

TECHNICAL REPORT 38

New Mexico State Engineer  
Santa Fe, New Mexico



# Capitan Aquifer Observation-Well Network Carlsbad to Jalisco New Mexico

by

W. L. Hiss

*Prepared in cooperation with  
the United States Geological Survey*



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1973

Cover illustration from Bartlett, 1854, v. 1, p. 118. Exposures of the Capitan Limestone and Delaware Mountain Group at Guadalupe Peak in the Guadalupe Mountains.

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CAPITAN AQUIFER OBSERVATION-WELL NETWORK,  
CARLSBAD TO JAL, NEW MEXICO

BY

W. L. Hiss

ABSTRACT

The Capitan aquifer observation-well network consists of twelve observation wells located in Eddy and Lea Counties, N. Mex., along an arc extending from southwest of Carlsbad around the north and east margins of the Delaware basin to southwest of Jal. Nine of the wells are abandoned deep oil and gas tests that were acquired from oil companies and then plugged back and completed in the aquifer as observation wells.

This report contains well-construction diagrams and descriptions, hydrographs for each well, and a general description of the geologic setting of the Capitan aquifer. The chemical characteristics of the fluid in the well columns are tabulated and the methods employed to convert the observed fluid levels to fresh-water head are discussed. The well construction, testing, and development histories were compiled from many sources and will be of interest to anyone contemplating future development or use of the wells.

The observation wells are being used to monitor the head in the Capitan aquifer and to measure the effects of fluid withdrawal in Lea County, N. Mex., and Winkler and Ward Counties, Texas. Water levels in five wells completed in the Capitan aquifer in northern Lea County have declined at an average of 1.4 feet per month during a 4-year period 1966-1970. Slight variations in the water levels, generally resulting in net long-term rises, have been detected in four converted oil tests and three additional observation wells in Eddy County during the same period.

## INTRODUCTION

### Purpose

The observation-well network described in this report was established as part of a study of the ground-water hydrology of the Capitan Limestone in southeastern New Mexico and western Texas.

Large quantities of saline ground water are being withdrawn from the Capitan aquifer in Lea County, N. Mex., and Winkler and Ward Counties, Texas (Guyton, 1958; Brackbill and Gaines, 1964; and Hiss, 1971). This water, along with some of the saline waste water produced with oil, is transported to other areas where it is injected into several formations to repressurize partially depleted oil fields.

Use of water in the Pecos River basin is limited by an interstate stream compact between the States of Texas and New Mexico (U.S. Congress, 1949; Lingle and Linford, 1961). Surface water in the entire basin and ground water in part of the basin and adjacent areas, all of which are within New Mexico, are controlled by the New Mexico State Engineer.

The intense competition for water within this area is reflected by the number of hearings concerning the use of ground water from the Capitan aquifer in the vicinity of Carlsbad, N. Mex., which have been held before the New Mexico State Engineer (New Mexico State Engineer Hearing, 1960, 1962, and 1963; New Mexico State Engineer, 1964).

The observation wells described in this report are being used to monitor the hydrostatic head in the Capitan aquifer and to measure the effects of fluid withdrawal in Lea County, N. Mex., and Winkler and Ward Counties, Texas. The information obtained will contribute to an understanding of the relationship between the Capitan aquifer and the Pecos River at Carlsbad and will be helpful in determining the effect, if any, of continued withdrawal of fluid from this aquifer on the flow of the Pecos River at Carlsbad.

### Scope of Report

The information contained in this report is primarily noninterpretative in nature and is limited to well-construction diagrams and descriptions, hydrographs for each well, and a general description of the geologic and hydrologic setting of the Capitan aquifer. The chemical character of the fluid in the well columns and the methods employed to convert the observed fluid levels to fresh-water head are discussed. The well construction, testing, and development history has been compiled from many sources and will be of interest to anyone contemplating future development or use of the wells.

## Location of Observation Wells

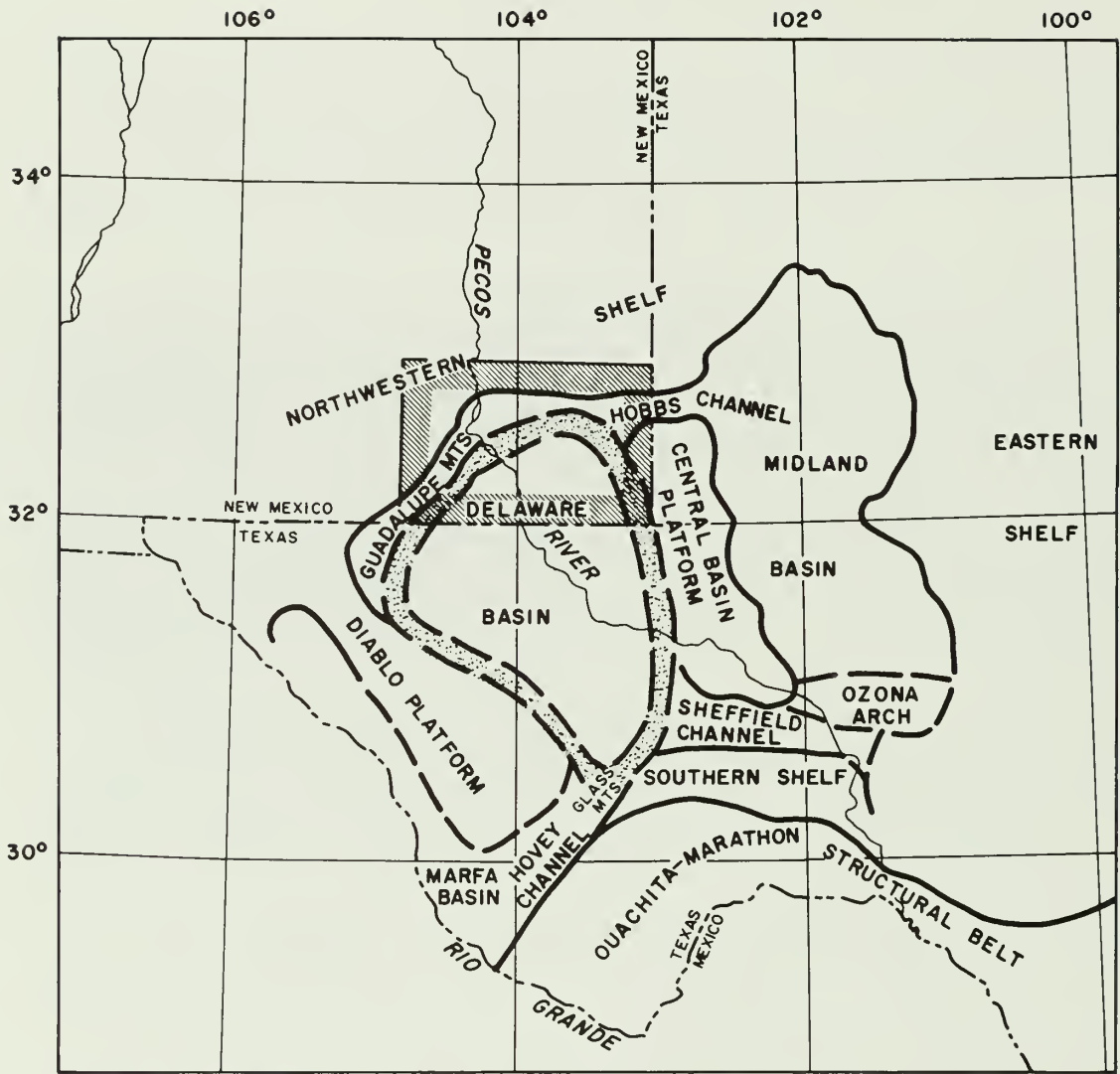
The Capitan aquifer observation-well network consists of 12 observation wells located along the areal extent of the Capitan Limestone in an arc extending from southwest of Carlsbad, N. Mex., around the north and east margins of the Delaware basin to southwest of Jal, N. Mex. (figs. 1 and 2).

## ACKNOWLEDGMENTS

The Capitan aquifer observation-well network was established in cooperation with the New Mexico State Engineer Office. Wells in the network were assigned to the U.S. Geological Survey by oil companies or loaned by the city of Carlsbad or private individuals. Messrs. E. R. Cox and J. S. Havens of the Geological Survey assisted the author during well completion and development operations. Messrs. L. E. Galyean, consulting programmer, and J. B. Peterson of the Geological Survey wrote the computer programs used to process the water-level data and to plot the hydrographs. The observation wells were serviced by Messrs. E. R. Cox, J. S. Havens, C. C. Cranston, R. L. Rogers, G. E. Welder, G. E. Maddox, H. E. Loble, and J. D. Stevens of the U.S. Geological Survey. Mr. G. J. Gail assisted the author with remedial work on the Yates State 1, Hackberry Deep Unit 1, and Humble State 1 observation wells and preparation of the data. Messrs. F. R. Allen, P. D. Akin, R. L. Borton, and Zane Spiegel, New Mexico State Engineer Office, assisted with the critical review of this report. The New Mexico State Land Office, New Mexico State Oil Conservation Commission, Conservation Division of the U.S. Geological Survey, and the U.S. Bureau of Land Management were helpful in several stages of the negotiations for and development of the observation-well network. Latitude-longitude coordinates and altitude data for several of the abandoned oil and gas test wells were obtained from the Permian Basin Well Data System tape file of scout records and are used with permission of Tobin Surveys, Inc. and Laughlin-Simmons and Company of Texas, Inc., respectively. The assistance of the many cooperating agencies, companies, and individuals is gratefully acknowledged.

## GEOLOGIC SETTING

The Capitan and Goat Seep Limestones represent either fringing reefs (Adams and Frenzel, 1950; Silver and Todd, 1969) or shelf margin organic mounds or banks (Achauer, 1969; Kendall, 1969) deposited in juxtaposition along the edge of the Delaware basin during Permian Guadalupe time (fig. 2). Dunham (1970) has described the Capitan Limestone as a "stratigraphic reef" because this linear carbonate complex is composed of particles wholly or largely bound with inorganically derived cement. A stratigraphic reef is differentiated from an "ecologic reef" which is composed of particles bound with organically derived cement. Except where well control is unusually dense, it is impossible



Base from U.S. Geological Survey  
United States base map.

0 50 100 150 MILES

EXPLANATION



Report area



Approximate position of Capitan and Goat Seep Limestones

Figure 1.--Tectonic elements in the Permian basin of west Texas and southeastern New Mexico (modified after Oriol, Meyers, and Crosby, 1967).



**EXPLANATION**

Approximate position of extreme shelfward limit

Basinal edge

Position of Copiton ouifer

Oil or gas field

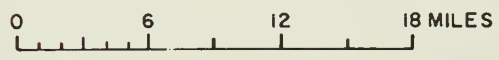
Wells used in stratigraphic sections only

Observation well

A ——— A'

Line of stratigraphic section  
(Sections shown on figures 3 & 4)

Note:  
Number by wells corresponds to well number used on stratigraphic sections



Base map modified from U.S. Geological Survey Oil and Gas Branch Map No. Roswell 38, revised March 1967.

Figure 2.--Areal extent of Lea and Eddy Counties, New Mexico.



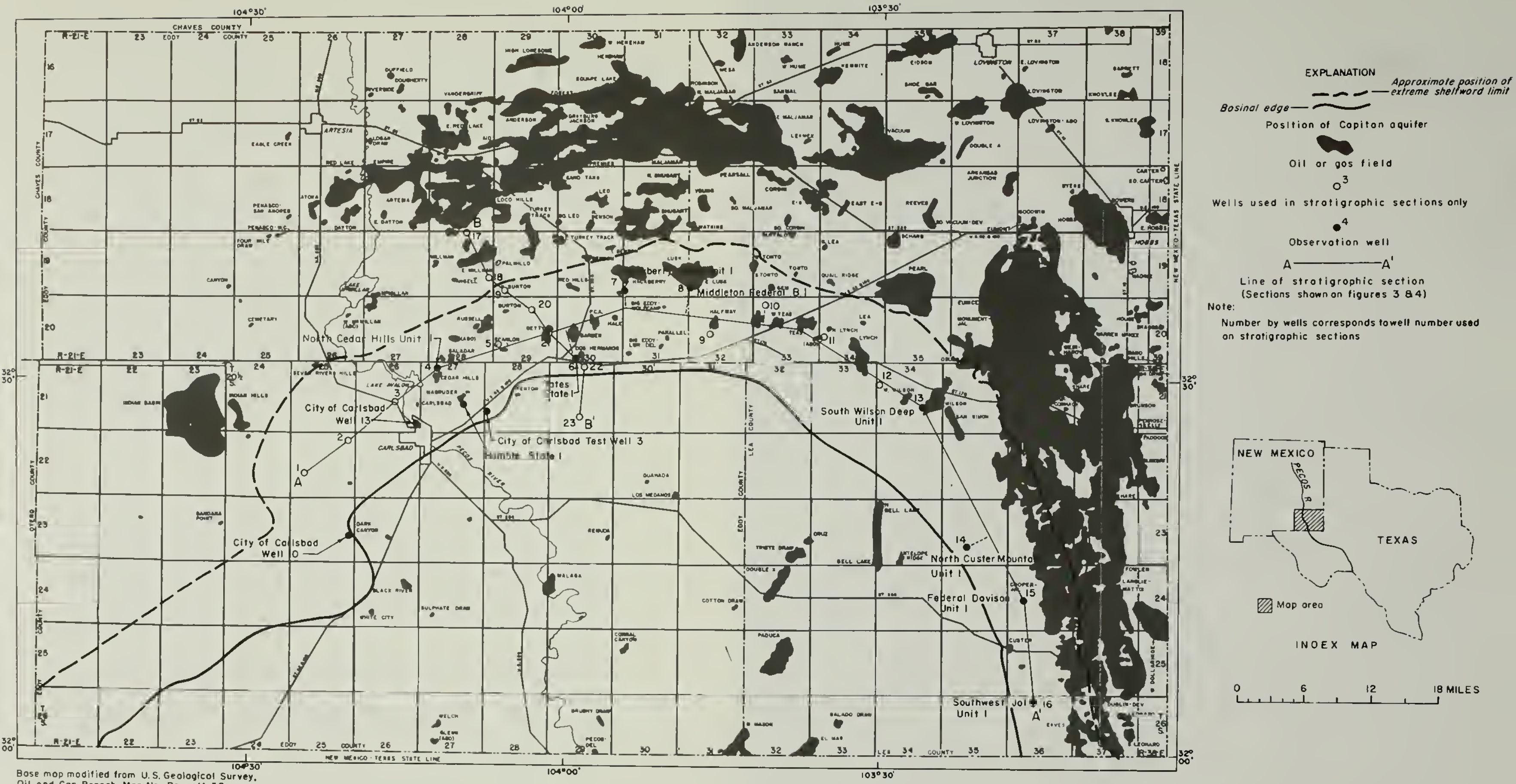


Figure 2.--Areal extent of the Capitan aquifer and the location of stratigraphic sections and Capitan aquifer observation wells in Eddy and Lea Counties, New Mexico.

to distinguish the boundary between the Goat Seep and Capitan Limestones in the subsurface.

