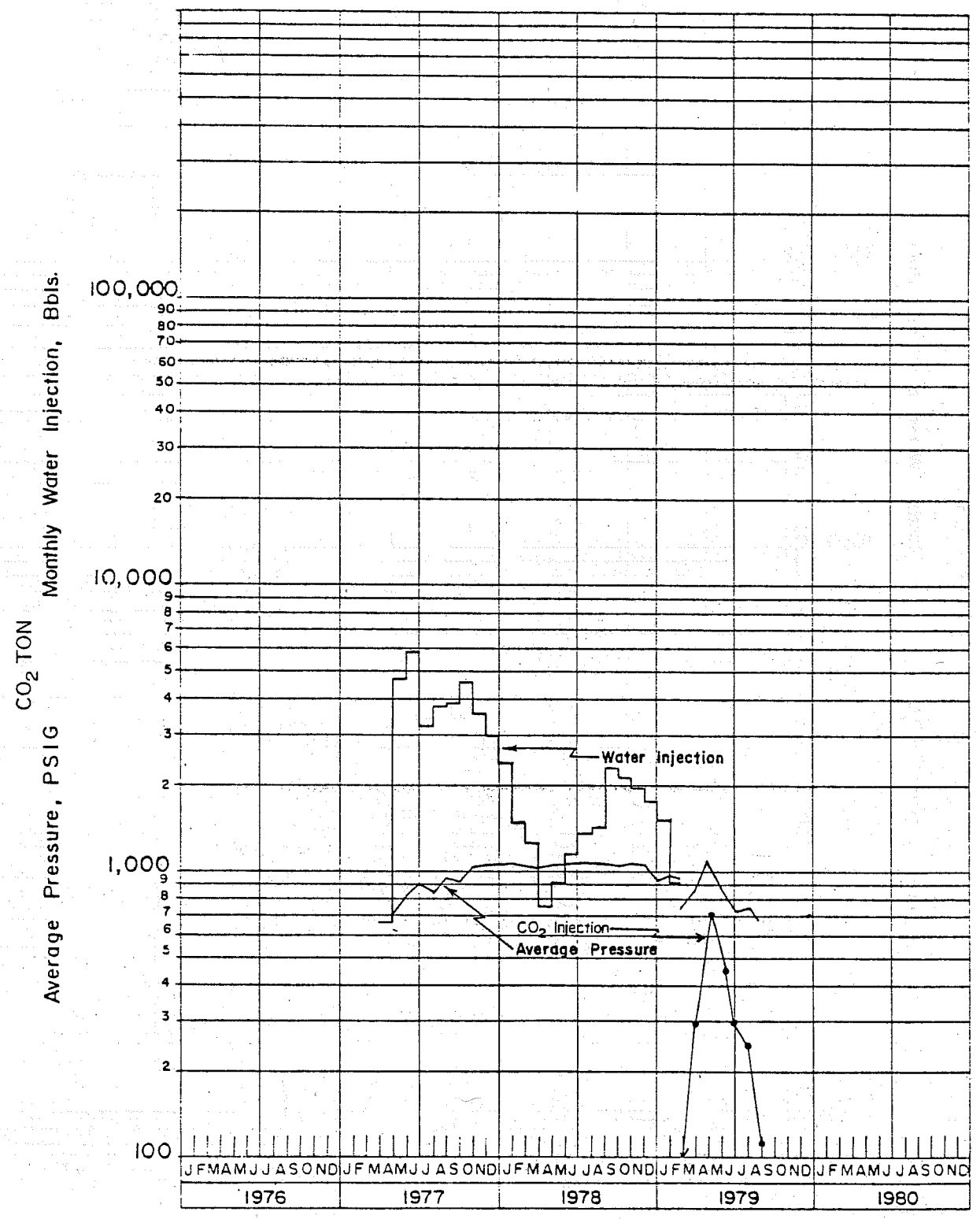
Graphical History of Carbon Dioxide Injection