The Goat Seep and Capitan Limestones are composed of limestone and dolomite with minor amounts of siltstone and sandstone. These units appear to have similar hydraulic properties and are treated singularly as the Capitan aquifer in this report (figs. 3 and 4). Within New Mexico, the Capitan aquifer varies from less than 800 to more than 2,200 feet in thickness and is continuous in the subsurface from Carlsbad to Jal, N. Mex. (fig. 3). In New Mexico, the Capitan aquifer varies in width from approximately 6 miles, along the west edge of the Central Basin platform in the vicinity of Jal, to approximately 12 miles in western Lea County.

The Capitan aquifer is underlain by sandstones, siltstones, and limestones of the Delaware Mountain Group and is overlain by the Artesia Group and the Salado Formation. It is bounded on the basinward side by impermeable anhydrite of the Castile Formation and grades shelfward into the interbedded dolomite, limestone, sandstone, and anhydrite of the Artesia Group and San Andres Limestone. The basinward edge of the Capitan aquifer is abrupt and can be sharply defined, whereas the shelfward edge is gradational and cannot be easily defined (fig. 4). The rock units surrounding the Capitan aquifer generally have significantly less permeability than the Capitan and, in most places, act as partial hydrologic barriers to movement of water into or out of the aquifer.

#### SOURCE AND OWNERSHIP OF OBSERVATION WELLS

The North Cedar Hills Unit 1, Humble State 1, Yates State 1, Hackberry Deep Unit 1, Middleton Federal B 1, South Wilson Deep Unit 1, North Custer Mountain Unit 1, Federal Davison 1, and Southwest Jal Unit 1 observation wells were drilled as exploratory test wells in unsuccessful searches for oil and gas accumulations of commercial value. These wells were obtained from cooperating oil companies at the time of their abandonment and converted to observation wells. The U.S. Geological Survey owns and is responsible for the use and disposition of these wells.

The City of Carlsbad Water Wells 10 and 13 are owned by the city of Carlsbad whereas the City of Carlsbad Test Well 3 is apparently still owned by Mr. Forrest Miller of Alpine, Texas. These three wells were drilled by the city of Carlsbad during various ground-water exploration programs and are on loan to the U.S. Geological Survey.

#### WELL CONSTRUCTION AND DEVELOPMENT

Well-construction diagrams and drilling and completion records for individual observation wells are given in Appendixes A through M. Other than installation of water-level recorders and recorder shelters,



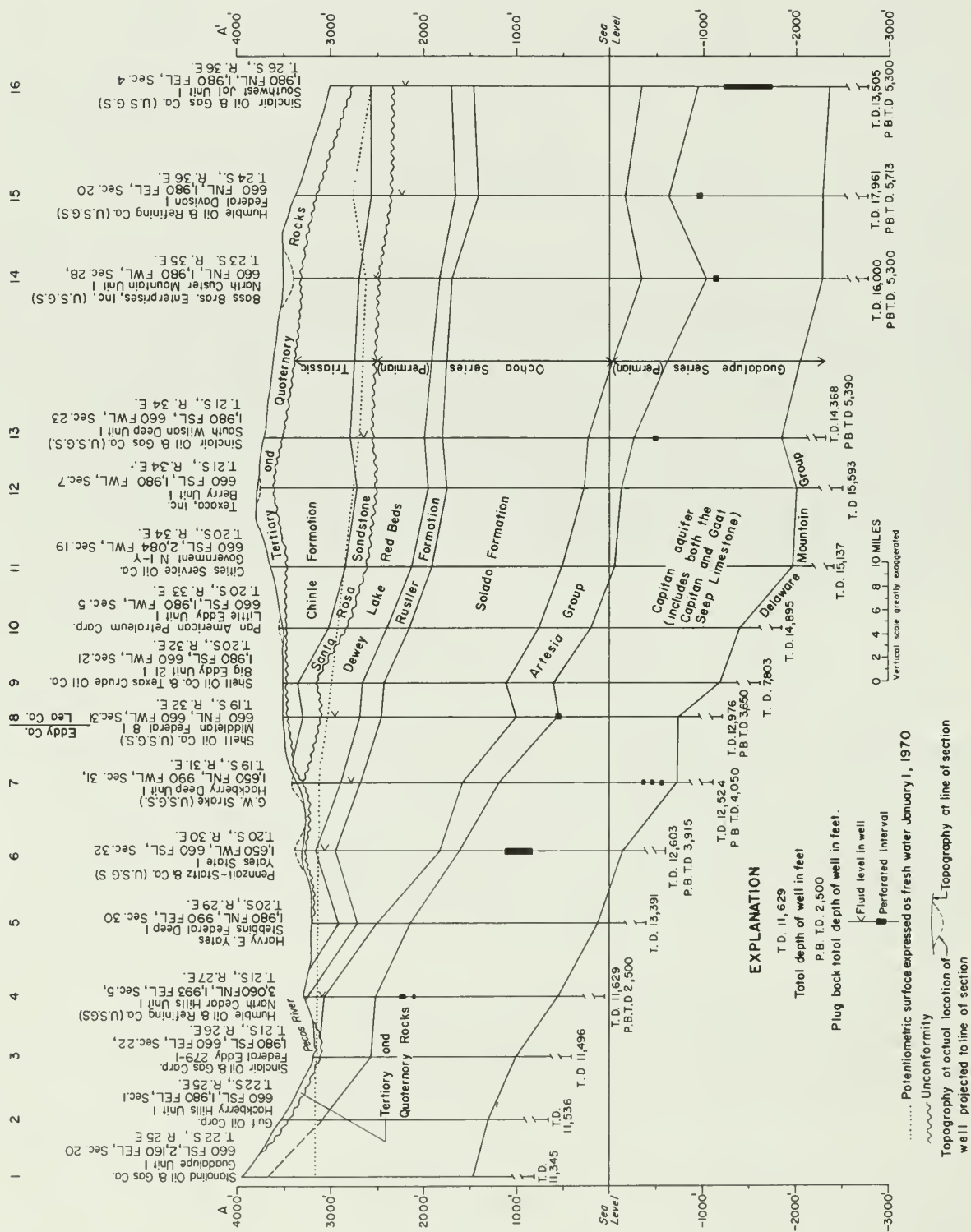


Figure 3.--Longitudinal stratigraphic section A-A' showing the position of the Capitan aquifer, Eddy and Lea Counties, New Mexico.





Figure 4.--Transverse stratigraphic section B-B' showing the position of the Capitan aquifer, Eddy County, New Mexico.

no construction or development work was performed on the wells loaned to the U.S. Geological Survey by the city of Carlsbad and Mr. Forrest Miller.

The wells which were received from oil companies were obtained at the time of abandonment. With the exception of the North Custer Mountain Unit 1 well, a cement plug was set by the operator at the base of the intermediate casing string which had been set through or near the base of the Capitan aquifer. The wells were then filled to the surface with either rotary drilling mud, brine, or fresh water and released to the U.S. Geological Survey. The North Custer Mountain Unit 1 well was received with the uncased part of the borehole plugged back to 12,800 feet. The well was filled with fresh water at the time of abandonment by the operator. A wire-line bridge plug was subsequently set at 5,300 feet near the base of the Capitan aquifer in this well.

The completion procedures generally followed by the U.S. Geological Survey included swabbing or bailing the mud or water from the casing, running perforating depth control logs, perforating, swabbing to test the effectiveness of perforations and stimulating the well with acid as necessary to increase the well productivity. The operations were usually concluded with a production swab test.

## WATER LEVELS

### Instrumentation

The 12 observation wells are equipped with float-operated recorders. Eleven of the observation wells are equipped with graphic recorders. A continuous record of the water level is available on paper strip charts for these wells. City of Carlsbad Test Well 3 is equipped with a digital recorder. Values representing the level of the water in this well are punched into a paper tape at 15-minute intervals. The water-level data contained on the punched paper tape are then transferred to magnetic tape for further processing by digital computer.

The depth to water from the land surface at the observation wells on January 1, 1970 ranged from 20 to 1,124 feet. Crooked holes in several of the wells cause the float line to foul on the casing. Line guides were installed to centralize the line in several of the deeper wells in an unsuccessful attempt to correct this problem. The line guides were subsequently removed and a small amount of motor oil was poured slowly down the hole along the float line. Application of motor oil to the float line has resulted in nearly normal operation of recorders on most of the wells.

### Data File

Record numbers compatible with the PBWDS (Permian Basin Well Data System) have been assigned to the observation wells converted from

abandoned oil and gas tests (Permian Basin Well Data System, 1964; Cooper, 1967). Unique record numbers used by the U.S. Geological Survey were assigned to the remaining observation wells in order to facilitate processing of the water-level data by computer methods. These record numbers are not compatible with the PBWDS system.

Water levels and other data pertaining to the observation wells were encoded in the format shown in figure 5 (Peterson and Hiss, 1970). One water-level reading per day was encoded for each observation well. Additional water levels were recorded at the time the recording strip charts were changed, during times of redevelopment or well testing, and whenever depth measurements were checked for accuracy with a steel tape or logging cable.

Daily water levels recorded at noon MST (Mountain Standard Time) were encoded for the wells equipped with graphic recorders. The highest daily water levels recorded were more readily available for the City of Carlsbad Test Well 3 and are used in this report for the period October 5, 1965, to February 18, 1969. Subsequently, the noon MST water-level measurements only were encoded for this well.

### Hydrographs

The hydrographs in figure 6 were plotted using all of the water-level data encoded in the OMNIANA data file used in the New Mexico District of the U.S. Geological Survey.

The description of status codes for the fluid-level records at a particular time is tabulated and included in figure 6. The alphabetic footnote keys plotted sequentially along the trace of a hydrograph refer to this table. The most frequently used footnotes, "Y" and "W", reflect the difficulty caused by fouling of the float line on the casing.

Narrative remarks concerning the general operations of the observation-well network or the recording instruments are tabulated in table 1. The numeric footnote keys plotted sequentially along the hydrograph trace refer to this table.

The discontinuities in the hydrograph traces (as shown in the November-December 1968 data for the North Cedar Hills Unit 1 observation well, for example) are the result of (1) corrections for original errors in measurement, (2) measurements made with different instruments that do not provide a common reading, and (3) changes in the fluid column specific gravity caused by swabbing or bailing the well.

None of the changes made to the measurements recorded in the observation wells have affected the major long-term trends shown in the hydrographs.

The water levels in the Capitan wells must be adjusted to represent head measurements for a fluid of a common specific gravity referenced to a common datum before head comparisons can be made.





Table 1

Narrative remarks concerning operation of the wells  
in the Capitan aquifer observation-well network<sup>1</sup>

City of Carlsbad Well 10:

1. Daily high water-level readings used through 12-31-65.  
Recorder installed.
2. Recorder not operating correctly from 8-7-66 to 8-10-66 due  
to flooding in nearby Dark Canyon.
3. Noon MST water-level readings begin.
4. Clock replaced and reset.
5. Recorder affected by rain or flood from 6-30-67 to 7-2-67.
6. Recorder affected by rain or flood from 8-30-68 to 9-1-68.
7. Record missing between 9-7-69 and 9-17-69. Paper supply de-  
pleted.
8. Recorder affected by rain or flood from 9-17-69 to 9-19-69.
9. Recorder affected by rain or flood from 10-20-69 to 10-24-69.
10. Recorder affected by rain or flood from 9-17-70 to 9-22-70.
11. Recorder affected by rain or flood from 10-5-70 to 10-10-70.
12. Clock stopped from 9-16-71 to 10-15-71. Counterweight hung  
on float wheel.

City of Carlsbad Well 13:

1. Daily high water-level readings used through 12-31-65.  
Recorder installed.
2. Noon MST water-level readings begin.
3. Weight came off. Float line loose from 6-15-67 to 6-27-67.
4. New clock installed.

North Cedar Hills Unit 1:

1. Acidized well.
2. Swabbed well.
3. Installed recorder.
4. Swabbed and acidized well.
5. Swabbed well.
6. Recorder re-installed.
7. Steel tape measurement.
8. Steel tape measurement.
9. Clock replaced.
10. Swabbing completed. Tape measurement taken 139 minutes  
after pumping ceased.
11. Steel tape measurement.
12. Chart paper roll changed.
13. Started to add float line and lost it down well.

Humble State 1:

1. Swabbed and acidized well.
2. Swabbed well.
3. Swabbed well.
4. Swabbed and acidized well.

<sup>1</sup>Narrative remarks apply to figure 6.

Table 1

Narrative remarks concerning operation of the wells  
in the Capitan aquifer observation-well network - Continued

Humble State 1 (Concluded):

5. Recorder installed.
6. Steel tape measurement.
7. Steel tape measurement.
8. Pen reset. Screws in clock had come off and float was pulled up.
9. Steel tape measurement.
10. Steel tape measurement.
11. Steel tape measurement.
12. Recorder and shelter removed on 12-29-71. Fluid column sampled on 12-30-71. Recorder reinstalled on 1-6-72. 1.2 feet of oil on top of fluid.
13. 3.3 feet of oil on top of fluid column on 2-28-72.

City of Carlsbad Test Well 3:

1. Digital recorder installed.
2. Daily high water-level readings used.
3. Data from 11-25-68 to 12-19-68 omitted because of unreliability.

Yates State 1:

1. Swabbed from 8-29-67 to 9-1-67.
2. Recorder installed.
3. Chart roll changed and pen inked.
4. Pen removed to check for oil in well.
5. Clock stopped from 4-21-69 to 5-21-69. Negator spring was binding.
6. Recorder replaced 6-18-69.
7. Pulse test. Recorder was not operating from 9-3-69 to 10-15-69.
8. Recorder replaced 11-18-69.
9. Recorder and shelter removed on 10-20-71. Length of oil column was 77.4 feet. Oil bailed from well on 10-22-71. Recorder reinstalled on 10-27-71.
10. Recorder and shelter removed on 12-27-71. Cast iron bridge plug set at 2,550 feet (KB) and well swabbed on 12-28-71 and 12-29-71. Recorder reinstalled on 1-6-72.
11. No oil present at top of water on 2-28-72.

Hackberry Deep Unit 1:

1. Treated with acid and swabbed. Ran aquifer performance test.
2. Recorder installed.
3. Swabbed and acidized well.
4. Wire-line measurement.
5. Poured 1 gallon of motor oil down well to free the line. Wire-line measurement.
6. Wire-line measurement used to make a correction to subsequent water-level data.