ROCK CREEK PILOT CO_2 PROJECT

INJECTION HISTORY

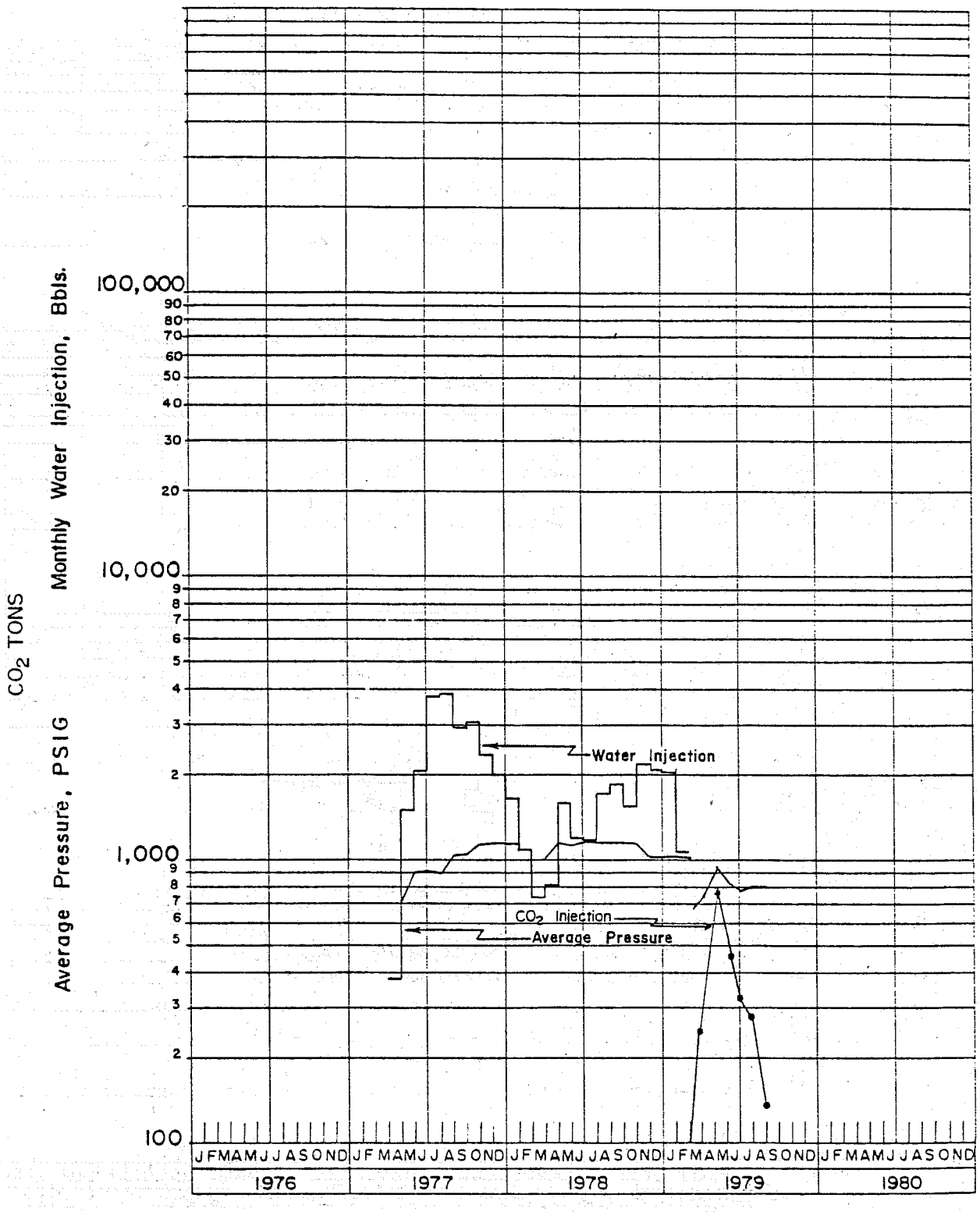
L. W. Shaffer P.I. No. 2



ROCK CREEK PILOT CO_2 PROJECT

INJECTION HISTORY

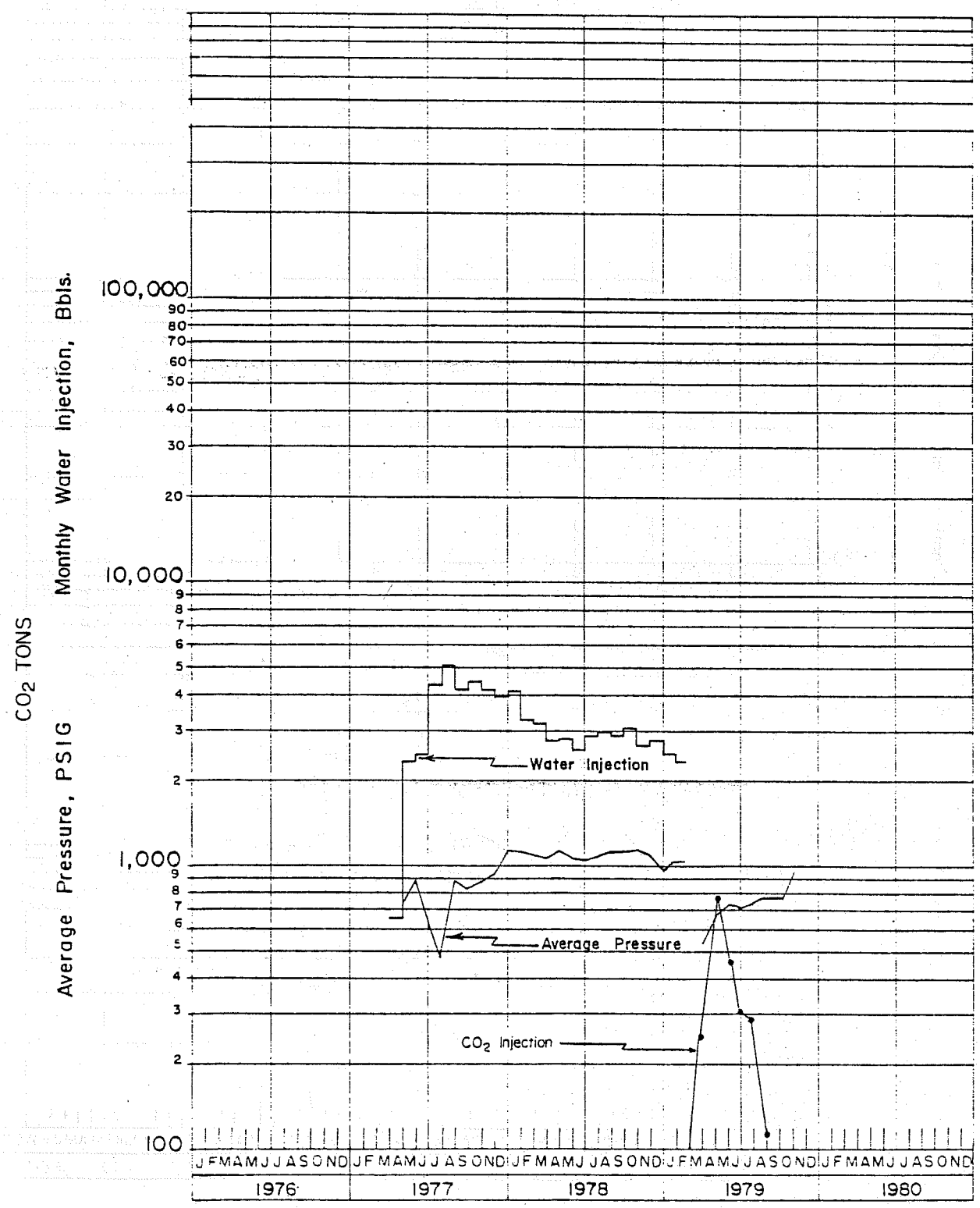
L. W. Shaffer P.I. No. 3



ROCK CREEK PILOT CO_2 PROJECT

INJECTION HISTORY

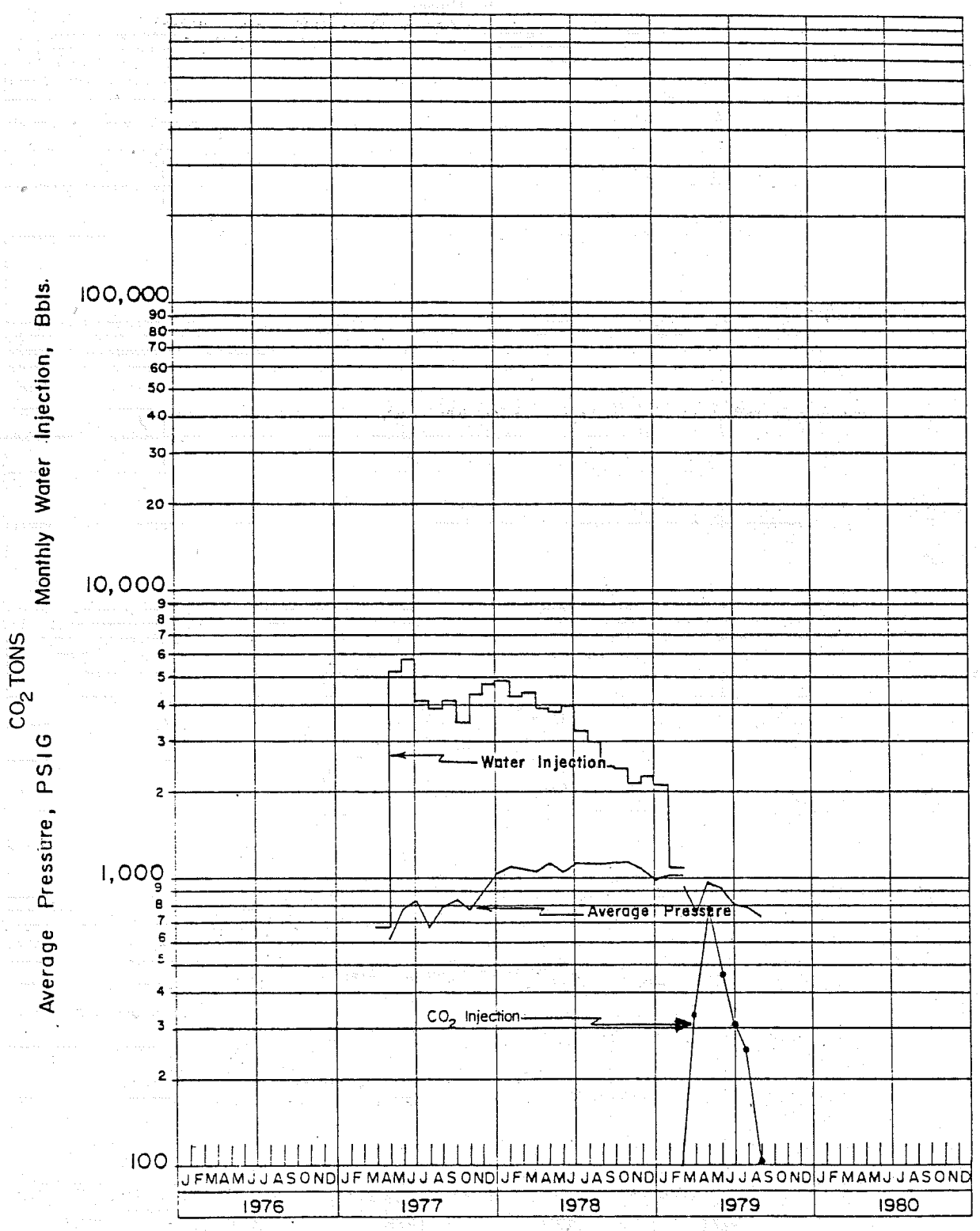
J. H. Looney P.I. No. 4



ROCK CREEK PILOT CO_2 PROJECT

INJECTION HISTORY

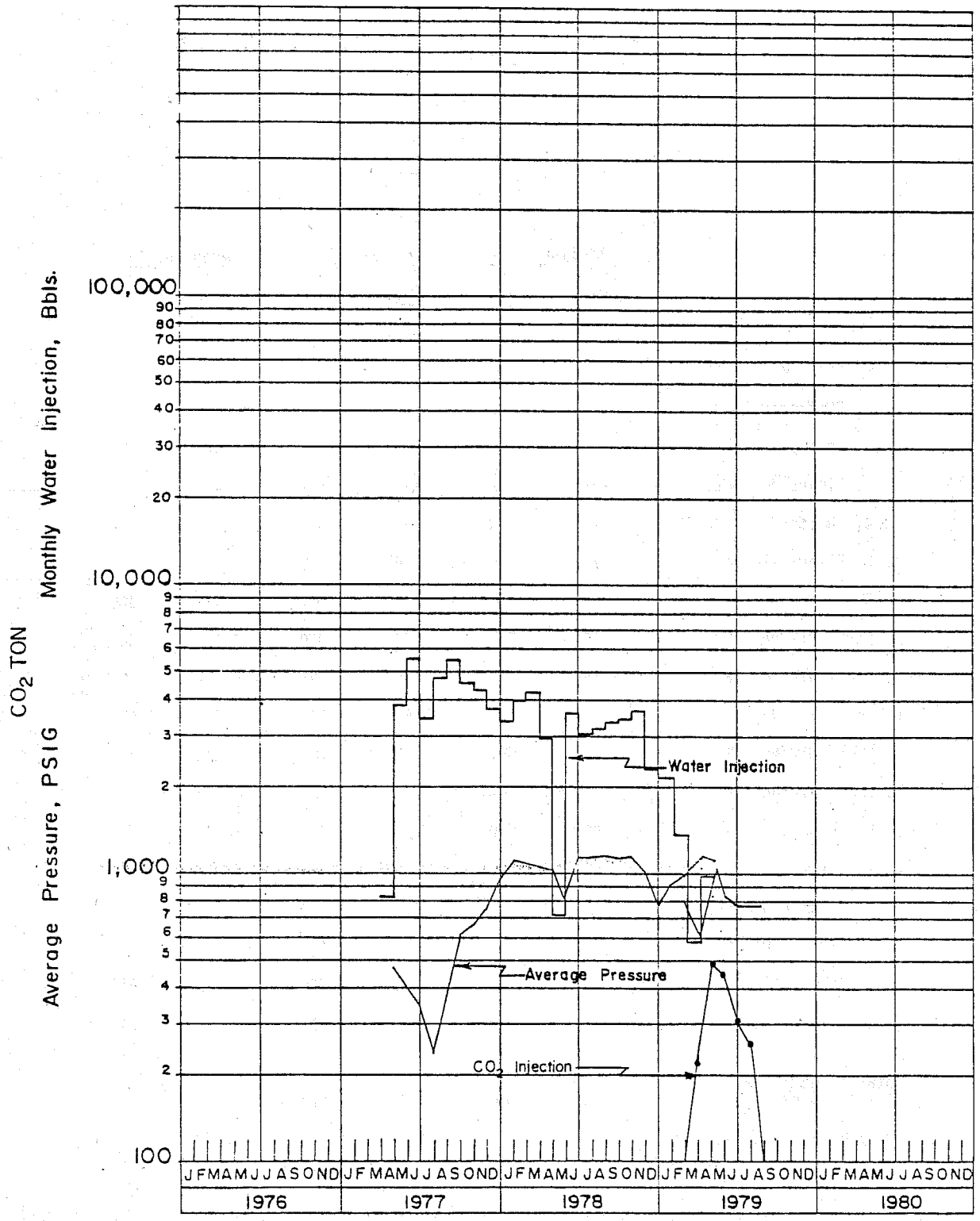
R. C. Elmore P.I. No. 5



ROCK CREEK PILOT CO_2 PROJECT

INJECTION HISTORY

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



APPENDIX G

History of Water Injection

ROCK CREEK PILOT CARBON DIOXIDE PROJECT
HISTORY OF WATER INJECTION

	October, 1976		November, 1976		December, 1976	
	Inj., Bbls.	Avg. WHP	Inj., Bbls.	Avg. WHP	Inj., Bbls.	Avg. WHP
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	---	---	---	---	---	---
R. C. Elmore WIW No. 1	1,785	0	2,461	0	4,479	0
R. C. Elmore WIW No. 4	1,244	510	2,326	825	2,263	800
E. Lewis WIW No. 17	1,909	730	3,288	820	3,318	800
E. Lewis WIW No. 18	1,754	750	3,196	785	2,951	800
E. Lewis WIW No. 27	---	---	2,878	715	3,016	800
E. Lewis WIW No. 28	1,990	660	1,926	705	1,342	765
E. Lewis WIW No. 29	---	---	967	725	1,198	815
J. H. Looney WIW No. 1	1,928	190	3,646	380	4,723	480
J. H. Looney WIW No. 5	---	---	1,768	750	1,326	800
L. W. Shaffer WIW No. 2	1,923	0	2,615	0	5,139	0
L. W. Shaffer WIW No. 8	2,046	405	3,417	350	3,156	495
L. W. Shaffer WIW No. 10	---	---	687	800	287	805
L. W. Shaffer WIW No. 11	---	---	452	815	327	845
Total Injection or Average Pressure	14,579	405	29,627	590	33,525	630
Cumulative Injection			44,206		77,731	

ROCK CREEK PILOT CARBON DIOXIDE PROJECT
HISTORY OF WATER INJECTION
Continued

	January, 1977		February, 1977		March, 1977	
	Inj., Bbls.	Avg. WHP	Inj., Bbls.	Avg. WHP	Inj., Bbls.	Avg. WHP
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	---	---	---	---	---	---
R. C. Elmore WIW No. 1	4,895	0	7,273	0	8,558	0
R. C. Elmore WIW No. 4	2,250	805	2,213	845	2,547	810
E. Lewis WIW No. 17	601	800	2,279	795	3,117	775
E. Lewis WIW No. 18	2,990	800	2,56[illegible]	840	2,595	810
E. Lewis WIW No. 27	2,696	805	1,687	855	1,814	810
E. Lewis WIW No. 28	1,326	765	1,194	795	3,027	740
E. Lewis WIW No. 29	1,081	820	782	870	685	860
J. H. Looney WIW No. 1	3,658	515	6,259	815	6,527	800
J. H. Looney WIW No. 5	1,344	820	1,101	870	1,073	860
L. W. Shaffer WIW No. 2	7,174	0	7,637	0	9,334	0
L. W. Shaffer WIW No. 8	3,785	575	4,328	790	3,961	690
L. W. Shaffer WIW No. 10	356	815	191	865	178	835
L. W. Shaffer WIW No. 11	484	850	267	885	277	865
Total Injection or Average Pressure	32,640	645	37,772	710	43,693	680
Cumulative Injection	110,371		148,143		191,836	