Table 1

Narrative remarks concerning operation of the wells  
in the Capitan aquifer observation-well network - Continued

Hackberry Deep Unit 1 (Concluded):

7. Measurement with logger.
8. Continual bubbling noise heard from well due to leakage of gas into borehole.
9. Can still hear bubbling noise.
10. Can hear only faint bubbling noise.
11. No audible bubbling noise.
12. Chart roll changed.
13. Clock stopped from 8-15-69 to 9-4-69 for pulse test.
14. Recorder and shelter removed. Length of oil column was 95.7 feet on 10-20-71. Oil bailed from well on 10-21-71. Recorder reinstalled on 10-27-71.
15. Tape parted in hole on second measurement, jamming float.
16. Float reinstalled and recorder in operation on 12-14-71.

Middleton Federal B 1:

1. Recorder installed.
2. Swabbed 245 barrels of water in 5 hours.
3. Pen skipping from 4-3-67 to 5-2-67.
4. Wire-line measurement ignored.
5. Logger measurement.
6. Counterweight caught on shelf from 9-9-68 to 9-19-68.
7. Added 12.13 feet of wire to float line. Water-level measured after unhooking counterweight.
8. Chart roll changed.
9. Wire added to float line.

South Wilson Deep Unit 1:

1. Recorder installed.
2. Wire-line measurement.
3. Logger measurement. Water-level records missing from 5-18-68 to 5-19-68. New float line installed.
4. Unreliable readings from 6-27-68 to 7-17-68 because of cat-tle rubbing against recorder shelter.
5. Pen reset. Beads on float wheel slipped.
6. Wire added.

North Custer Mountain Unit 1:

1. Swabbed approximately 330 barrels of water in 3 days.
2. Depthometer measurement.
3. Swabbed and bailed approximately 330 barrels of water in 2 days.
4. Acidized with 1,000 gallons regular 15 percent acid.
5. Swabbed approximately 540 barrels of water at 42 gallons per minute.
6. Static water level after swabbing.
7. Recorder installed. Steel tape measurement.
8. Wire-line measurement.

Table 1

Narrative remarks concerning operation of the wells  
in the Capitan aquifer observation-well network - Concluded

North Custer Mountain Unit 1 (Concluded):

9. Measurement made but not used.
10. Logger and steel tape measurement.
11. Beads out of holes on float wheel. Counterweight 0.3 feet from float wheel. Added 8.93 feet of float cable. Pen reset to 865.64.
12. Wire added.
13. Float line sporadically hung from 9-12-69 to 9-17-69.
14. Weight hung on wheel. Added 10 feet of float line.

Federal Davison 1:

1. Recorder installed.
2. Clock replaced.
3. Added 20 feet of wire.
4. Wire-line measurement.
5. Wire-line measurement.
6. Large rise in water level. Duration of rise was 9 hours.
7. New clock installed.
8. Correction from logger measurement added to water-level readings from 4-17-68 to 5-16-68.
9. Float counterweight ran out of wire; weight hanging on float wheel. Wire spliced and added.
10. Float line added.
11. Cable added to float line.
12. Float line sporadically hung from 7-18-69 to 8-19-69.

Southwest Jal Unit 1:

1. Swabbed and acidized.
2. Logger measurement.
3. Water-level recorder installed.
4. Wire-line measurement ignored in preference to logger measurement.
5. Wire-line measurement ignored in preference to logger measurement.
6. Logger measurement.
7. Float counterweight hung on float wheel between 10-9-68 and 10-17-68. Float line lengthened.
8. Float line lengthened.
9. Float line sporadically hung.



However, the movement or changes in the measured unadjusted water levels can be used for comparison of water-level trends established in the aquifer.

The hydrographs of the 12 observation wells can be separated into two distinct groups. With the exception of the Hackberry Deep Unit 1 well, the fluid levels in the wells located in Eddy County seem to respond primarily to climatic conditions and the withdrawal of water for municipal, industrial, agricultural, and other uses in the Pecos River valley. Water levels in the Hackberry Deep Unit 1 and all of the observation wells located in Lea County are definitely lowering in response to withdrawal of water for industrial purposes from the Capitan aquifer in Lea County, N. Mex., and Ward and Winkler Counties, Texas. Withdrawal of fluids from adjacent formations of Guadalupe age in hydraulic connection with the Capitan aquifer also contributes to the decline in water levels in Lea County.

#### WATER QUALITY

Water produced from the Capitan aquifer is generally much less mineralized than water in other formations of Guadalupe age (Hiss, 1970; Hiss, Peterson, and Ramsey, 1969). The least mineralized water in the Capitan aquifer in New Mexico occurs west of the Pecos River in the vicinity of Carlsbad and to the southwest in the Guadalupe Mountains (Hiss, 1970). The chloride ion content of water produced from the Capitan aquifer in the vicinity of Carlsbad is less than 300 mg/l (milligrams per liter). Water in the Capitan aquifer becomes progressively more saline east of the Pecos River in Eddy County. Water containing chloride ion concentrations greater than 20,000 mg/l is produced in the vicinity of the boundary between Eddy and Lea Counties. Water in the Capitan aquifer along the western margin of the Central Basin platform in Lea County generally contains from 1,000 to 10,000 mg/l of chloride ions.

The chemical quality of water produced from the observation wells is tabulated in table 2. The large difference between the chloride and sulfate ion concentrations shown for two samples of water produced from the Middleton Federal B 1 well on October 26, 1966, is due to determination of these constituents by different methods in separate laboratories.

#### Well-Numbering System Used in Table 2

Capitan aquifer observation wells are listed and identified in table 2 by a location number assigned by the U.S. Geological Survey and the New Mexico State Engineer Office. The location number is a description of the geographic location of the well based on the system of public land surveys. It indicates the location of the well to the nearest 10-acre tract, when the well can be located that accurately. The location number consists of a series of numbers corresponding to the township, range, section, and tract within a section, in that order,

Table 2.--Chemical quality of water in Capitan aquifer observation wells

Location number	Well name	Aquifer	Interval or sampling depth (feet)	Date	Silica (SiO <sub>2</sub> )	Calcium (Ca)	Magnesium (Mg)	Sodium + Potassium (Na+K)	Bicarbonate (HCO <sub>3</sub> )	Carbonate (CO <sub>3</sub> )	Sulfate (SO <sub>4</sub> )	Chloride (Cl)	Fluoride (F)	Total dissolved solids	Calcium magnesium silicate	Non-carbonate	Specific gravity 20°C	SAR	Specific conductance (microhm-cmhos at 25°C)	pH
31,27, 5,411	City of Carlsbad Well 13	Capitan	30 <sup>466/</sup>	12- 6-63	---	27	14	---	16	2	80	284	---	---	124	108	0.9986	---	1,130	9.0
36,221	do.	do.	100 <sup>466/</sup>	12- 6-63	2.8	26	12	173	14	3	77	282	0.5	603	116	100	.9985	6.8	1,120	9.1
36,221	do.	do.	170 <sup>466/</sup>	12- 6-63	---	220	71	---	240	0	611	270	---	---	860	644	1.0000	---	2,160	7.3
36,221	do.	do.	250 <sup>466/</sup>	12- 6-63	---	224	71	---	240	0	619	278	---	---	852	656	.9999	---	2,210	7.3
36,221	do.	do.	300 <sup>466/</sup>	12- 6-63	15	236	70	193	232	0	659	290	.5	1,670	878	688	.9998	2.8	2,290	7.3
21,27, 5,411	North Cedar Hills Unit 1	do.	1,007 <sup>-1,170</sup>	12-11-68	---	1,400	576	8,260	626	0	3,690	13,800	---	28,000	5,860	5,350	1.020	---	39,000	6.4
21,27, 23,330 <sup>1/</sup>	Humble State 1	do.	1,538 <sup>-1,936</sup>	11- 3-67	26	7,080	4,580	3,810	650	0	1,570	30,200	7.0	47,600	36,500	36,000	1.044	9.1	86,100	6.5
23,330	do.	do.	250 <sup>2,461/</sup>	12-30-71	---	2,508	1,976	12,453	34	---	2,240	28,053	---	49,310	14,400	---	1.033	---	50,000	6.1
23,330	do.	do.	500 <sup>2,461/</sup>	12-30-71	---	2,596	2,019	12,219	34	---	2,135	28,053	---	49,780	14,800	---	1.032	---	51,020	6.1
23,330	do.	do.	750 <sup>2,461/</sup>	12-30-71	---	2,508	1,976	11,234	49	---	2,100	26,277	---	55,666	14,400	---	1.032	---	52,083	6.3
23,330	do.	do.	1,000 <sup>2,461/</sup>	12-30-71	---	2,464	2,002	11,191	41	---	1,995	26,277	---	53,100	14,400	---	1.032	---	46,083	6.1
23,330	do.	do.	1,250 <sup>2,461/</sup>	12-30-71	---	2,420	2,029	11,185	44	---	1,995	26,277	---	48,072	14,400	---	1.033	---	46,083	6.2
23,330	do.	do.	1,500 <sup>2,461/</sup>	12-30-71	---	2,640	1,993	9,983	44	---	1,715	24,857	---	46,038	14,800	---	1.030	---	48,543	5.8
23,330	do.	do.	1,750 <sup>2,461/</sup>	12-30-71	---	2,596	1,995	10,559	38	---	1,925	25,567	---	54,296	14,700	---	1.031	---	45,662	5.8
23,330	do.	do.	2,000 <sup>2,461/</sup>	12-30-71	---	2,728	2,109	9,342	61	---	1,610	24,302	---	45,474	15,500	---	1.029	---	46,083	5.8
23,330	do.	do.	2,250 <sup>2,461/</sup>	12-30-71	---	2,728	2,134	8,765	78	---	1,540	23,791	---	50,452	15,600	---	1.029	---	46,083	5.9
23,330	do.	do.	2,500 <sup>2,461/</sup>	12-30-71	---	2,552	2,046	10,609	56	---	1,750	25,567	---	46,004	14,800	---	1.030	---	46,083	6.0
21,28, 30,16 <sup>2/</sup>	City of Carlsbad Test Well 3	do.	640 <sup>-1,060</sup>	8-11-61	---	1,120	388	6,400	312	0	3,430	10,300	---	22,400	4,370	---	---	---	28,600	7.6
30,161	do.	do.	100 <sup>465/</sup>	10- 5-61	.6	1,060	342	5,760	6	0	3,360	9,300	1.8	20,600	4,050	4,050	1.012	39	28,200	5.6
30,161	do.	do.	350 <sup>465/</sup>	10- 5-61	.0	1,050	352	5,600	4	0	3,360	9,050	1.5	20,300	4,080	4,080	1.012	38	28,200	5.3
30,161	do.	do.	675 <sup>465/</sup>	10- 5-61	18	1,120	356	5,150	143	0	3,440	8,300	1.9	19,300	4,240	4,120	1.012	34	26,600	7.0
30,161	do.	do.	750 <sup>465/</sup>	10- 5-61	31	1,060	342	5,780	370	0	3,350	9,500	2.6	21,600	4,320	4,010	1.013	39	29,200	7.1
30,161	do.	do.	900 <sup>465/</sup>	10- 5-61	56	1,240	416	6,560	784	0	3,410	10,600	1.9	23,800	4,800	4,150	1.015	41	32,100	7.4
20,30, 32,341	Yates State 1	do.	2,239 <sup>-2,515</sup>	9- 2-67	---	1,490	480	11,900	460	0	4,190	18,400	---	35,900	5,600	5,340	1.023	---	50,000	6.5
32,341	do.	do.	2,239 <sup>-2,515</sup>	1-28-69	---	---	---	---	---	---	---	18,000	---	---	---	---	1.020	---	49,400	---
32,341	do.	do.	423 <sup>2,461/</sup>	10-22-71	---	1,122	558	11,384	7	---	3,780	18,465	---	35,385	5,100	---	1.023 <sup>1/</sup>	---	48,780	4.95
32,341	do.	do.	1,023 <sup>2,461/</sup>	10-22-71	---	979	511	10,789	7	---	3,430	17,400	---	33,173	4,550	---	1.021	---	45,249	4.9
32,341	do.	do.	1,272 <sup>2,461/</sup>	10-22-71	---	946	507	10,277	7	---	3,220	16,689	---	31,700	4,450	---	1.020	---	44,444	4.9
32,341	do.	do.	1,772 <sup>2,461/</sup>	10-22-71	---	836	367	9,268	10	---	2,660	14,914	---	28,086	3,600	---	1.017	---	40,000	5.1
32,341	do.	do.	2,272 <sup>2,461/</sup>	10-22-71	---	744	350	7,708	15	---	2,450	12,428	---	23,710	3,300	---	1.015	---	33,557	5.7
32,341	do.	do.	2,472 <sup>2,461/</sup>	10-22-71	---	590	243	6,101	32	---	1,820	9,801	---	18,587	2,475	---	1.011	---	29,851	6.7
32,341	do.	do.	2,500 <sup>2,461/</sup>	12-28-71	---	968	457	9,930	98	---	3,150	15,979	---	32,626	4,300	---	1.023	---	43,860	6.5
32,341	do.	do.	2,800 <sup>2,461/</sup>	12-28-71	---	748	347	7,665	44	---	2,310	12,428	---	24,600	3,300	---	1.016	---	29,499	6.4
32,341	do.	do.	3,100 <sup>2,461/</sup>	12-28-71	---	550	261	5,894	31	---	1,750	9,517	---	17,626	2,450	---	1.012	---	22,989	6.4
32,341	do.	do.	3,400 <sup>2,461/</sup>	12-28-71	---	440	243	4,659	37	---	1,330	7,670	---	14,630	2,100	---	1.010	---	19,531	6.9
32,341	do.	do.	3,700 <sup>2,461/</sup>	12-28-71	---	414	198	4,650	41	---	1,260	7,528	---	13,610	1,850	---	1.010	---	17,513	7.1
32,341	do.	do.	3,900 <sup>2,461/</sup>	12-28-71	---	404	228	4,327	39	---	1,260	7,102	---	13,322	1,950	---	1.008	---	16,207	7.3
32,341	do.	do.	500 <sup>2,461/</sup>	12-29-71	---	1,452	600	14,313	537	---	4,550	22,726	---	43,610	6,100	---	1.030	---	50,000	7.3

Table 2.--Chemical quality of water in Capitan aquifer observation wells - Concluded