ROCK CREEK PILOT CARBON DIOXIDE PROJECT
HISTORY OF WATER INJECTION
Continued

	April, 1977		May, 1977		June, 1977	
	Inj., Bbls.	Avg. WHP	Inj., Bbls.	Avg. WHP	Inj., Bbls.	Avg. WHP
E. Lewis P.I. No. 1	624	595	2,603	815	3,117	605
L. W. Shaffer P.I. No. 2	662	700	4,622	820	5,816	900
L. W. Shaffer P.I. No. 3	380	715	1,501	890	2,126	905
J. H. Looney P.I. No. 4	648	715	2,304	880	2,471	615
R. C. Elmore P.I. No. 5	673	610	5,230	765	5,700	825
L. W. Shaffer P.I. No. 6	818	465	3,799	400	5,506	345
R. C. Elmore WIW No. 1	5,166	0	12,738	0	7,422	0
R. C. Elmore WIW No. 4	2,643	755	2,345	810	2,694	945
E. Lewis WIW No. 17	3,376	790	3,985	875	4,612	955
E. Lewis WIW No. 18	2,406	790	3,039	830	3,177	940
E. Lewis WIW No. 27	2,720	790	3,969	860	4,803	945
E. Lewis WIW No. 28	4,899	630	4,495	825	5,005	915
E. Lewis WIW No. 29	976	825	1,016	885	2,537	935
J. H. Looney WIW No. 1	5,905	775	6,223	845	6,450	930
J. H. Looney WIW No. 5	1,359	805	4,421	775	4,791	605
L. W. Shaffer WIW No. 2	4,418	0	6,451	0	4,946	0
L. W. Shaffer WIW No. 8	3,951	690	4,442	840	4,824	920
L. W. Shaffer WIW No. 10	253	825	2,920	865	4,843	960
L. W. Shaffer WIW No. 11	473	810	4,236	840	4,454	955
Total Injection or Average Pressure	42,350	645	80,339	725	85,294	745
Cumulative Injection	234,186		314,525		399,819	

ROCK CREEK PILOT CARBON DIOXIDE PROJECT
HISTORY OF WATER INJECTION
Continued

	July, 1977		August, 1977		September, 1977	
	Inj., Bbls.	Avg. WHP	Inj., Bbls.	Avg. WHP	Inj., Bbls.	Avg. WHP
E. Lewis P.I. No. 1	3,701	390	4,104	715	3,977	770
L. W. Shaffer P.I. No. 2	3,205	845	3,777	940	3,944	920
L. W. Shaffer P.I. No. 3	3,773	885	3,851	1030	2,967	1040
J. H. Looney P.I. No. 4	4,363	475	5,053	875	4,172	820
R. C. Elmore P.I. No. 5	4,080	660	3,883	795	4,097	835
L. W. Shaffer P.I. No. 6	3,441	235	4,746	370	5,439	605
R. C. Elmore WIW No. 1	7,601	0	6,415	0	10,332	40
R. C. Elmore WIW No. 4	2,876	950	3,068	1025	2,936	1045
E. Lewis WIW No. 17	4,145	970	0	---	226	325
E. Lewis WIW No. 18	3,329	965	3,444	1035	3,071	1020
E. Lewis WIW No. 27	4,987	970	5,178	1045	4,352	1030
E. Lewis WIW No. 28	5,274	900	5,776	985	4,331	940
E. Lewis WIW No. 29	2,759	925	4,524	1035	3,655	915
J. H. Looney WIW No. 1	6,487	930	6,494	980	5,932	1015
J. H. Looney WIW No. 5	5,480	695	6,169	860	5,918	755
L. W. Shaffer WIW No. 2	8,393	0	6,236	0	7,456	0
L. W. Shaffer WIW No. 8	4,918	940	5,260	1015	5,056	985
L. W. Shaffer WIW No. 10	5,354	960	5,204	1040	4,411	980
L. W. Shaffer WIW No. 11	4,601	965	5,215	1040	4,825	1020
Total Injection or Average Pressure	88,767	720	88,397	820	87,047	790
Cumulative Injection	488,586		576,983		664,030	

ROCK CREEK PILOT CARBON DIOXIDE PROJECT
HISTORY OF WATER INJECTION
Continued

	October, 1977		November, 1977		December, 1977	
	Inj., Bbls.	Avg. WHP	Inj., Bbls.	Avg. WHP	Inj., Bbls.	Avg. WHP
E. Lewis P.I. No. 1	1,627	745	4,236	685	4,452	945
L. W. Shaffer P.I. No. 2	4,511	1015	3,570	1040	2,987	1055
L. W. Shaffer P.I. No. 3	3,053	1130	2,354	1155	1,979	1160
J. H. Looney P.I. No. 4	4,438	865	4,168	930	3,957	1110
R. C. Elmore P.I. No. 5	3,495	775	4,328	880	4,682	1035
L. W. Shaffer P.I. No. 6	4,534	660	4,304	750	3,775	955
R. C. Elmore WIW No. 1	10,589	225	9,779	315	12,393	565
R. C. Elmore WIW No. 4	3,060	1055	2,883	1075	2,892	1070
E. Lewis WIW No. 17	3,383	870	1,854	385	3,310	820
E. Lewis WIW No. 18	3,299	1075	2,957	1090	3,978	1080
E. Lewis WIW No. 27	4,429	1090	3,606	1095	3,177	1095
E. Lewis WIW No. 28	3,590	890	2,980	965	2,491	1000
E. Lewis WIW No. 29	2,603	765	2,131	815	2,032	860
J. H. Looney WIW No. 1	5,190	895	4,717	925	5,119	990
J. H. Looney WIW No. 5	6,007	825	5,373	865	5,672	950
L. W. Shaffer WIW No. 2	10,064	90	11,448	195	10,070	245
L. W. Shaffer WIW No. 8	4,383	815	4,072	840	4,530	945
L. W. Shaffer WIW No. 10	3,949	910	3,899	1020	3,759	1085
L. W. Shaffer WIW No. 11	4,825	1035	4,523	1075	4,267	1095
Total Injection or Average Pressure	87,029	830	83,182	845	85,522	950
Cumulative Injection	751,059		834,241		919,763	

ROCK CREEK PILOT CARBON DIOXIDE PROJECT
HISTORY OF WATER INJECTION
Continued

	January, 1978		February, 1978		March, 1973	
	Inj., Bbls.	Avg. WHP	Inj., Bbls.	Avg. WHP	Inj., Bbls.	Avg. WHP
E. Lewis P.I. No. 1	3,817	1070	2,889	N.R.*	2,667	1025
L. W. Shaffer P.I. No. 2	2,381	1065	1,484	N.R.	1,239	1020
L. W. Shaffer P.I. No. 3	1,653	1150	1,090	N.R.	741	1000
J. H. Looney P.I. No. 4	4,125	1105	3,282	N.R.	3,188	1070
R. C. Elmore P.I. No. 5	4,826	1090	4,251	N.R.	4,350	1050
L. W. Shaffer P.I. No. 6	3,344	1100	3,984	N.R.	4,272	1045
R. C. Elmore WIW No. 1	4,124	725	0	---	0	---
R. C. Elmore WIW No. 4	2,691	1065	2,319	N.R.	2,460	1040
E. Lewis WIW No. 17	4,203	855	4,425	N.R.	5,225	985
E. Lewis WIW No. 18	4,753	1065	4,664	N.R.	5,471	1000
E. Lewis WIW No. 27	2,790	1090	2,282	N.R.	2,138	1050
E. Lewis WIW No. 28	2,572	890	2,048	N.R.	1,855	990
E. Lewis WIW No. 29	2,777	980	3,144	N.R.	3,276	1045
J. H. Looney WIW No. 1	4,588	895	4,199	N.R.	4,247	1030
J. H. Looney WIW No. 5	5,493	955	4,745	N.R.	4,868	1025
L. W. Shaffer WIW No. 2	10,866	430	12,544	N.R.	15,220	945
L. W. Shaffer WIW No. 8	4,191	975	3,360	N.R.	3,292	975
L. W. Shaffer WIW No. 10	3,099	1085	2,064	N.R.	1,466	1050
L. W. Shaffer WIW No. 11	4,064	1085	3,439	N.R.	3,330	1055
Total Injection or Average Pressure	76,357	985	66,213	985	69,305	1020
Cumulative Injection	996,120		1,062,333		1,131,638	

*Not Recorded

ROCK CREEK PILOT CARBON DIOXIDE PROJECT
HISTORY OF WATER INJECTION
Continued

	April, 1978		May, 1978		June, 1978	
	Inj., Bbls.	Avg. WHP	Inj., Bbls.	Avg. WHP	Inj., Bbls.	Avg. WHP
E. Lewis P.I. No. 1	2,432	1070	2,225	1030	2,177	1120
L. W. Shaffer P.I. No. 2	751	1045	910	1060	1,142	1075
L. W. Shaffer P.I. No. 3	814	1140	1,595	1115	1,176	1170
J. H. Looney P.I. No. 4	2,769	1115	2,791	1065	2,586	1055
R. C. Elmore P.I. No. 5	3,873	1115	3,789	1050	3,883	1110
L. W. Shaffer P.I. No. 6	2,951	1020	720	810	3,574	1120
R. C. Elmore WIW No. 1	1,371	450	4,773	765	3,696	130
R. C. Elmore WIW No. 4	2,319	1090	2,253	1035	2,128	1090
E. Lewis WIW No. 17	3,453	825	549	480	2,325	1100
E. Lewis WIW No. 18	4,406	940	6,342	1040	4,266	730
E. Lewis WIW No. 27	1,444	1085	605	990	1,491	1090
E. Lewis WIW No. 28	1,639	1015	1,484	990	1,823	1040
E. Lewis WIW No. 29	2,873	1080	771	1065	2,294	1030
J. H. Looney WIW No. 1	4,090	1075	4,080	1035	3,815	1085
J. H. Looney WIW No. 5	4,487	1070	3,775	975	4,268	1075
L. W. Shaffer WIW No. 2	14,703	970	13,864	975	8,001	750
L. W. Shaffer WIW No. 8	3,241	1035	3,314	975	3,123	1060
L. W. Shaffer WIW No. 10	1,480	820	1,696	980	1,907	1105
L. W. Shaffer WIW No. 11	2,467	1090	2,703	1040	1,851	1145
Total Injection or Average Pressure	61,563	1000	58,239	975	55,526	1005
Cumulative Injection	1,193,201		1,251,440		1,306,966	