Location number	Well name	Aquifer	Producing interval or sampling depth (feet)	Date	Silica (SiO <sub>2</sub> )	Calcium (Ca)	Magnesium (Mg)	Sodium + Potassium (Na+K)	Bicarbonate (HCO <sub>3</sub> )	Carbonate (CO <sub>3</sub> )	Sulfate (SO <sub>4</sub> )	Chloride (Cl)	Fluoride (F)	Total dissolved solids	Calcium magnesium carbonate	Hardness as CaCO <sub>3</sub>	Specific gravity 20°C	SAR	Specific conductance (micromhos at 25°C)	pH
20.30, 32.341	Yates State 1 - Concluded	Capitan	1,000 <sup>2</sup> / <sub>4610</sub>	12-29-71	---	1,452	600	13,808	595	---	4,410	22,016	---	43,712	6,100	1.031	---	---	50,000	7.1
32.341	do.	do.	1,500 <sup>2</sup> / <sub>4610</sub>	12-29-71	---	1,452	552	14,387	576	---	4,480	22,726	---	43,730	5,900	1.031	---	---	52,083	7.1
32.341	do.	do.	2,000 <sup>2</sup> / <sub>4610</sub>	12-29-71	---	1,452	552	14,385	571	---	4,480	22,726	---	43,858	5,900	1.030	---	---	50,000	7.1
32.341	do.	do.	2,500 <sup>2</sup> / <sub>4610</sub>	12-29-71	---	946	482	10,348	134	---	3,080	16,689	---	32,058	4,350	1.022	---	---	43,680	6.9
19.31.31.132 <sup>1</sup> / <sub>4</sub>	Hackberry Deep Unit 1	do.	2,113 <sup>462</sup> / <sub>4627</sub>	12-15-66	---	---	---	---	---	---	---	87,500	---	---	---	1.109	---	---	175,000	---
31.132 <sup>1</sup> / <sub>4</sub>	do.	do.	3,005 <sup>462</sup> / <sub>4627</sub>	12-15-66	---	---	---	---	---	---	---	87,000	---	---	---	1.109	---	---	174,000	---
31.132 <sup>1</sup> / <sub>4</sub>	do.	do.	3,746 <sup>462</sup> / <sub>4627</sub>	12-15-66	---	---	---	---	---	---	---	87,500	---	---	---	1.109	---	---	174,000	---
31.132 <sup>1</sup> / <sub>4</sub>	do.	do.	3,832 <sup>462</sup> / <sub>4627</sub>	12-15-66	---	---	---	---	---	---	---	102,000	---	---	---	1.130	---	---	194,000	---
31.132 <sup>1</sup> / <sub>4</sub>	do.	do.	3,936 <sup>462</sup> / <sub>4627</sub>	12-15-66	---	---	---	---	---	---	---	106,000	---	---	---	1.134	---	---	197,000	---
31.132 <sup>1</sup> / <sub>4</sub>	do.	do.	750 <sup>2</sup> / <sub>4627</sub>	10-21-71	---	1,892	1,767	69,691	5	---	5,320	112,210	---	191,024	12,000	1.115 <sup>12</sup> / <sub>4</sub>	---	---	200,000	5.0
31.132 <sup>1</sup> / <sub>4</sub>	do.	do.	1,520 <sup>2</sup> / <sub>4627</sub>	10-21-71	---	1,848	1,842	68,569	0	---	5,110	110,790	---	188,307	12,200	1.114	---	---	196,078	4.9
31.132 <sup>1</sup> / <sub>4</sub>	do.	do.	2,020 <sup>2</sup> / <sub>4627</sub>	10-21-71	---	1,804	1,699	69,879	2	---	5,250	112,210	---	190,993	11,900	1.115	---	---	200,000	5.0
31.132 <sup>1</sup> / <sub>4</sub>	do.	do.	2,770 <sup>2</sup> / <sub>4627</sub>	10-21-71	---	1,716	1,825	69,756	10	---	5,250	112,210	---	190,902	11,800	1.115	---	---	200,000	5.25
31.132 <sup>1</sup> / <sub>4</sub>	do.	do.	3,270 <sup>2</sup> / <sub>4627</sub>	10-21-71	---	1,760	1,701	69,874	5	---	5,110	112,210	---	190,791	11,400	1.116	---	---	200,000	5.1
31.132 <sup>1</sup> / <sub>4</sub>	do.	do.	3,770 <sup>2</sup> / <sub>4627</sub>	10-21-71	---	1,980	1,883	66,796	649	---	4,970	107,949	---	184,227	12,700	1.112	---	---	196,078	7.1
19.32.31.110 <sup>2</sup> / <sub>4</sub>	Middleton Federal 8 1	Seven Rivers-Capitan	2,923 <sup>2</sup> / <sub>2,957</sub>	9-26-63	9.2	1,032	537	8,530	357	---	3,430	13,210	---	27,200	4,668	1.024	---	---	---	7.8
31.110	do.	do.	2,923 <sup>2</sup> / <sub>2,957</sub>	10-26-66	---	1,200	446	7,810	460	0	3,650 <sup>9</sup> / <sub>4</sub>	12,500 <sup>9</sup> / <sub>4</sub>	---	25,800	4,830	1.017	48	36,100	6.8	
31.110 <sup>2</sup> / <sub>4</sub>	do.	do.	2,923 <sup>2</sup> / <sub>2,957</sub>	10-26-66	---	1,095	933	7,950	389	---	454 <sup>9</sup> / <sub>4</sub>	17,900 <sup>9</sup> / <sub>4</sub>	---	28,740	---	1.020	---	---	---	7.5
21.34.23.310 <sup>2</sup> / <sub>4</sub>	South Wilson Deep Unit 1	Capitan	4,169-4,187	10-25-66	---	---	---	---	---	---	---	5,920	---	---	---	1.012	---	---	---	---
23.310	do.	do.	4,169-4,187	10-25-66	---	1,040	302	3,190	480	0	2,820	5,250	---	12,800	3,830	1.008	22.0	18,300	6.7	
23.35.28.120 <sup>1</sup> / <sub>4</sub>	North Custer Mountain Unit 1	do.	4,470-4,507	10-12-66	---	---	---	---	---	---	---	23,200	---	---	---	1.029	---	---	59,500	6.4
28.120 <sup>1</sup> / <sub>4</sub>	do.	do.	4,470-4,507	10-12-66	---	1,500	1,270	11,370	488	---	465	23,900	---	---	---	1.034	---	---	---	---
24.36.20.210 <sup>1</sup> / <sub>4</sub>	Federal Davison 1	do.	1,073 <sup>468</sup> / <sub>468</sub>	11-4-66	---	---	---	---	---	---	---	157,000	---	---	---	1.173	---	---	215,000	---
20.210 <sup>1</sup> / <sub>4</sub>	do.	do.	2,134 <sup>468</sup> / <sub>468</sub>	11-4-66	---	---	---	---	---	---	---	160,000	---	---	---	1.177	---	---	219,000	8.0
20.210 <sup>1</sup> / <sub>4</sub>	do.	do.	4,000 <sup>468</sup> / <sub>468</sub>	11-4-66	---	---	---	---	---	---	---	161,000	---	---	---	1.176	---	---	219,000	8.2
20.210 <sup>1</sup> / <sub>4</sub>	do.	do.	5,500 <sup>468</sup> / <sub>468</sub>	11-4-66	---	---	---	---	---	---	---	160,000	---	---	---	1.179	---	---	220,000	8.3
20.210 <sup>1</sup> / <sub>4</sub>	do.	do.	1,500 <sup>468</sup> / <sub>468</sub>	11-15-72	---	820	1,592	66,389	288	14	6,215	103,688	---	173,468	---	1.109	---	---	---	8.7
26.36.4.230 <sup>1</sup> / <sub>4</sub>	Southwest Jal Unit 1	do.	4,199-4,695	6-14-66	---	---	---	---	---	---	---	82,500	---	---	---	1.106	---	---	168,000	---

1/ Water does not represent formation fluid.  
2/ Commercial service laboratory analysis.  
3/ Density of oil at top of fluid column is 0.818 at 17.5°C.  
4/ Spot samples in fluid column.  
5/ Plugged-back production interval 640-906.  
6/ Producing interval 290-319.  
7/ Producing interval 2,728-3,239.  
8/ Producing interval 2,728-3,239.  
9/ Difference in chloride and sulfate due to determination by different methods.  
10/ Producing interval 2,709-2,515.  
11/ Producing interval 1,538-1,936.  
12/ Density of oil at top of fluid column is 0.796 at 20°C.

Note: (Wells are listed in order of increasing distance from Carlsbad, N. Mex. along trace of the Capitan aquifer. Analyses are by U.S. Geological Survey unless otherwise indicated. Chemical constituents are in milligrams per liter.)

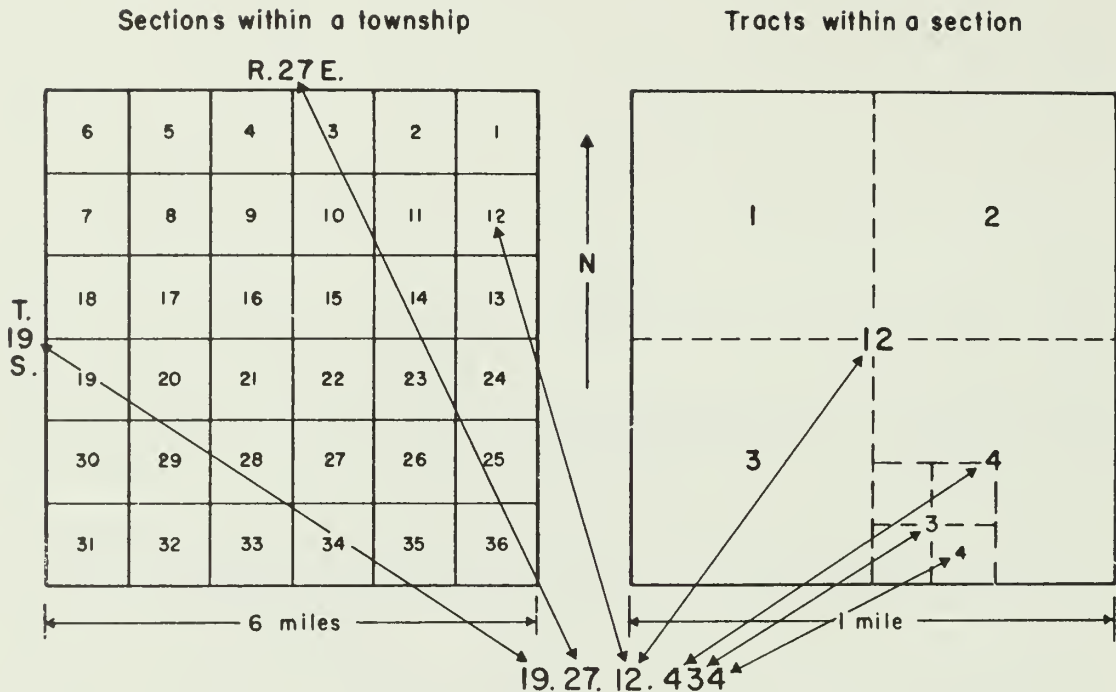


Figure 7.--Diagram showing system used in table 2 to number wells in New Mexico.

as illustrated in figure 7. If a well has not been located closely enough to be placed within a particular section or tract, a zero is used for that part of the number.

#### Adjustment of Water Levels for Variation in Specific Gravity

Differing amounts of acid and water with characteristics unlike the formation water were injected into six of the observation wells during well-testing and well-development operations. All of the injected fluid was not recovered from the Humble State 1, Hackberry Deep Unit 1, North Custer Mountain Unit 1, and Southwest Jal Unit 1 observation wells. The load water was not removed from the Federal Davison 1 well. The average specific gravity of the water comprising the fluid column in the 12 observation wells ranges from 1.010 in the South Wilson Deep Unit 1 well to 1.109 in the Federal Davison 1 well and is often not representative of the specific gravity of Capitan aquifer water mapped in reports by Hiss (1970) and Hiss, Peterson, and Ramsey (1969). However, representative formation water levels can easily be computed for the wells containing nonrepresentative fluid. Water levels measured in the observation wells must also be referenced to a common datum and to a fluid of common specific gravity before regional comparisons of head can be made. The potentiometric surface in the Capitan aquifer observation wells was computed using water with a specific gravity of 1.0 (fresh water) and with sea level as a reference datum. Methods of determining hydraulic head in ground-water systems containing formation water of varying specific gravities have been discussed by Lusczynski (1961).

The physical setting and variables used in computing the fresh-water head (defined by Lusczynski, 1961, p. 4247, as the "water level in a well filled with fresh water from that point [sea level] to a level high enough to balance the existing pressure at the point [sea level]") are diagrammed on figure 8. The procedures described below were followed in computing the potentiometric surface shown on figure 3.

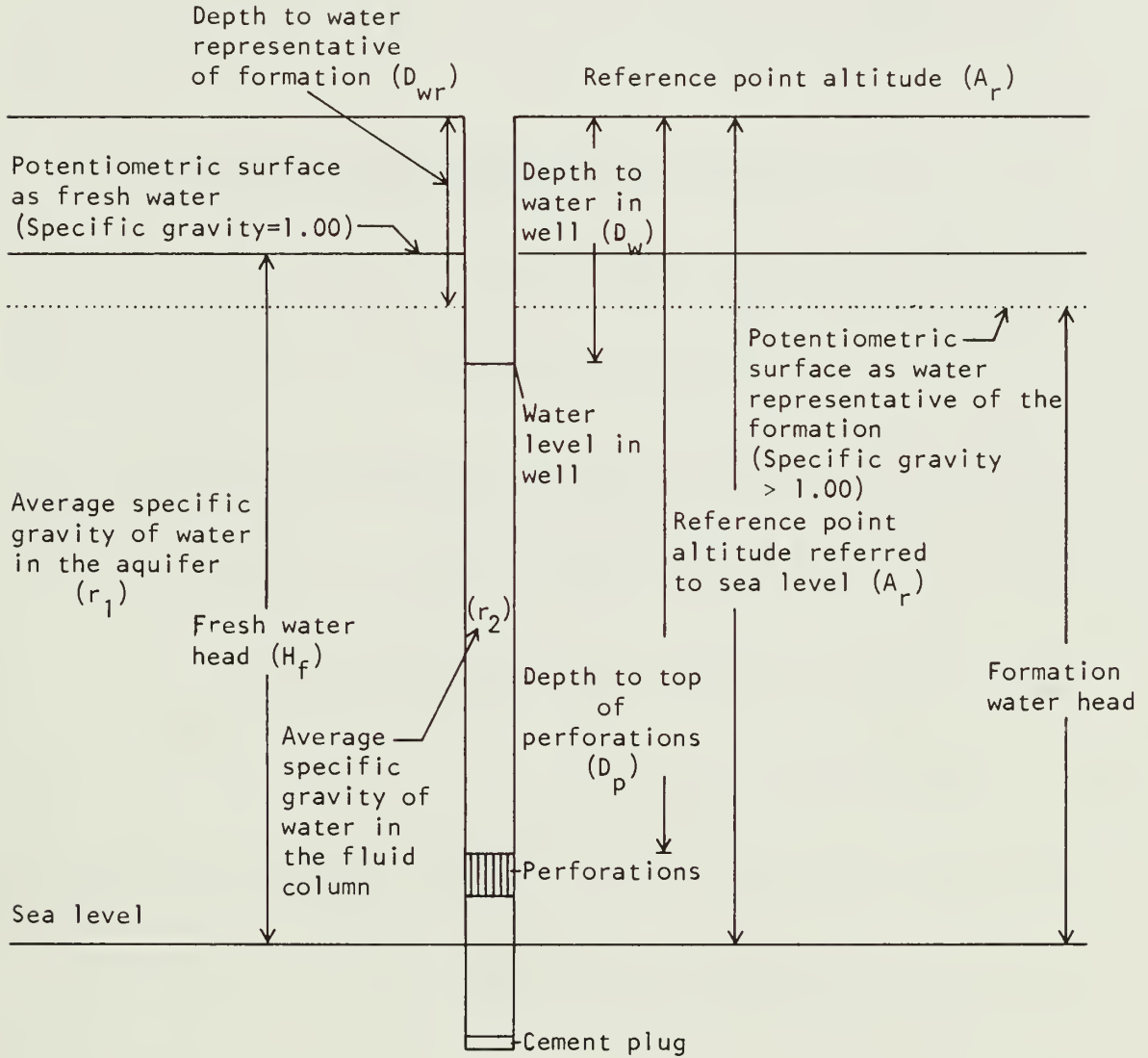


Figure 8.--Schematic diagram with variables used to compute fresh-water head in a well.