ROCK CREEK PILOT CARBON DIOXIDE PROJECT
HISTORY OF WATER INJECTION
Continued

	July, 1978		August, 1978		September, 1978	
	Inj., Bbls.	Avg. WHP	Inj., Bbls.	Avg. WHP	Inj., Bbls.	Avg. WHP
E. Lewis P.I. No. 1	2,533	1045	2,824	1085	2,907	1075
L. W. Shaffer P.I. No. 2	1,348	1065	1,414	1065	2,300	1055
L. W. Shaffer P.I. No. 3	1,181	1165	1,177	1160	1,698	1150
J. H. Looney P.I. No. 4	2,876	1085	2,944	1110	2,870	1120
R. C. Elmore P.I. No. 5	3,236	1110	2,957	1110	2,414	1120
L. W. Shaffer P.I. No. 6	3,049	1125	3,152	1130	3,321	1120
R. C. Elmore WIW No. 1	9,383	625	9,267	775	7,916	740
R. C. Elmore WIW No. 4	1,199	885	1,720	1100	1,556	1105
E. Lewis WIW No. 17	2,625	1120	2,634	1110	2,967	1105
E. Lewis WIW No. 18	3,815	615	551	755	0	--
E. Lewis WIW No. 27	1,627	1105	1,594	1105	1,339	1110
E. Lewis WIW No. 28	2,175	1025	2,398	1020	2,636	1020
E. Lewis WIW No. 28	2,243	1100	1,981	1105	1,737	1105
J. H. Looney WIW No. 1	3,600	1095	3,348	1080	2,930	1055
J. H. Looney WIW No. 5	4,065	1090	4,059	1085	3,841	1085
L. W. Shaffer WIW No. 2	3,077	700	4,529	305	499	440
L. W. Shaffer WIW No. 8	3,110	1065	2,922	1065	2,630	1070
L. W. Shaffer WIW No. 10	1,834	1085	2,393	1090	2,346	1115
L. W. Shaffer WIW No. 11	2,064	1065	2,395	1070	2,216	1080
Total Injection or Average Pressure	55,040	1010	54,259	1015	48,123	1035
Cumulative Injection	1,362,006		1,416,265		1,464,388	

ROCK CREEK PILOT CARBON DIOXIDE PROJECT
HISTORY OF WATER INJECTION
Continued

	October, 1978		November, 1978		December, 1978	
	Inj., Bbls.	Avg. WHP	Inj., Bbls.	Avg. WHP	Inj., Bbls.	Avg. WHP
E. Lewis P.I. No. 1	2,971	1080	2,896	1045	2,343	935
L. W. Shaffer P.I. No. 2	2,122	1075	1,961	1045	1,757	935
L. W. Shaffer P.I. No. 3	1,842	1155	1,532	1125	2,174	1025
J. H. Looney P.I. No. 4	3,043	1135	2,671	1095	2,771	995
R. C. Elmore P.I. No. 5	2,366	1125	2,122	1080	2,229	985
L. W. Shaffer P.I. No. 6	3,411	1135	3,640	1020	2,361	790
R. C. Elmore WIW No. 1	8,703	855	3,352	460	8,900	760
R. C. Elmore WIW No. 4	1,507	1105	1,472	1080	1,386	975
E. Lewis WIW No. 17	3,166	1110	810	1095	488	1005
E. Lewis WIW No. 18	0	--	212	1050	2,100	975
E. Lewis WIW No. 27	1,218	1110	1,209	1080	1,278	1015
E. Lewis WIW No. 28	2,948	1030	3,064	1000	2,982	920
E. Lewis WIW No. 29	1,601	1100	1,788	1080	1,661	995
J. H. Looney WIW No. 1	3,009	1100	2,849	1080	2,686	1005
J. H. Looney WIW No. 5	3,847	1085	3,818	1065	3,737	990
L. W. Shaffer WIW No. 2	2,066	835	1,666	995	2,929	955
L. W. Shaffer WIW No. 8	2,487	1060	2,383	1035	2,284	950
L. W. Shaffer WIW No. 10	2,220	1105	2,123	1085	1,742	980
L. W. Shaffer WIW No. 11	2,308	1110	2,218	1085	1,800	1015
Total Injection or Average Pressure	50,835	1075	41,786	1030	47,608	960
Cumulative Injection	1,515,223		1,557,009		1,604,617	

ROCK CREEK PILOT CARBON DIOXIDE PROJECT
HISTORY OF WATER INJECTION
Continued

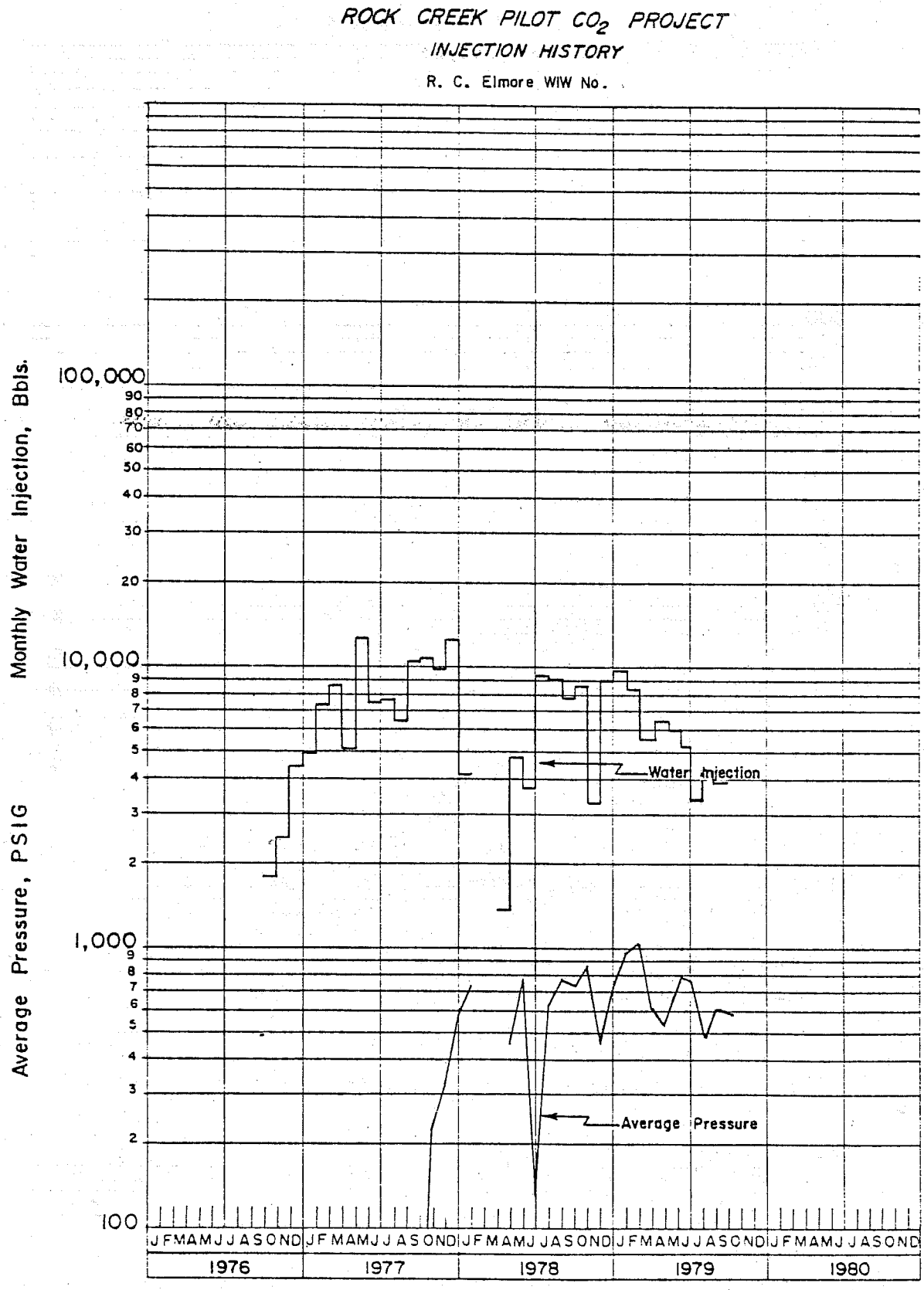
	January, 1979		February, 1979		March, 1979	
	Inj., Bbls.	Avg. WHP	Inj., Bbls.	Avg. WHP	Inj., Bbls.	Avg. WHP
E. Lewis P.I. No. 1	2,303	975	1,202	975	0	--
L. W. Shaffer P.I. No. 2	1,654	970	909	955	0	--
L. W. Shaffer P.I. No. 3	2,105	1060	1,108	1055	0	--
J. H. Looney P.I. No. 4	2,639	1035	1,503	1040	0	--
R. C. Elmore P.I. No. 5	2,143	1035	1,182	1040	0	--
L. W. Shaffer P.I. No. 6	2,199	910	1,482	980	581	1120
R. C. Elmore WIW No. 1	9,660	985	8,400	1020	5,604	610
R. C. Elmore WIW No. 4	1,254	1015	1,131	1040	1,305	1085
E. Lewis WIW No. 17	529	1020	414	1045	411	1000
E. Lewis WIW No. 18	2,122	985	1,915	1015	2,158	1015
E. Lewis WIW No. 27	1,193	1025	983	1050	1,342	1090
E. Lewis WIW No. 28	1,929	930	2,075	970	2,132	1000
E. Lewis WIW No. 29	1,288	1010	1,058	1035	962	750
J. H. Looney WIW No. 1	2,689	1015	2,542	1040	3,069	1090
J. H. Looney WIW No. 5	3,609	1010	3,027	1035	3,722	1085
L. W. Shaffer WIW No. 2	2,853	975	2,443	995	2,836	990
L. W. Shaffer WIW No. 8	2,231	965	2,008	985	2,472	1020
L. W. Shaffer WIW No. 10	1,604	1020	1,161	1050	1,283	1080
L. W. Shaffer WIW No. 11	1,765	1030	1,501	1040	1,818	1100
Total Injection or Average Pressure	45,769	1000	36,044	1020	29,695	1000
Cumulative Injection	1,650,386		1,686,430		1,716,125	