The average specific gravity of the water in the fluid column,  $r_2$ , is computed from analyses of samples taken at different depths in the well casing (table 2). The level of water in the fluid column is controlled by the formation-water head, which is computed from the top of the perforations in the well. The average specific gravity of the formation water ( $r_1$ ) can be visually extrapolated from data in table 2 and from figure 7 of the report by Hiss (1970). The balance between the actual and formation-water columns of fluid can then be computed with the following equation:

$$r_1(D_p - D_{wr}) = r_2(D_p - D_w) \quad (1)$$

where  $r_1$  = average specific gravity representative of water contained in the aquifer between the perforations and the sea-level datum, in feet

$r_2$  = average specific gravity of water in fluid column, in feet

$D_p$  = depth to top of perforated section from the reference point, in feet

$D_{wr}$  = depth to potentiometric surface of representative formation water measured from the reference point, in feet

$D_w$  = depth to nonrepresentative water in well measured from the reference point, in feet

The depth to representative formation water from the reference point is then obtained by solving equation (1) for  $D_{wr}$ :

$$D_{wr} = D_p - \frac{r_2}{r_1}(D_p - D_w) \quad (2)$$

The formation-water head can be computed easily by subtracting the depth to formation water ( $D_{wr}$ ) from the reference altitude ( $A_r$ ).

The formation-water head can then be converted to fresh-water head by using the following formula:

$$H_f = r_1(A_r - D_{wr}) \quad (3)$$

where  $A_r$  = reference altitude above mean sea level which, in this case, is equal to the surface altitude, in feet

$H_f$  = fresh-water head (specific gravity of water = 1.00), in feet

Substituting  $D_{wr}$  from equation (2) into equation (3) gives:

$$H_f = r_1(A_r - D_p) + r_2(D_p - D_w) \quad (4)$$

The fractional amount of head calculated in equation (4) by multiplying the distance from the sea-level datum ( $A_r - D_p$ ) by the average specific gravity of representative formation water ( $r_1$ ) is used to adjust the point head measurement to sea level.

Equation (4) is the general expression used to convert observed water levels to fresh-water head in the Capitan aquifer observation-well network. Table 3 contains data used to compute fresh-water head in the observation wells.

#### Water-Level Corrections for the Yates State 1 and Hackberry Deep Unit 1 Observation Wells

The levels of fluid in the Yates State 1, and Hackberry Deep Unit 1 wells are affected by small quantities of oil that have been gradually seeping into the wells. Depths to fluid measured in each well have been adjusted to reflect depths to the top of a fluid column composed only of water by following the procedures outlined below.

The depths to both the top of the oil and water in each borehole are measured with a steel tape. The water-oil interface is detected by coating the lower part of the tape with a chemical that changes color in a reaction to water. The physical problem is diagrammed in figure 9. Variables employed in the calculation of the corrected fluid level are:

$r_w$  = specific gravity of water in the fluid column

$r_o$  = specific gravity of oil in the fluid column

$D_w$  = depth to water, in feet

$D_o$  = depth to the upper surface of the oil at the top  
of the fluid column, in feet

$D_{wc}$  = corrected depth to top of a fluid column composed of water only, in feet

$c$  = correction added to depth measurement ( $D_o$ ) to  
compute the corrected depth measurement ( $D_{wc}$ ),  
in feet

In the following equation, an oil column with specific gravity  $r_o$  is balanced with a column of the water with specific gravity  $r_w$ :

$$r_o(D_w - D_o) = r_w(D_w - D_{wc}) \quad (5)$$

The depth to the top of the fluid, ( $D_o$ ), is measured by the water-level recorder. A value "c" added to  $D_o$  gives the corrected depth to the top of the fluid in the well bore ( $D_{wc}$ ):

Table 3.--Data used to compute fresh-water head in Capitan aquifer observation wells

Observation wells	Average specific gravity of water in fluid column	Depth to uppermost perforation adjusted to the land surface datum (feet)	Depth to water to Jan. 1, 1970 (feet)	Altitude of land surface (feet above mean sea level)	Average specific gravity of representative formation water	Altitude of fresh-water head (feet above mean sea level)
City of Carlsbad Well 10	1.000 <sup>1/</sup>	open-hole completion	398	3,501.70	1.014	3,147
City of Carlsbad Well 13	1.000	289	20	3,121.84	1.014	3,137
North Cedar Hills Unit 1	1.020	990	195	3,280.0	1.018	3,144
Humble State 1	1.032	1,538	162	3,230.2	1.018	3,145
City of Carlsbad Test Well 3	1.012	630	94	3,181.71	1.018	3,137
Yates State 1	1.023	2,223	303 <sup>2/</sup>	3,365.0	1.018	3,129
Hackberry Deep Unit 1	1.115	3,726	624 <sup>2/</sup>	3,397.0	1.018	3,124
Middleton Federal B 1	1.020	2,913	557	3,518.0	1.016	3,012
South Wilson Deep Unit 1	1.010	4,169	1,064	3,717.0	1.010	2,675
North Custer Mountain Unit 1	1.030	4,451	878	3,387.0	1.008	2,606
Federal Davison 1	1.109	4,252	1,124	3,355.0	1.005	2,567
Southwest Jal Unit 1	1.106	4,199	786	2,985.0	1.005	2,556

<sup>1/</sup> Estimated<sup>2/</sup> Adjusted for oil at top of water column



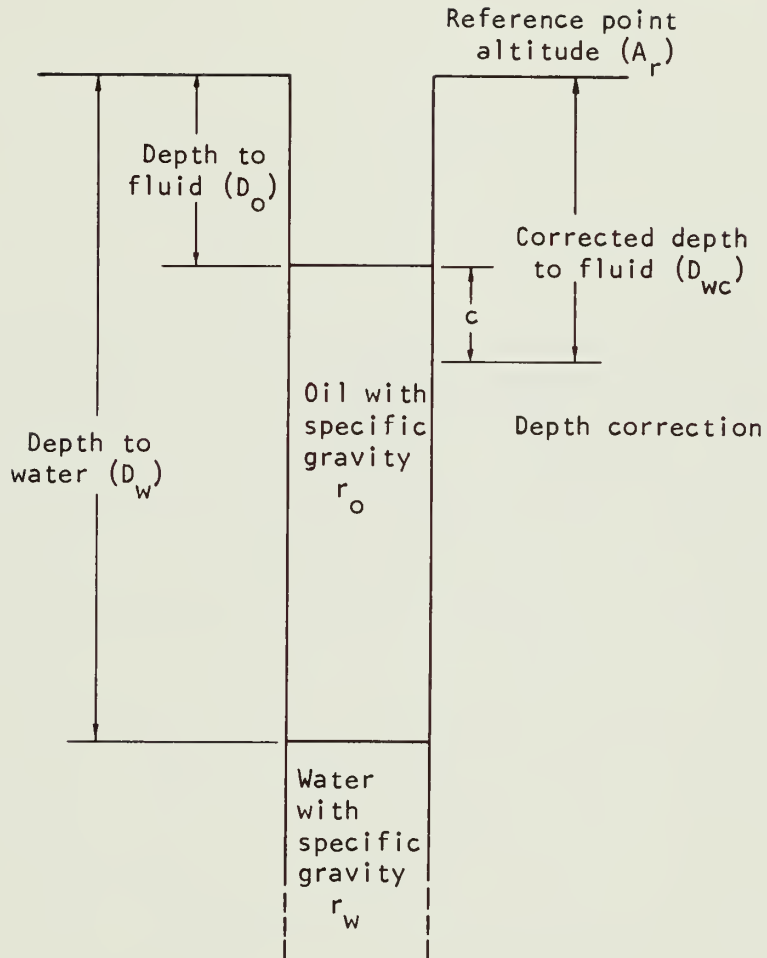


Figure 9.--Oil-water relationship in the Yates State 1 and Hackberry Deep Unit 1 observation wells.

$$D_{wc} = D_o + c \quad (6)$$

After algebraically adding  $D_w$  to each side and transposing terms, equation (6) becomes:

$$D_w - D_o - c = D_w - D_{wc}$$

Substituting in equation (5) gives:

$$r_o(D_w - D_o) = r_w(D_w - D_o - c) \quad (7)$$

Solving equation (7) for "c" gives:

$$c = (D_w - D_o) - r_o/r_w(D_w - D_o)$$

or

$$c = (D_w - D_o)(1 - r_o/r_w) \quad (8)$$

and the corrected depth to water therefore becomes:

$$D_{wc} = D_o + (D_w - D_o)(1 - r_o/r_w) \quad (9)$$

The depth to the oil-water interface in the Yates State 1 observation well was measured approximately once each month after the oil seepage was first noted in January 1969. A cast iron bridge plug was set in the casing in December 1971 to prevent further oil seepage into the borehole (Appendix M). During the period January 1969 to October 1971 the oil influx rate has been uniform. Based on this information, the correction factor has been extrapolated linearly between measurements and applied to water levels measured from 1967 to the present date (figs. 6 and 10). Specific gravities of oil and water employed in computing the corrected depth-to-water measurements for the Yates State 1 well were 0.818 and 1.023, respectively (tables 2 and 3).

Oil was first noted to be seeping into the Hackberry Deep Unit 1 observation well in September 1971. The rate of influx of oil into the well up to this time was not measured. However, inspection of the uncorrected hydrograph in figure 6 strongly suggests that oil first began to seep into the well during the later part of September 1969. The corrected water-level values shown in the hydrograph in figure 6 were computed using a linear correction for a constant rate of oil influx (fig. 11). Specific gravities of 0.796 and 1.115 (Tables 2 and 3) for oil and water, respectively, were used in computing the adjustments. The trend of the adjusted hydrograph is an extension of the trend established during the first 32 months of record and is subparallel to the hydrograph for the Middleton Federal B 1 observation well located approximately 6 miles to the east. The assumed linearity of oil influx from September 1969 to October 1971 thus appears to be valid.

Measurements of the oil-water and oil-air interfaces for a period of approximately one year after the removal of the oil in the Hackberry Deep Unit 1 observation well during October 1971 indicate the rate of oil influx into the well is probably slightly nonlinear (fig. 11). The correction factor applied to the water-level measurements after October 1971, therefore, is computed by utilizing a point-to-point averaging method, rather than linear extrapolation. The specific gravities for the oil and water in the observation well remain the same as before the October 1971 workover operations.

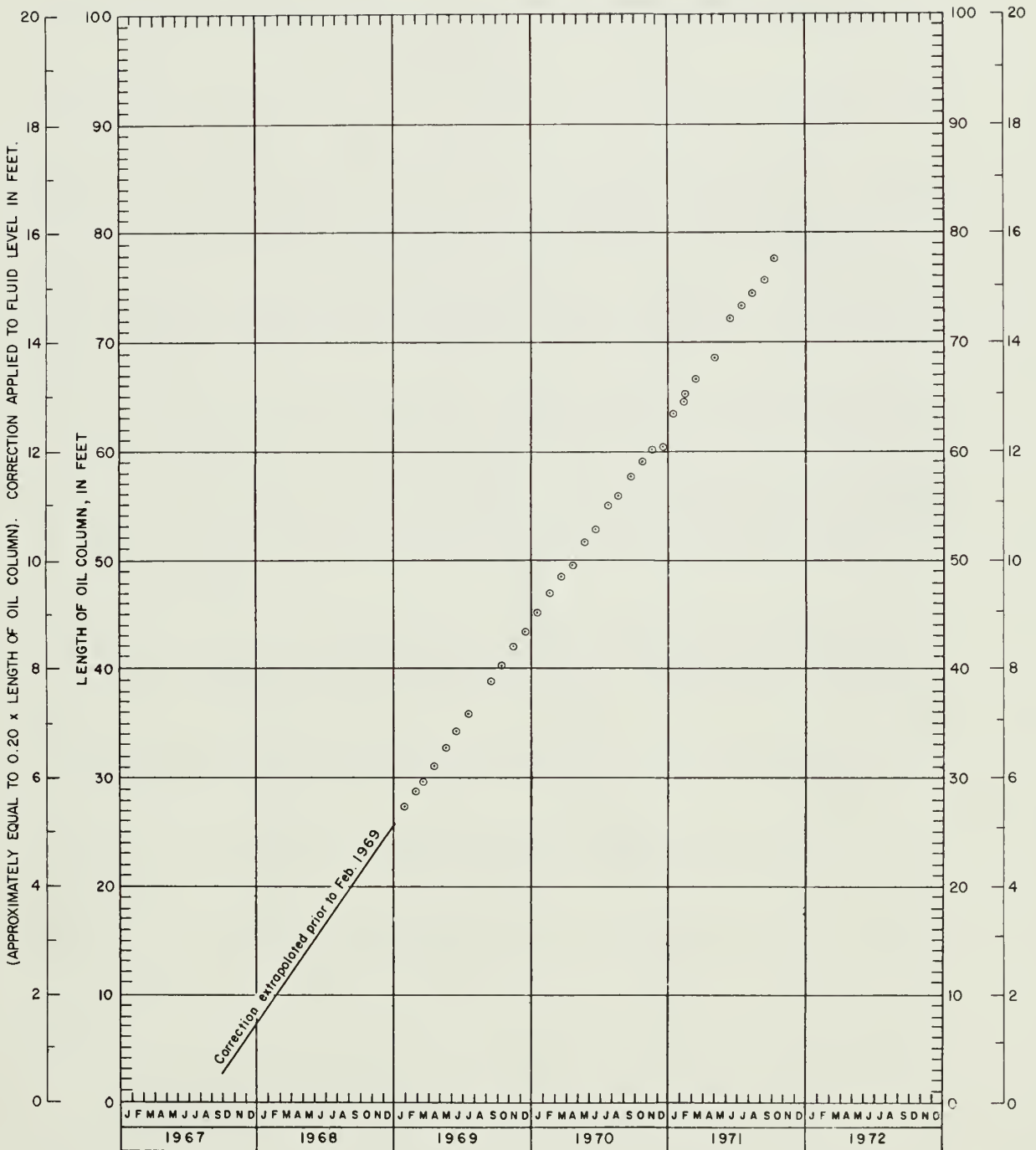


Figure 10.--Length of oil column and corresponding fluid-level corrections for the Yates State 1 observation well, Eddy County, New Mexico.

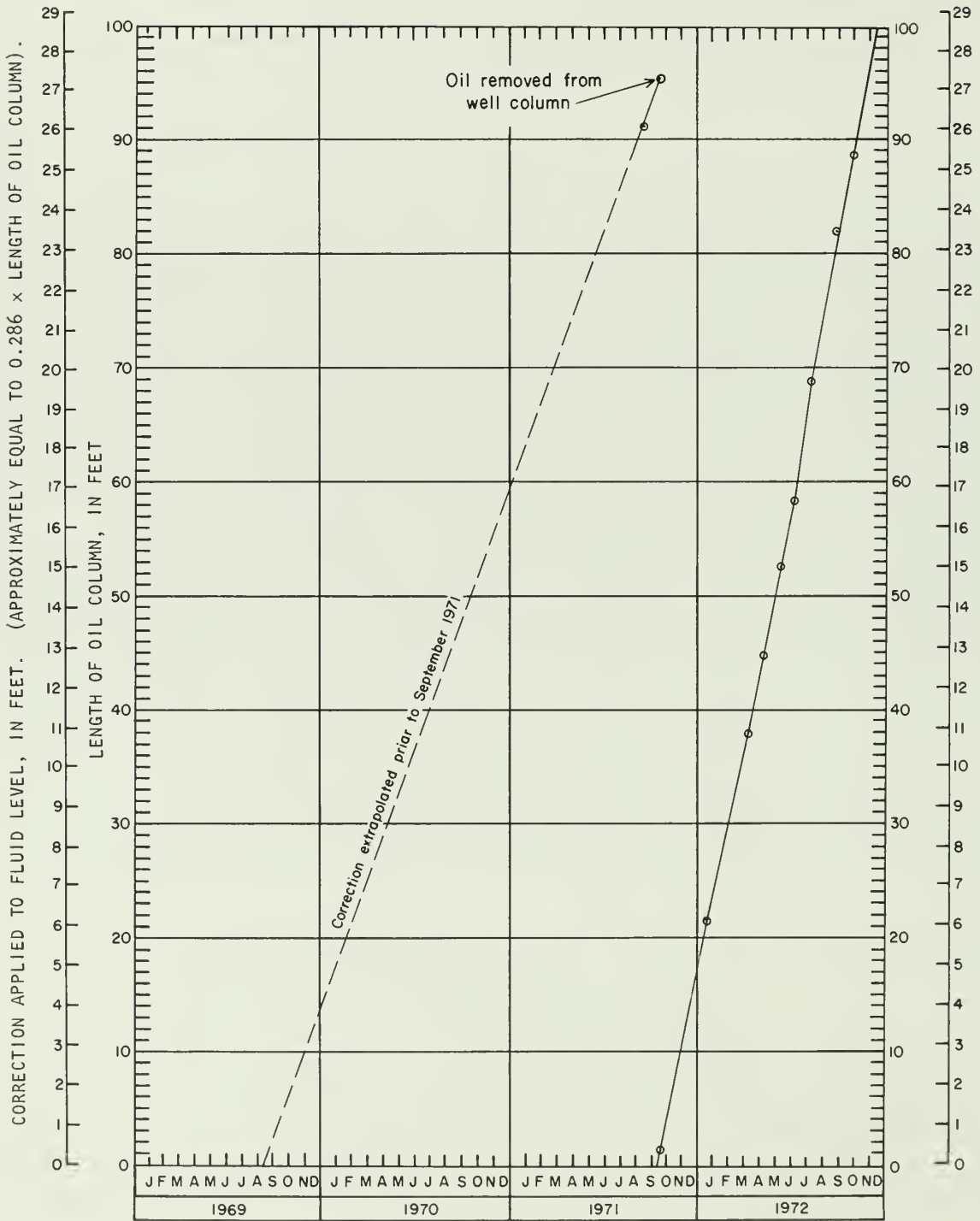


Figure 11.--Length of oil column and corresponding fluid-level corrections for the Hackberry Deep Unit 1 observation well, Eddy County, New Mexico.

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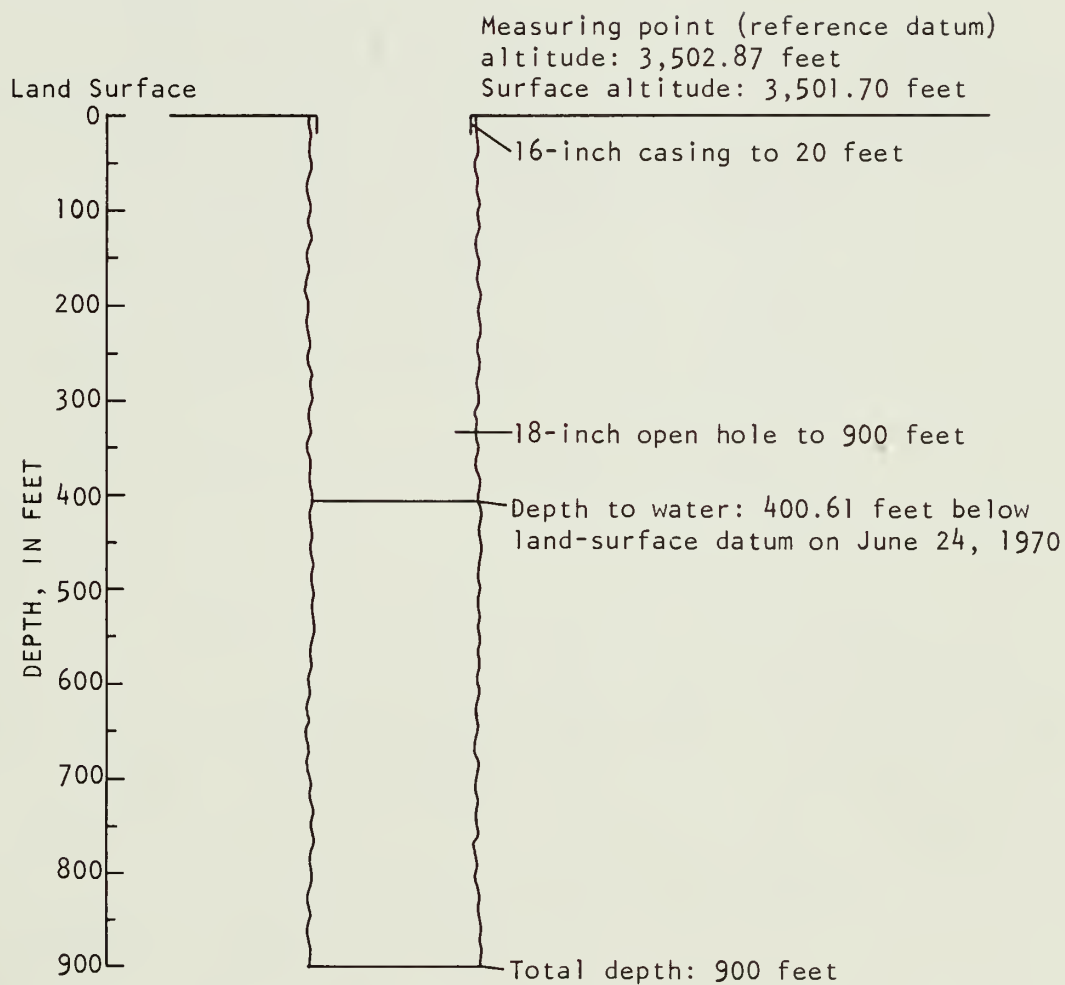
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APPENDIXES



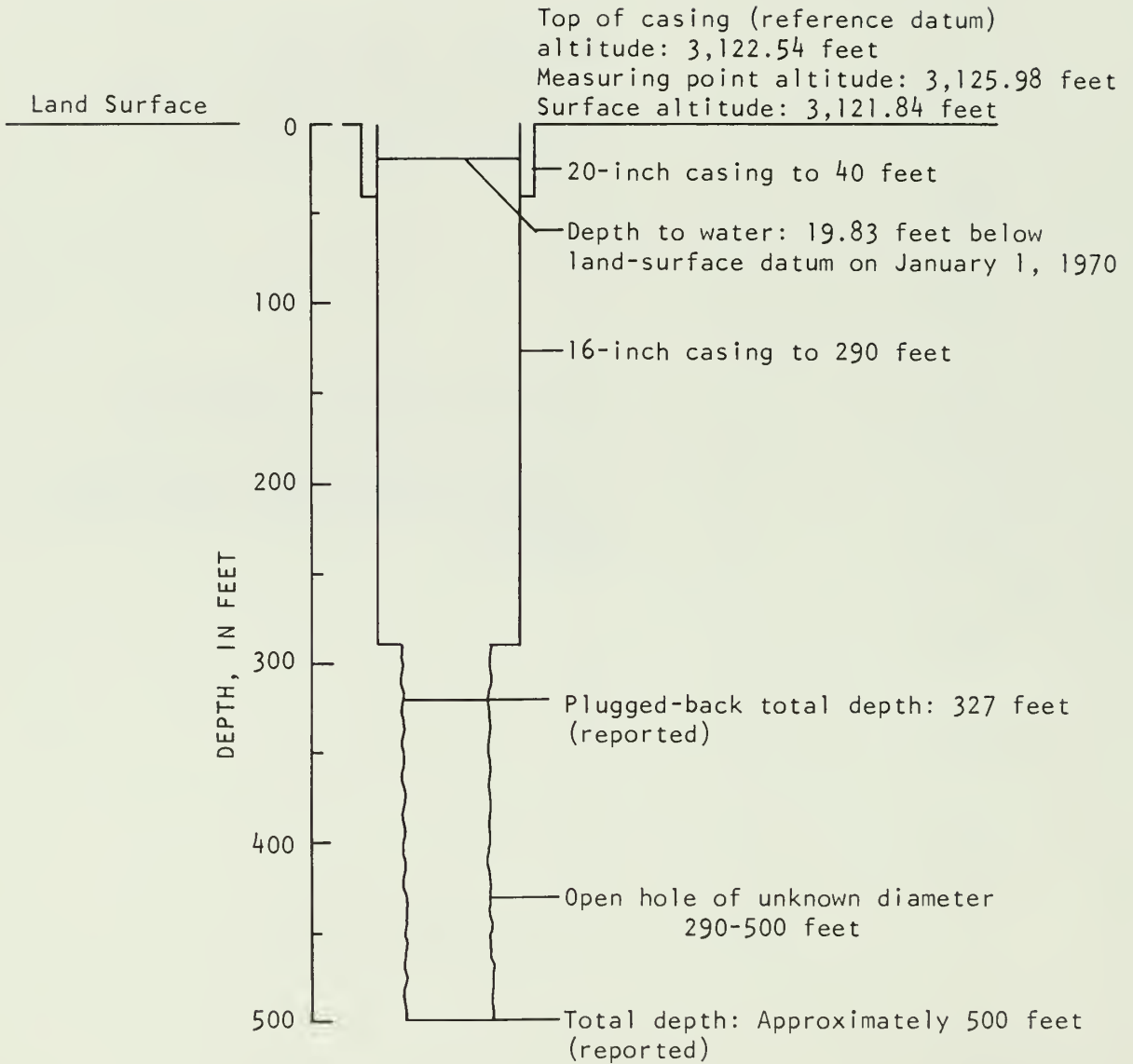
City of Carlsbad Well 10



Appendix A.--Well-construction details for City of Carlsbad Well 10

(Dark Canyon Well 1), SW $\frac{1}{4}$ NW $\frac{1}{4}$ NE $\frac{1}{4}$  sec. 24, T. 23 S., R. 25 E.,  
Eddy County, New Mexico.