ROCK CREEK PILOT CARBON DIOXIDE PROJECT
HISTORY OF WATER INJECTION
Continued

	April, 1979		May, 1979		June, 1979	
	Inj., Bbls.	Avg. WHP	Inj., Bbls.	Avg. WHP	Inj., Bbls.	Avg. WHP
E. Lewis P.I. No. 1	0	--	0	--	0	--
L. W. Shaffer P.I. No. 2	0	--	0	--	0	--
L. W. Shaffer P.I. No. 3	0	--	0	--	0	--
J. H. Looney P.I. No. 4	0	--	0	--	0	--
R. C. Elmore P.I. No. 5	0	--	0	--	0	--
L. W. Shaffer P.I. No. 6	992	1110	0	--	0	--
R. C. Elmore WIW No. 1	6,386	540	6,068	795	5,191	775
R. C. Elmore WIW No. 4	980	955	1,011	1145	1,205	1165
E. Lewis WIW No. 17	326	990	266	1000	251	1000
E. Lewis WIW No. 18	1,226	980	1,172	1000	1,314	1000
E. Lewis WIW No. 27	1,222	1085	1,090	1145	1,147	1165
E. Lewis WIW No. 28	2,136	1055	2,624	1070	3,627	1060
E. Lewis WIW No. 29	1,117	830	1,021	1160	1,000	1175
J. H. Looney WIW No. 1	2,266	920	2,435	1150	2,670	1170
J. H. Looney WIW No. 5	3,325	1060	3,386	1135	3,301	1165
L. W. Shaffer WIW No. 2	1,359	1000	940	1000	1,327	1000
L. W. Shaffer WIW No. 8	2,189	1030	2,156	1105	2,293	1120
L. W. Shaffer WIW No. 10	953	1115	918	1155	1,098	1170
L. W. Shaffer WIW No. 11	1,318	1125	1,149	1155	1,298	1175
Total Injection or Average Pressure	25,795	985	24,236	1080	25,722	1085
Cumulative Injection	1,741,920		1,766,156		1,791,878	