City of Carlsbad Well 13

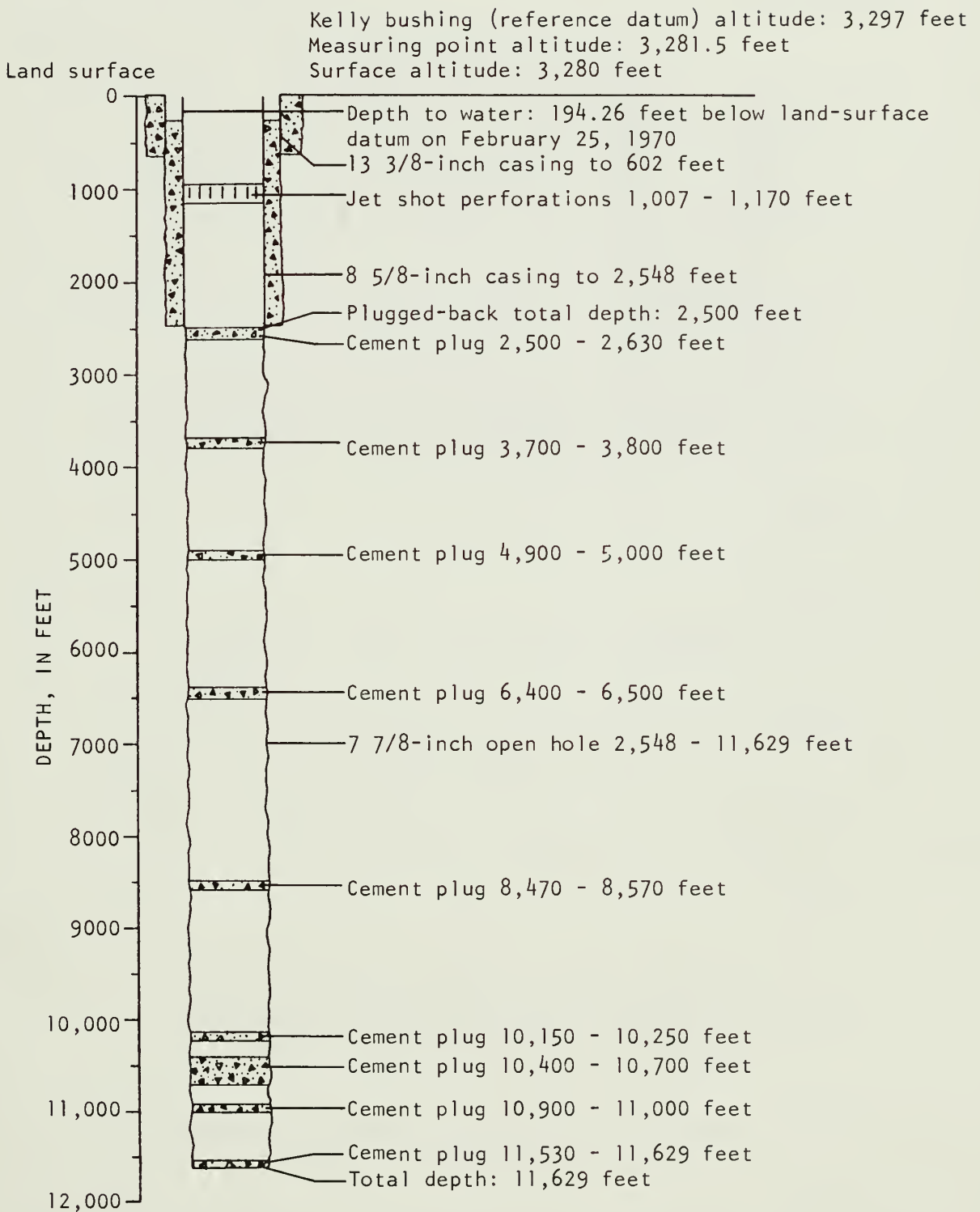


Appendix B.--Well-construction details for City of Carlsbad

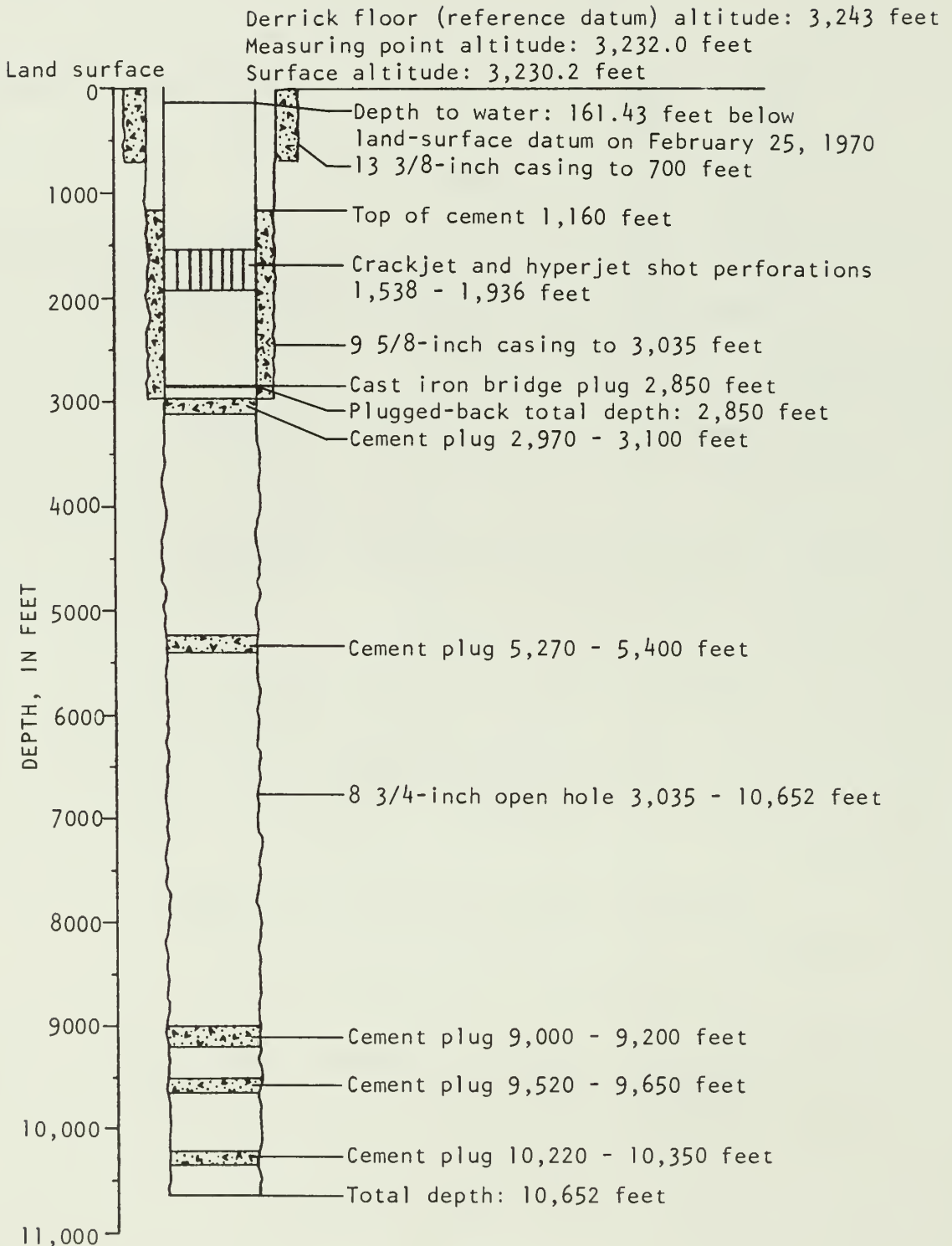
Well 13 (La Huerta East Well), NW $\frac{1}{4}$ NE $\frac{1}{4}$ NE $\frac{1}{4}$  sec. 36,

T. 21 S., R. 26 E., Eddy County, New Mexico.

North Cedar Hills Unit 1

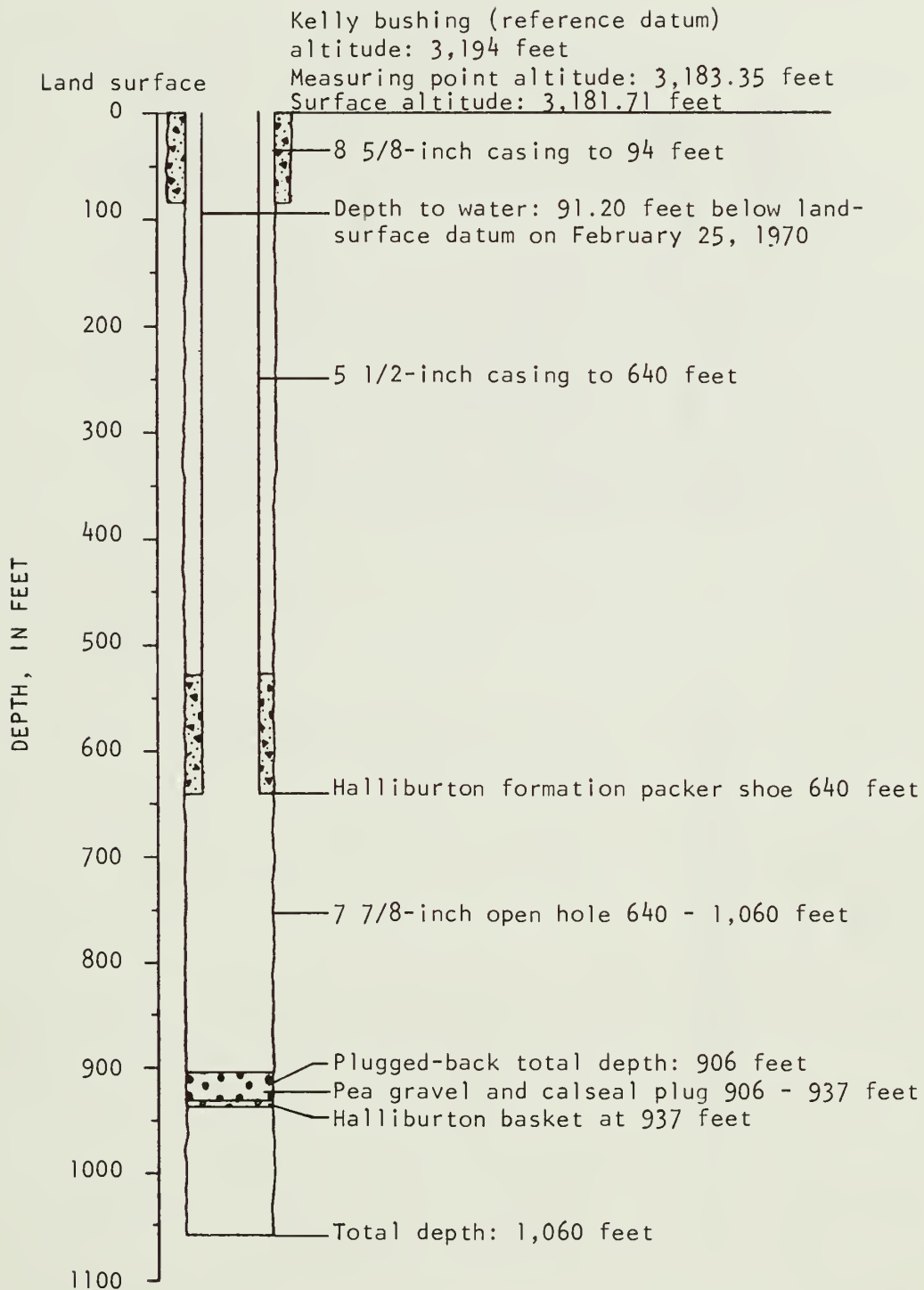


Appendix C. --Well-construction details for North Cedar Hills Unit 1, 1,993 feet from east line and 3,060 feet from north line of sec. 5, T. 21 S., R. 27 E., Eddy County, New Mexico.

Humble State 1

Appendix D.--Well-construction details for Humble State 1, 660 feet from south line and 660 feet from west line of sec. 23, T. 21 S., R. 27 E., Eddy County, New Mexico.

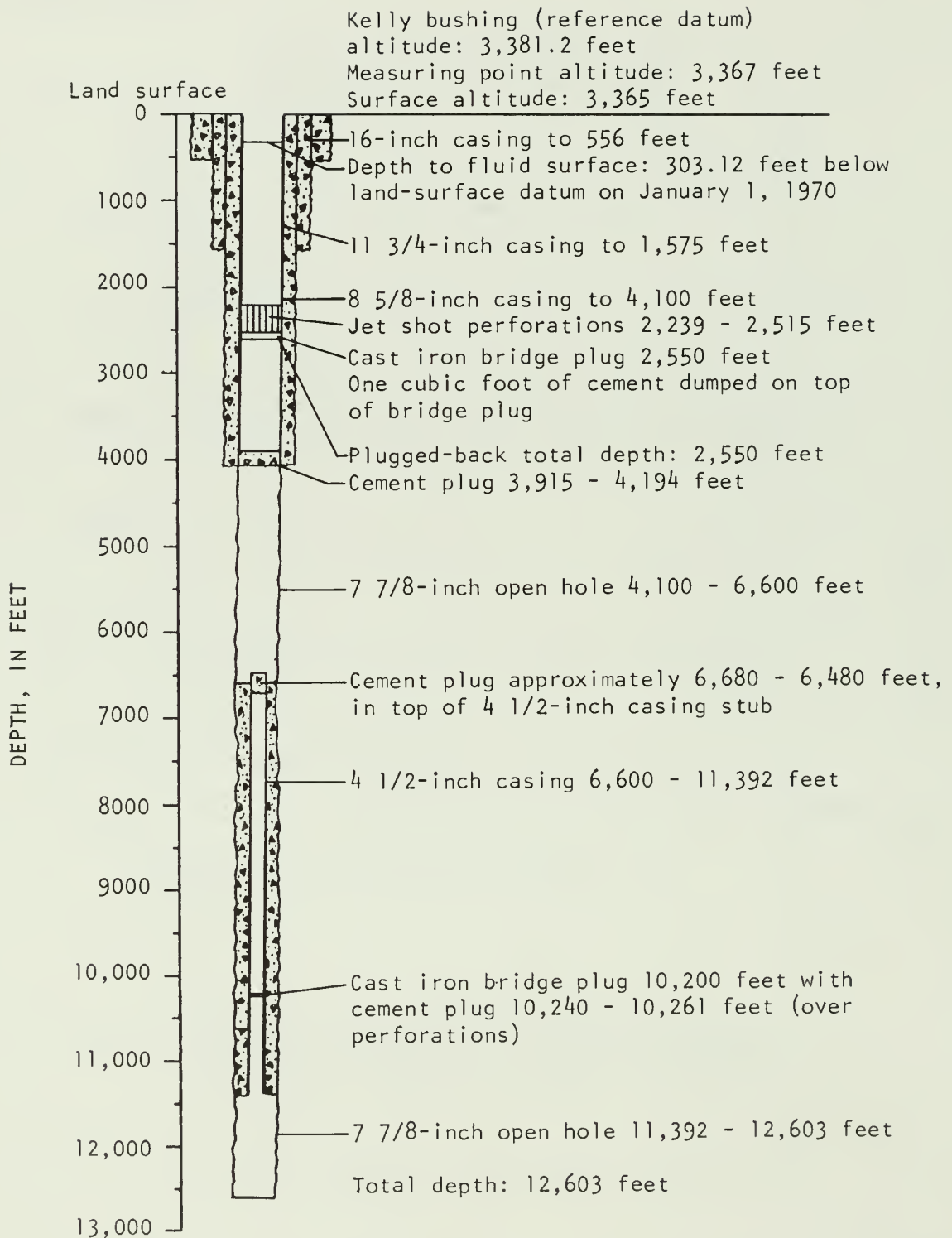
City of Carlsbad Test Well 3



Appendix E.--Well-construction details for City of Carlsbad Test Well 3  
(Miller Nix-Yates Federal 1), 1,650 feet from north line  
and 1,650 feet from west line of sec. 30, T. 21 S.,  
R. 28 E., Eddy County, New Mexico.