APPENDIX H

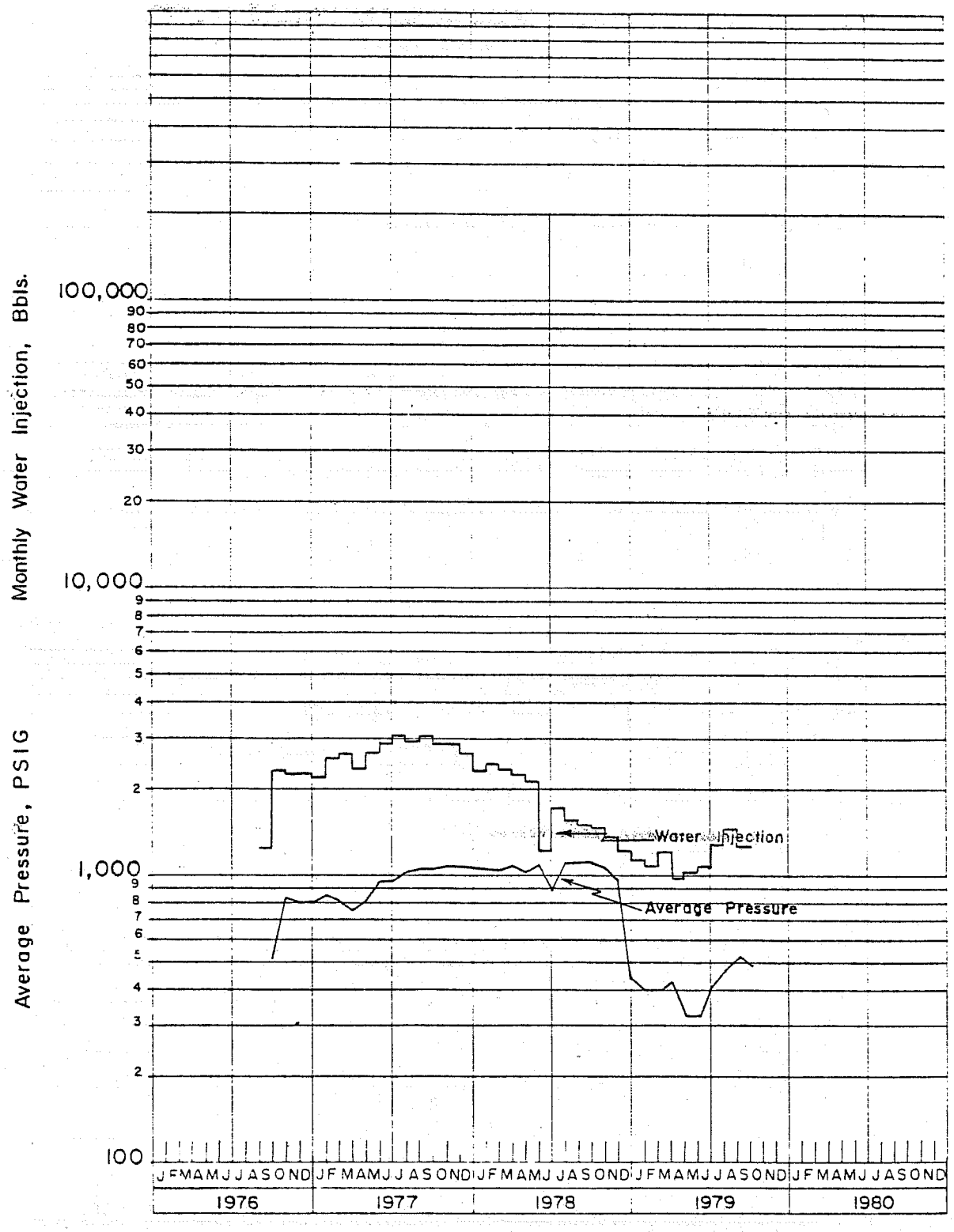
Graphical History of Water Injection



ROCK CREEK PILOT CO_2 PROJECT

INJECTION HISTORY

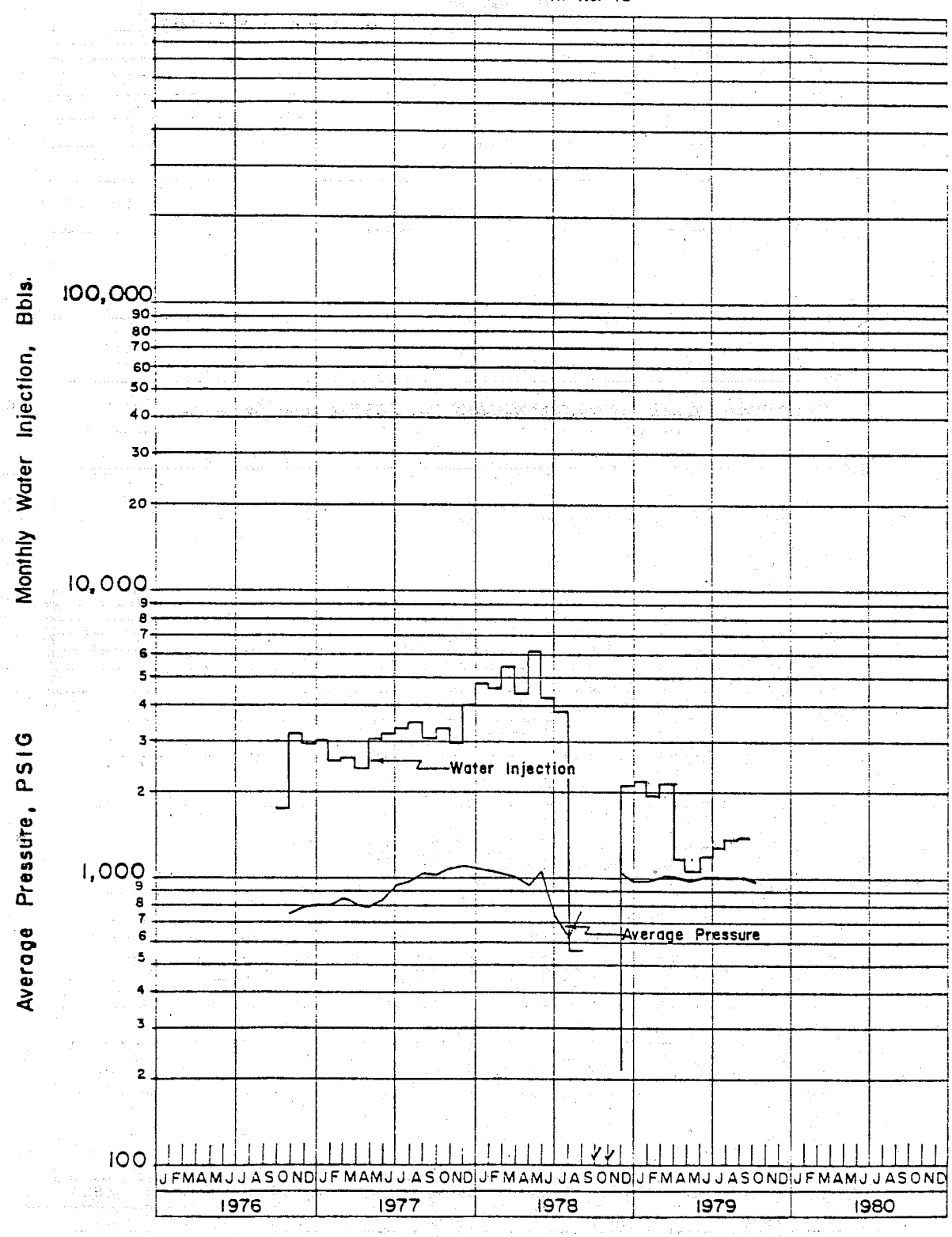
R. C. Elmore WIW No. 4



ROCK CREEK PILOT CO_2 PROJECT

INJECTION HISTORY

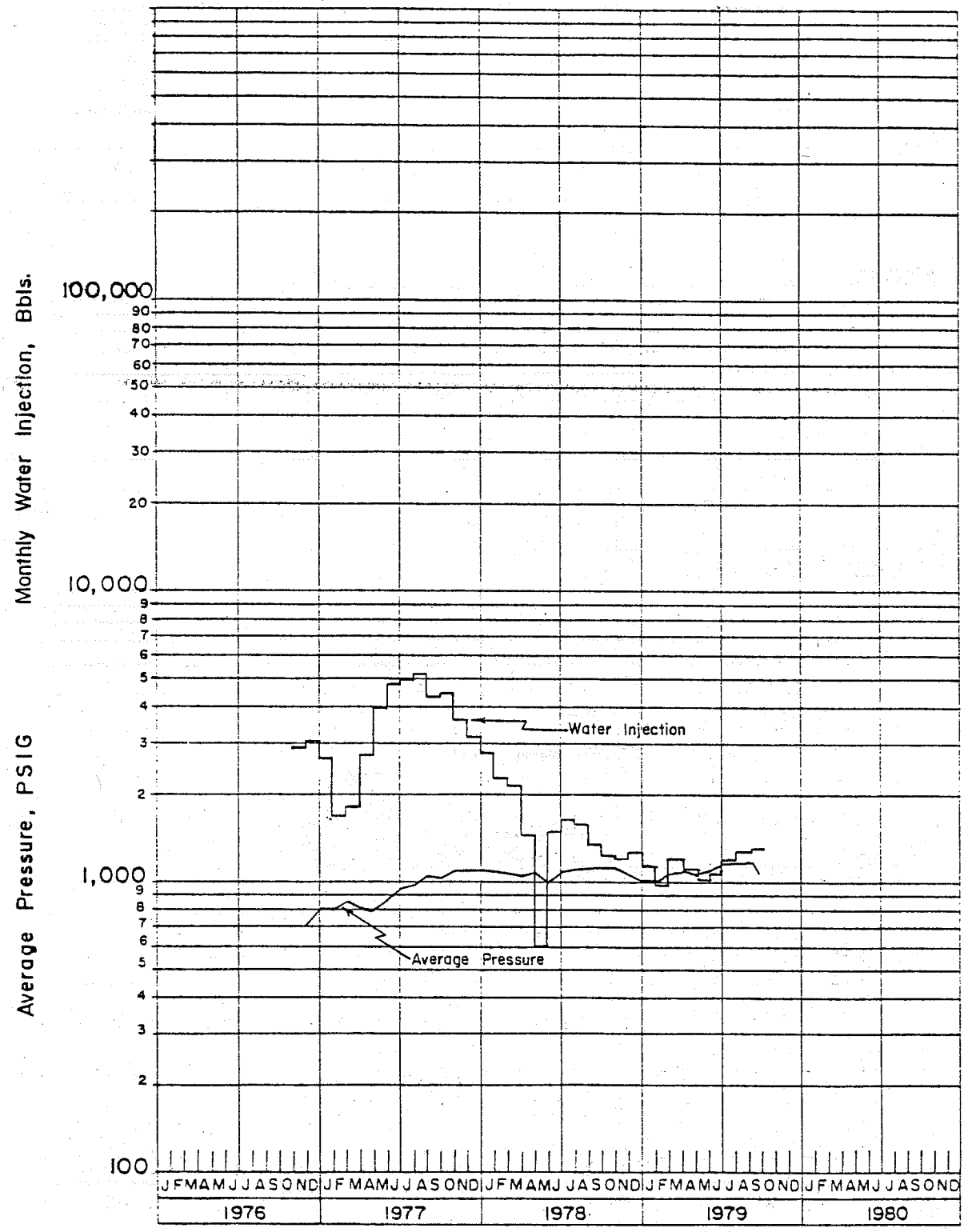
E. Lewis WIW No. 18



ROCK CREEK PILOT CO_2 PROJECT

INJECTION HISTORY

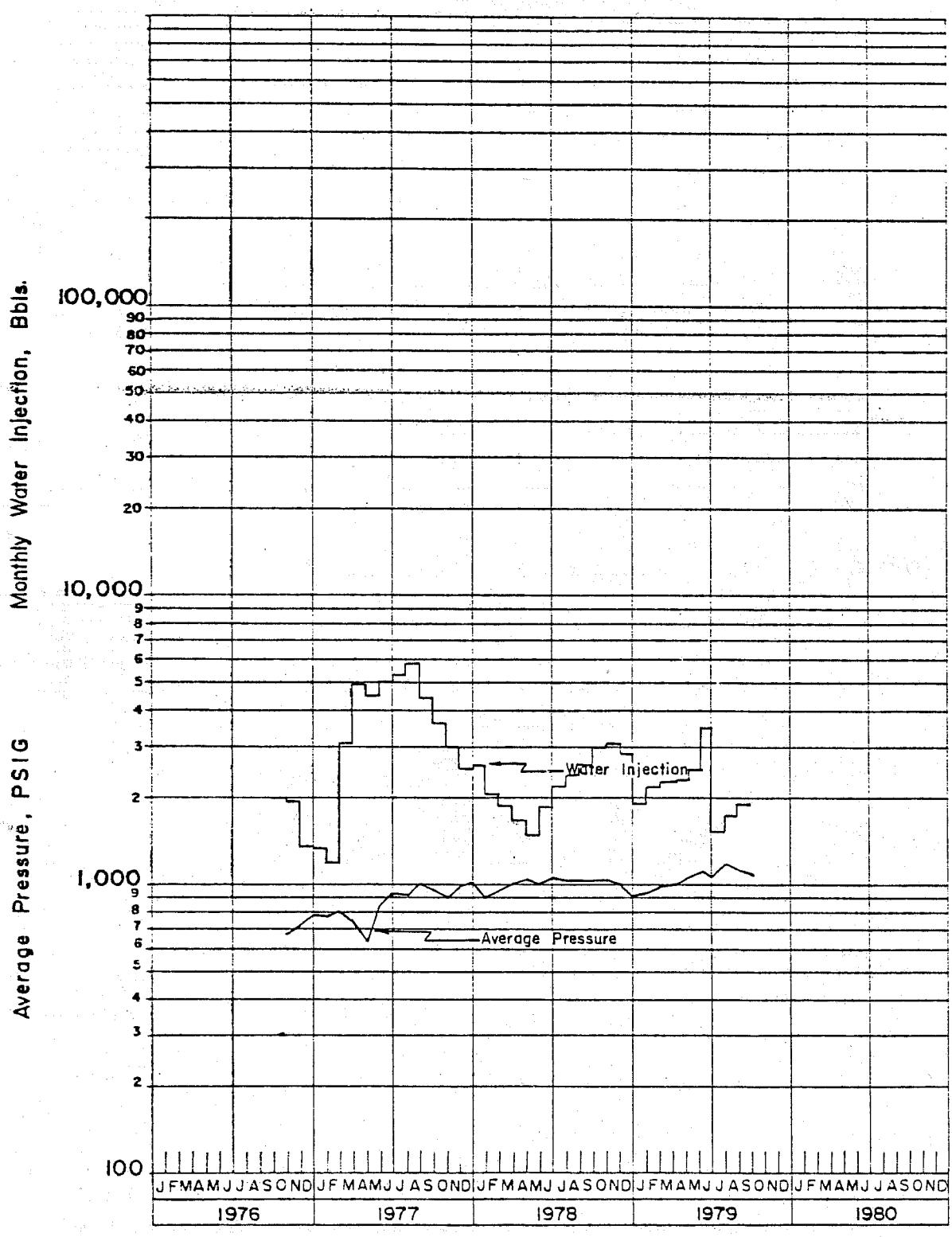
E. Lewis WIW No. 27



ROCK CREEK PILOT CO_2 PROJECT

INJECTION HISTORY

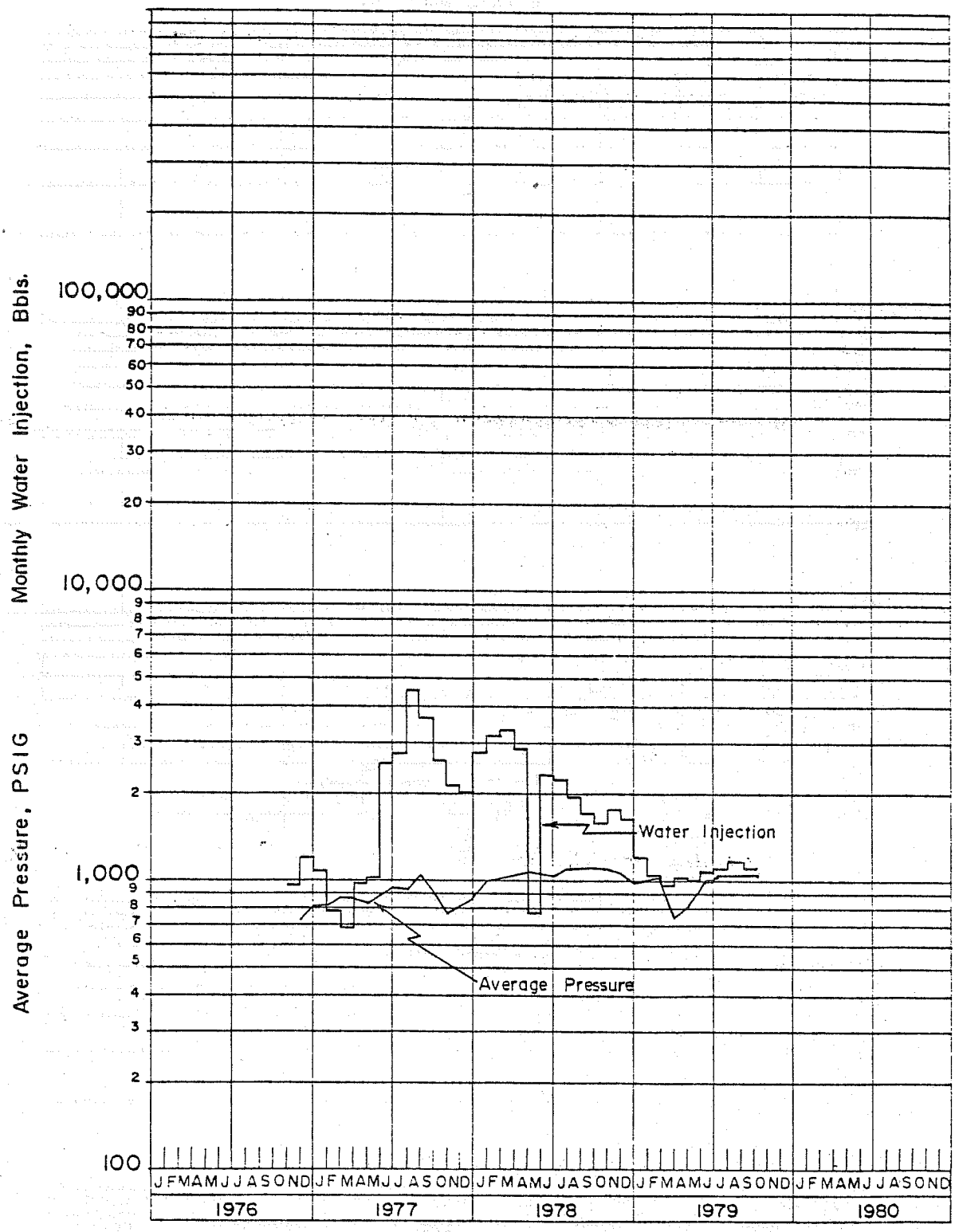
E. Lewis WIW No. 28



ROCK CREEK PILOT CO_2 PROJECT

INJECTION HISTORY

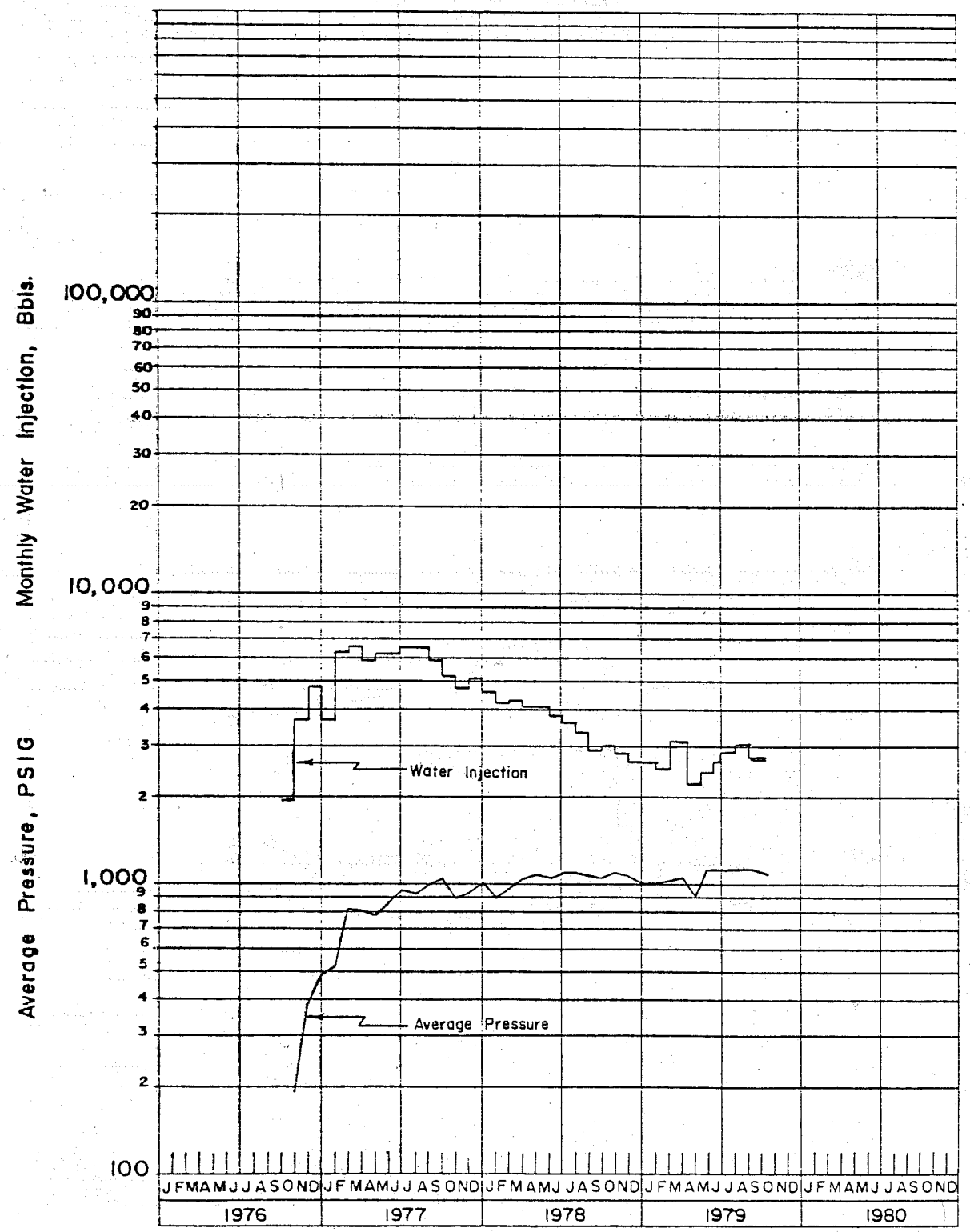
E. Lewis WIW No. 29



ROCK CREEK PILOT CO_2 PROJECT

INJECTION HISTORY

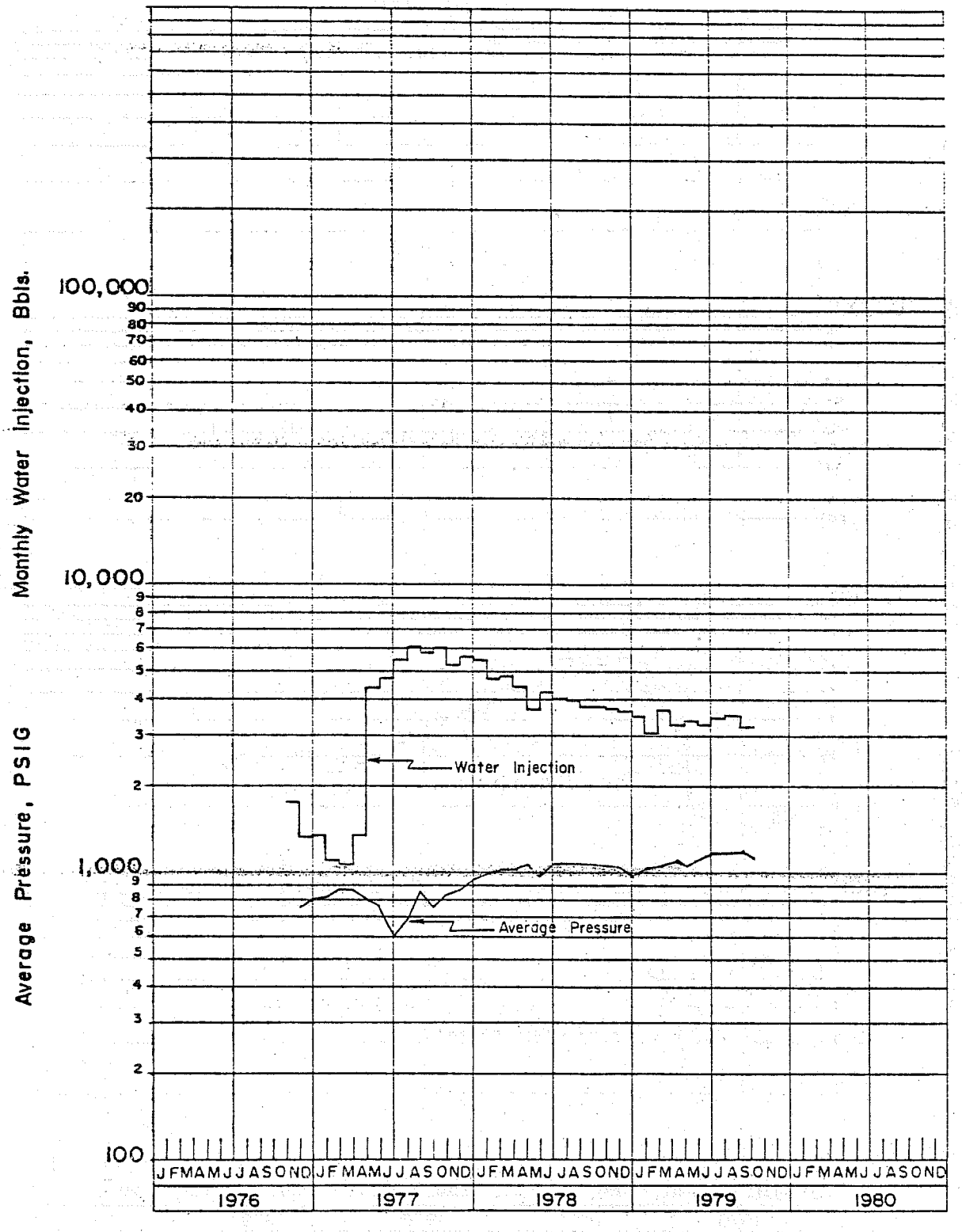
J. H. Looney WIW No. 1



ROCK CREEK PILOT CO_2 PROJECT

INJECTION HISTORY

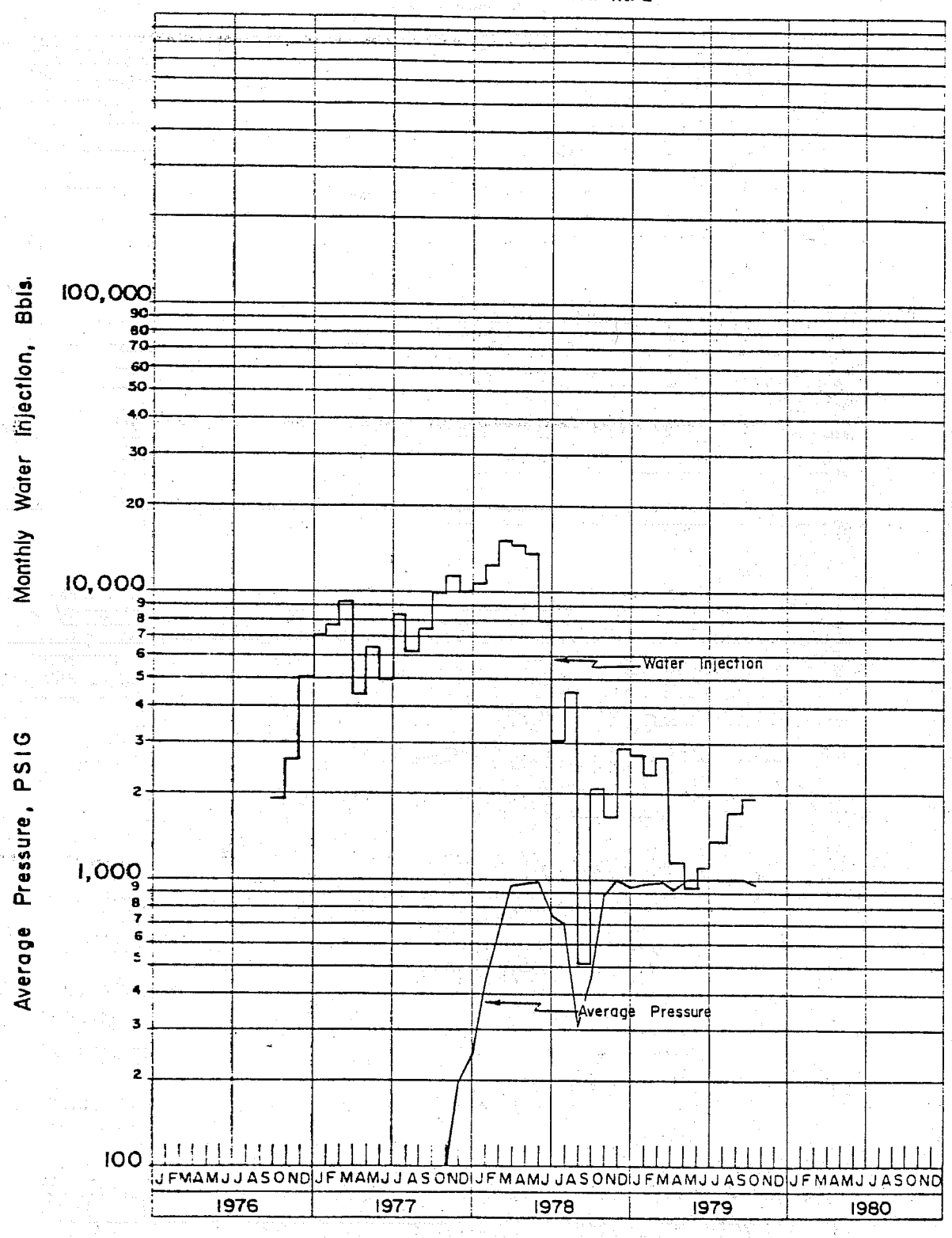
J. H. Looney WIW No. 5



ROCK CREEK PILOT CO_2 PROJECT

INJECTION HISTORY

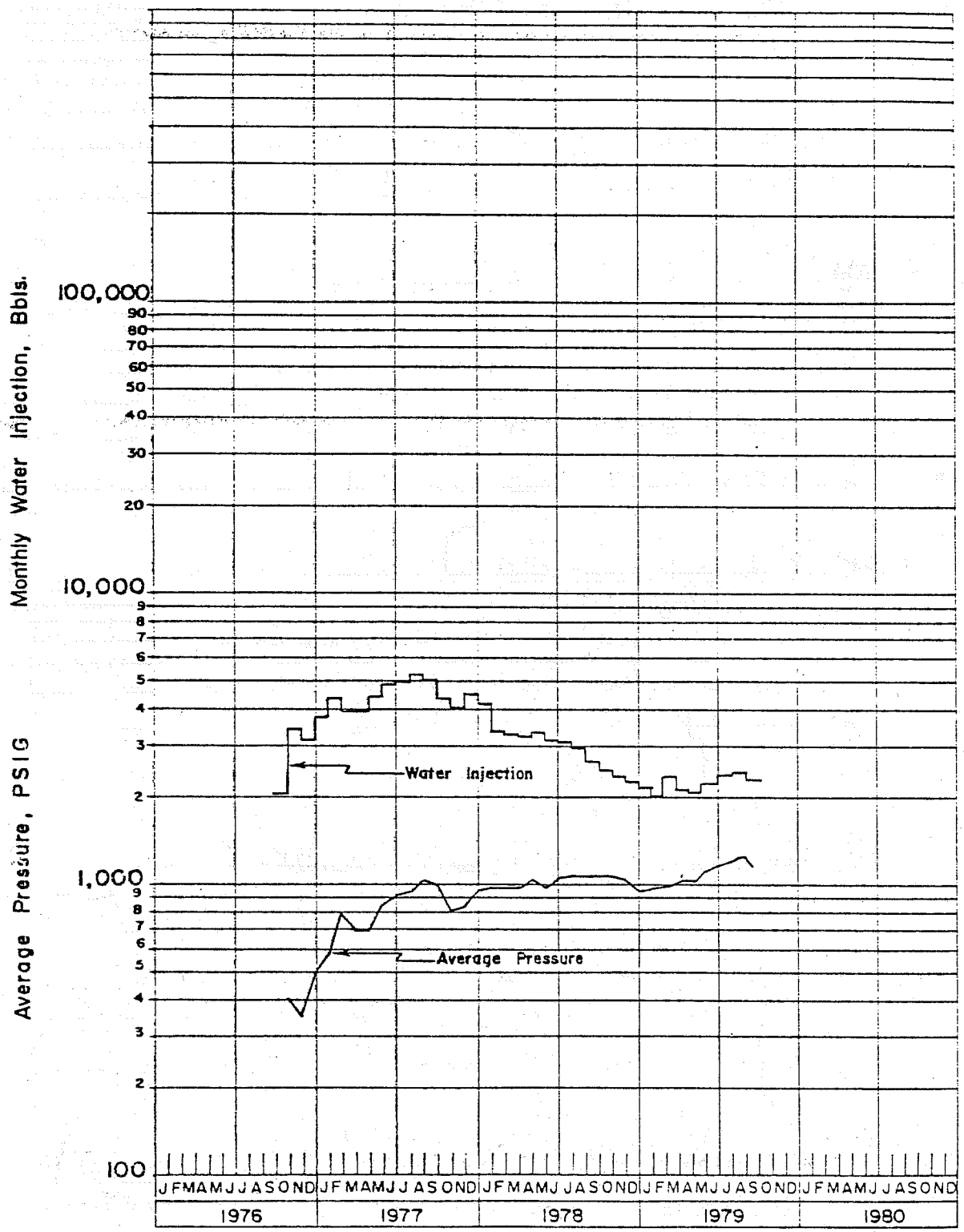
L. W. Shaffer WIW No. 2



ROCK CREEK PILOT CO_2 PROJECT

INJECTION HISTORY

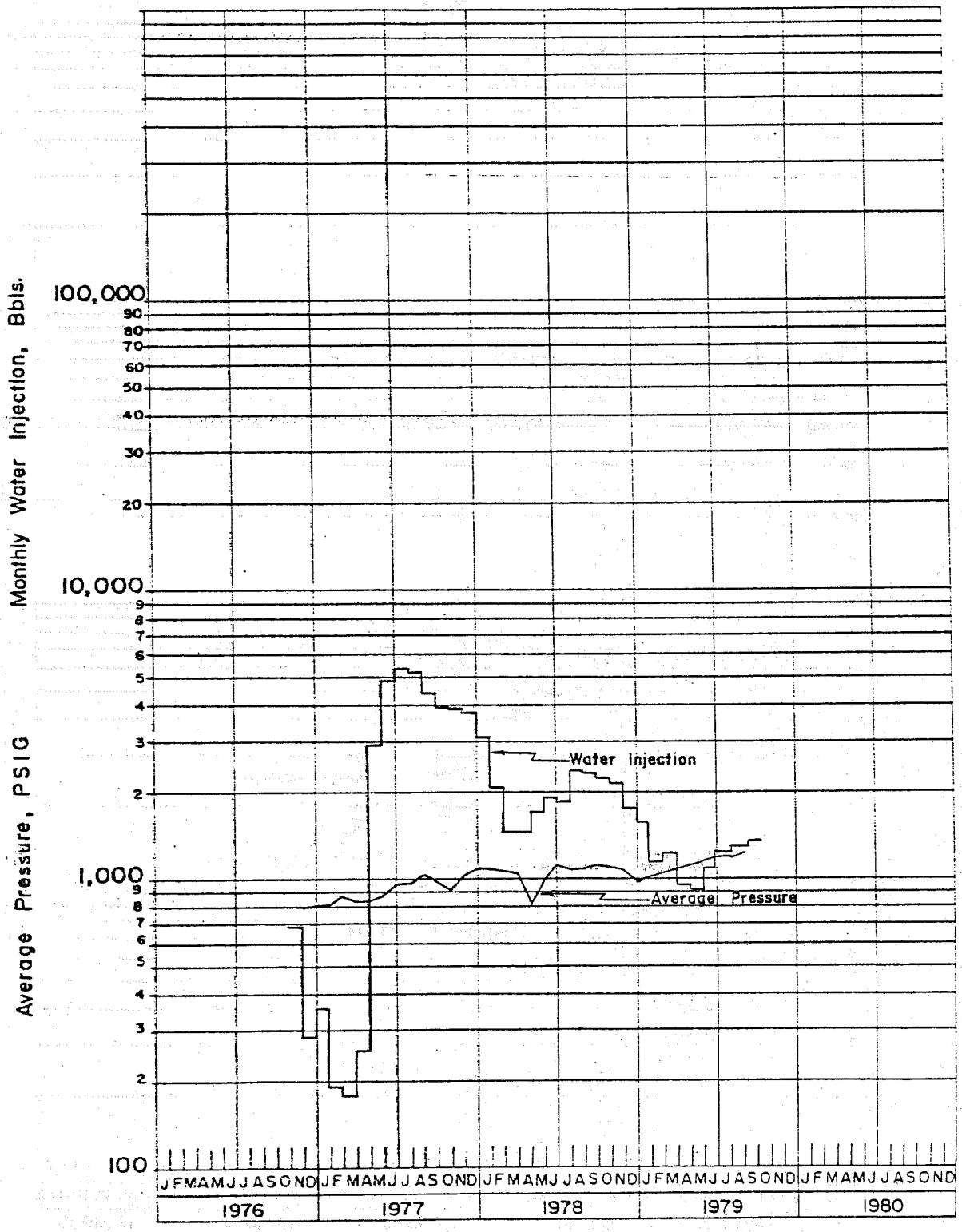
L. W. Shaffer WIW No. 8



ROCK CREEK PILOT CO_2 PROJECT

INJECTION HISTORY

L. W. Shaffer WIW No. 10



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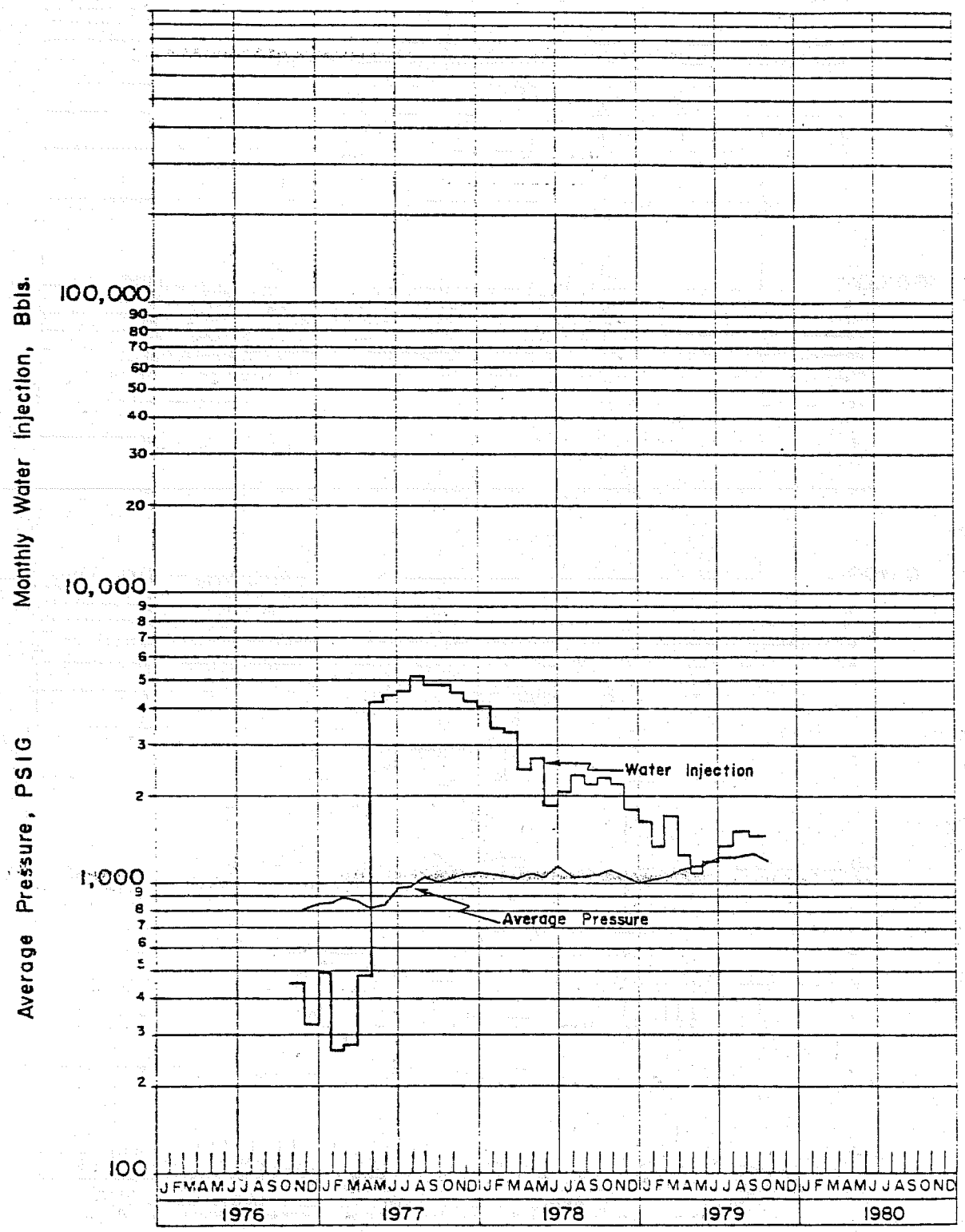
ROCK CREEK PILOT CO_2 PROJECT

INJECTION HISTORY

L. W. Shaffer WIW No. 11