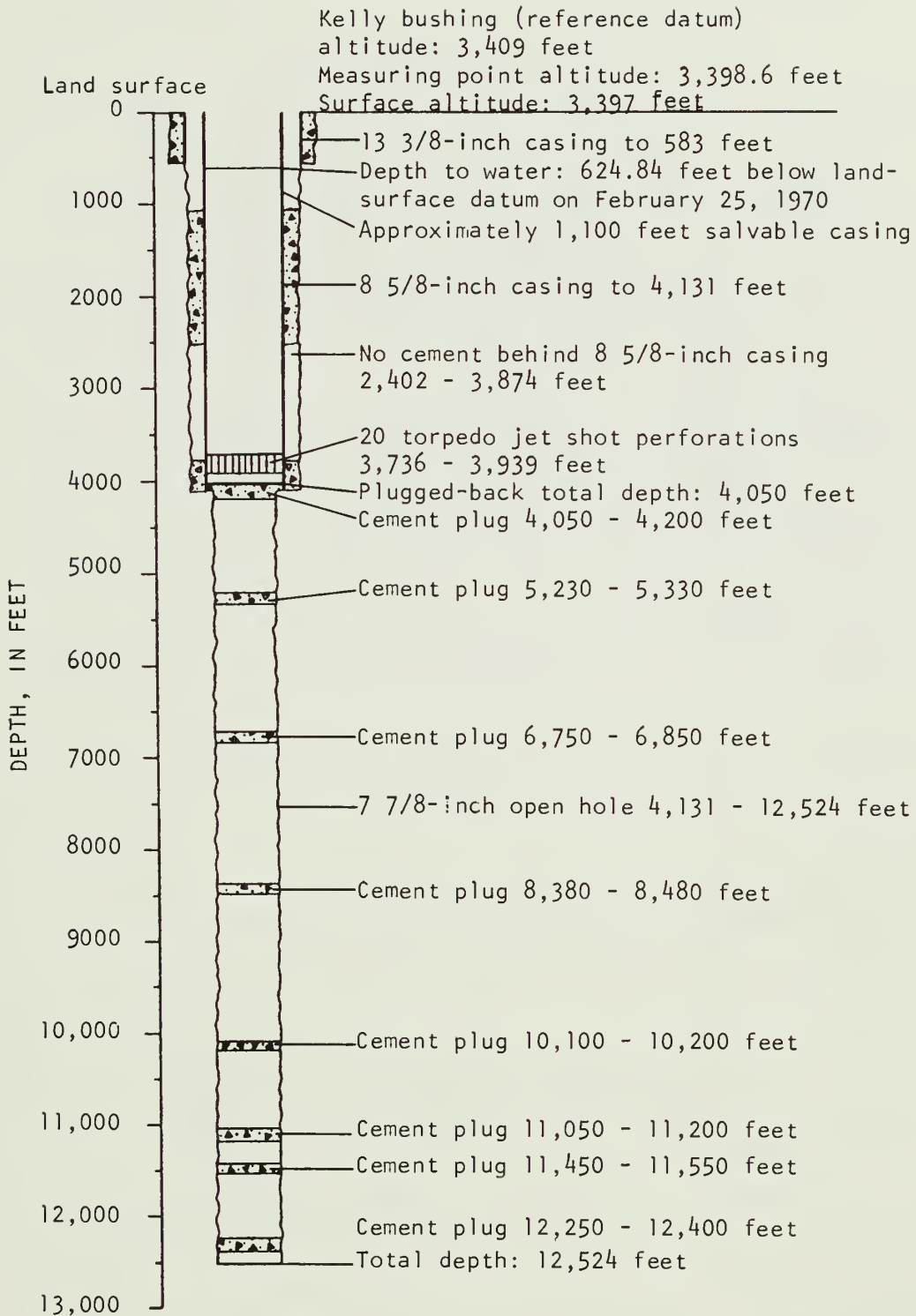


## Yates State 1



Appendix F.--Well-construction details for Yates State 1, 660 feet from south line and 1,650 feet from west line of sec. 32, T. 20 S., R. 30 E., Eddy County, New Mexico.

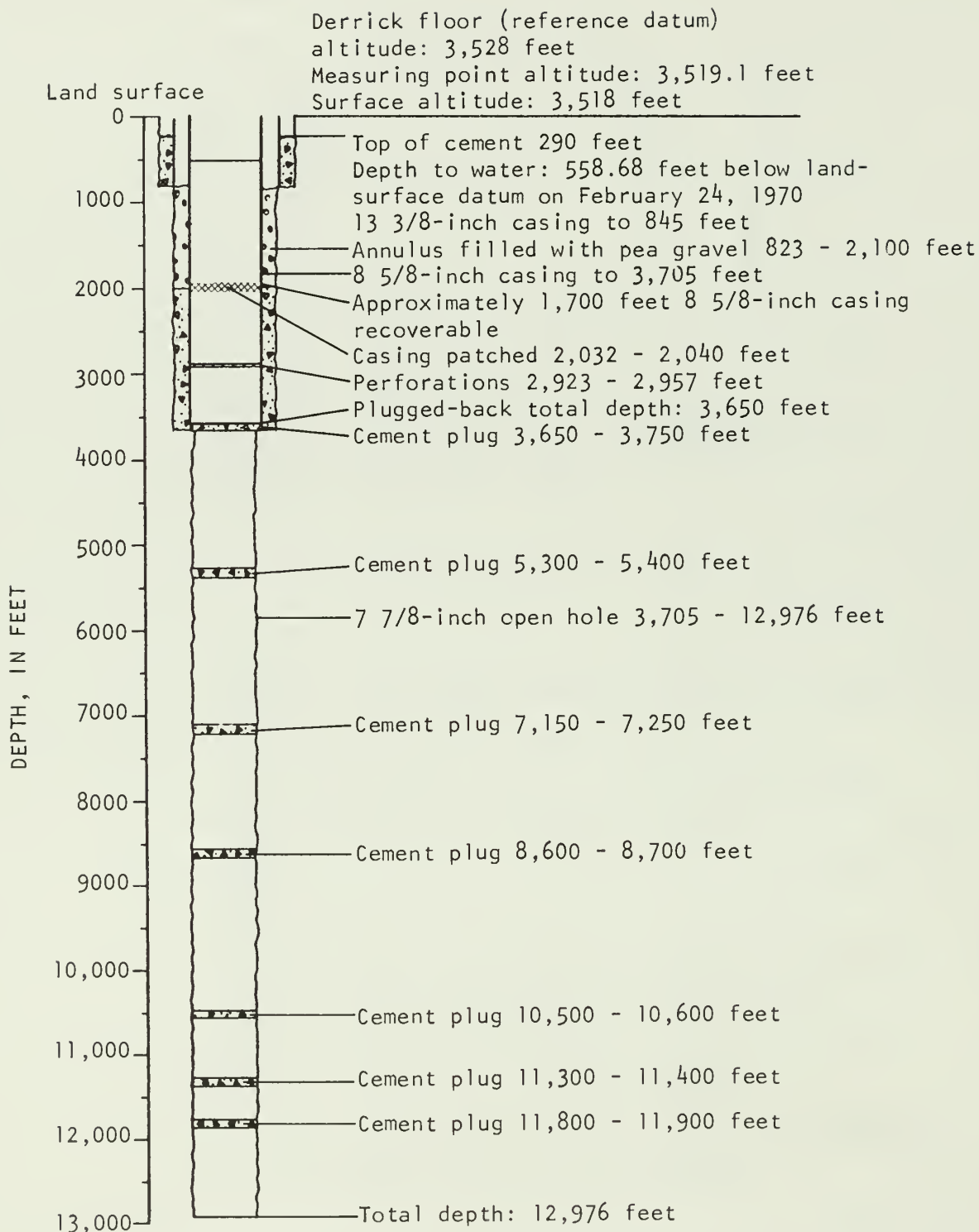
Hackberry Deep Unit 1



Appendix G.--Well-construction details for Hackberry Deep Unit 1,

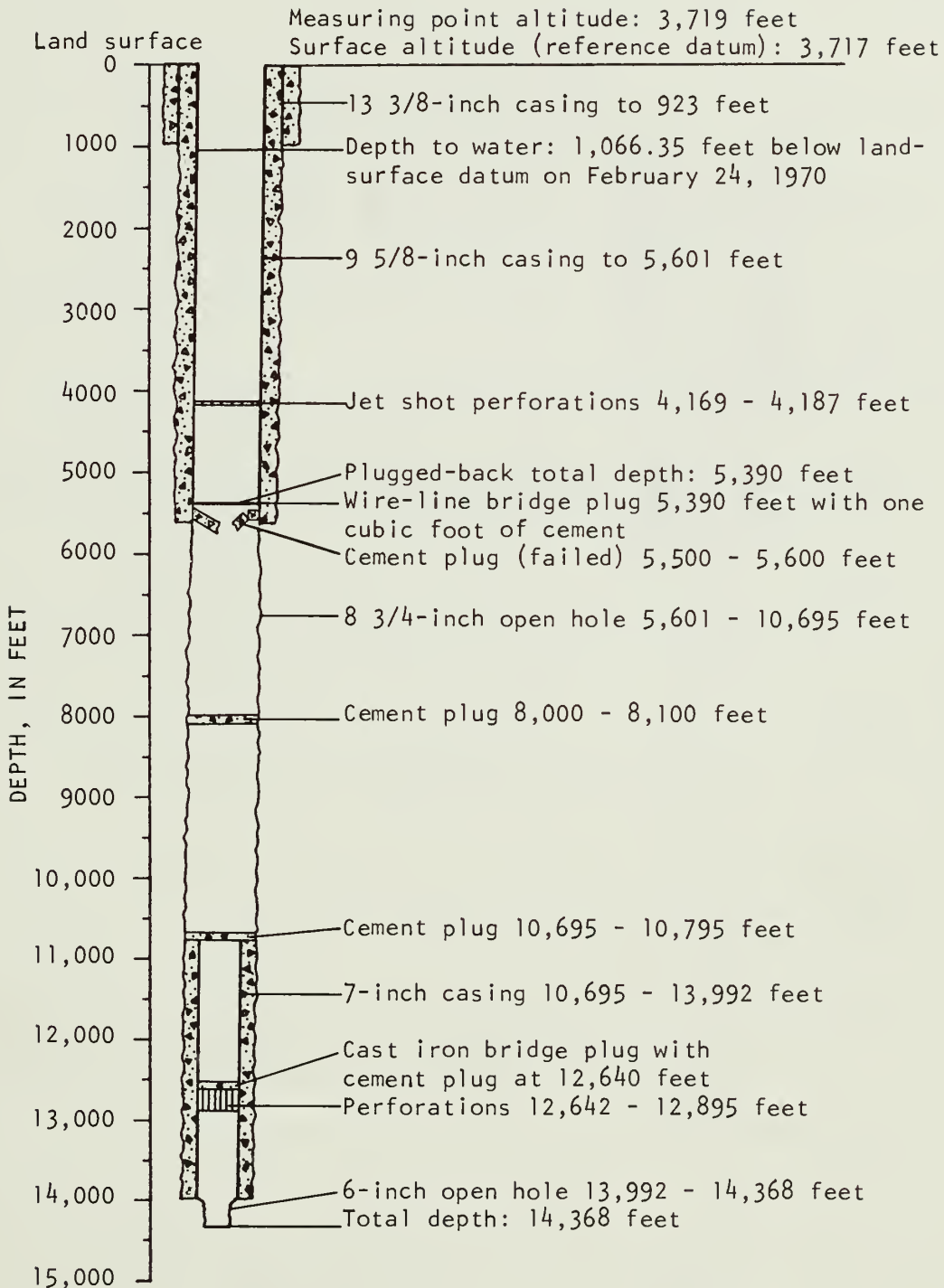
1,650 feet from north line and 990 feet from west line  
of sec. 31, T. 19 S., R. 31 E., Eddy County, New Mexico.

## Middleton Federal B 1



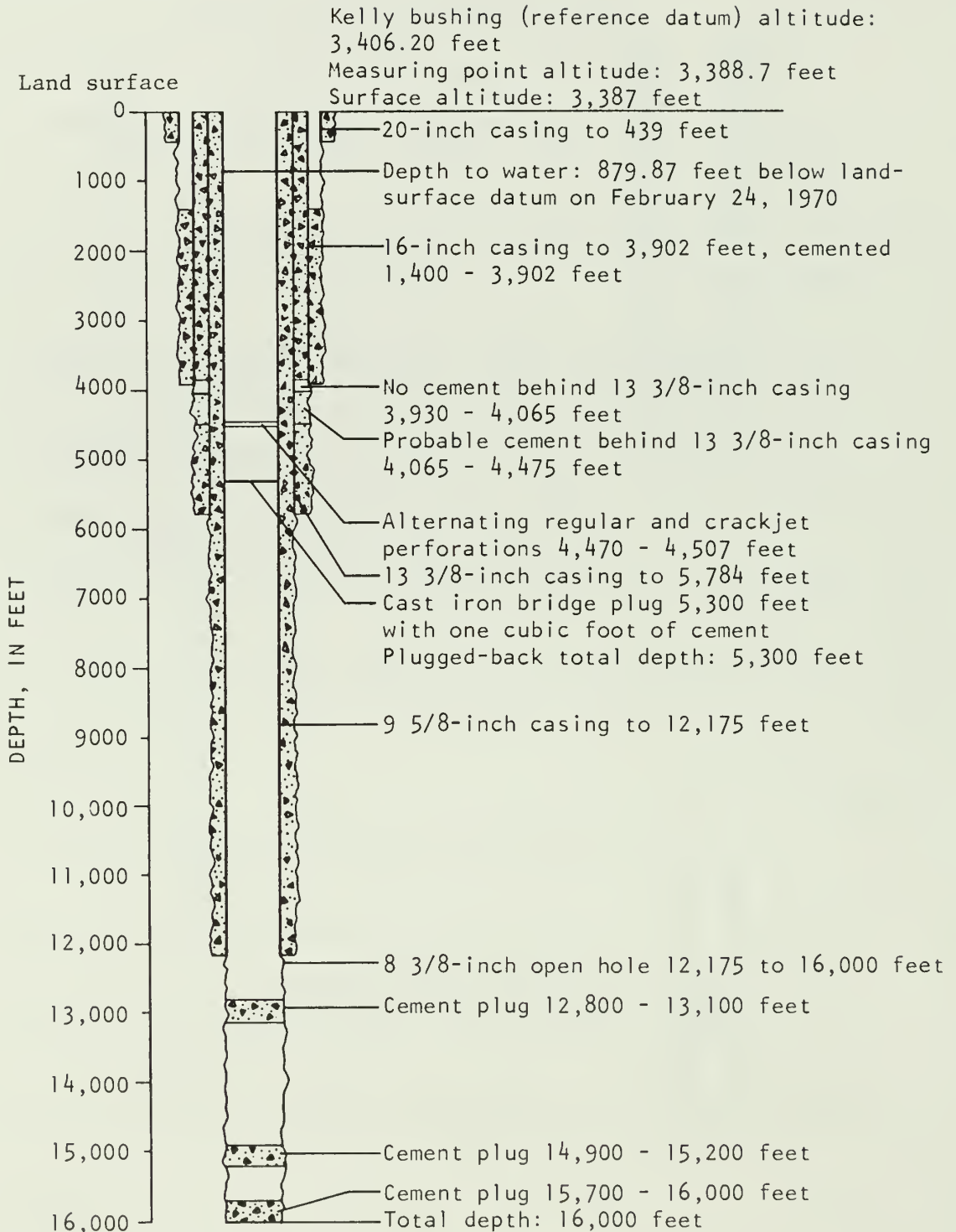
Appendix H.--Well-construction details for Middleton Federal B 1,  
660 feet from north line and 660 feet from west line  
of sec. 31, T. 19 S., R. 32 E., Lea County, New Mexico.

South Wilson Deep Unit 1



Appendix I.--Well-construction details for South Wilson Deep Unit 1, 1,980 feet from south line and 660 feet from west line of sec. 23, T. 21 S., R. 34 E., Lea County, New Mexico.

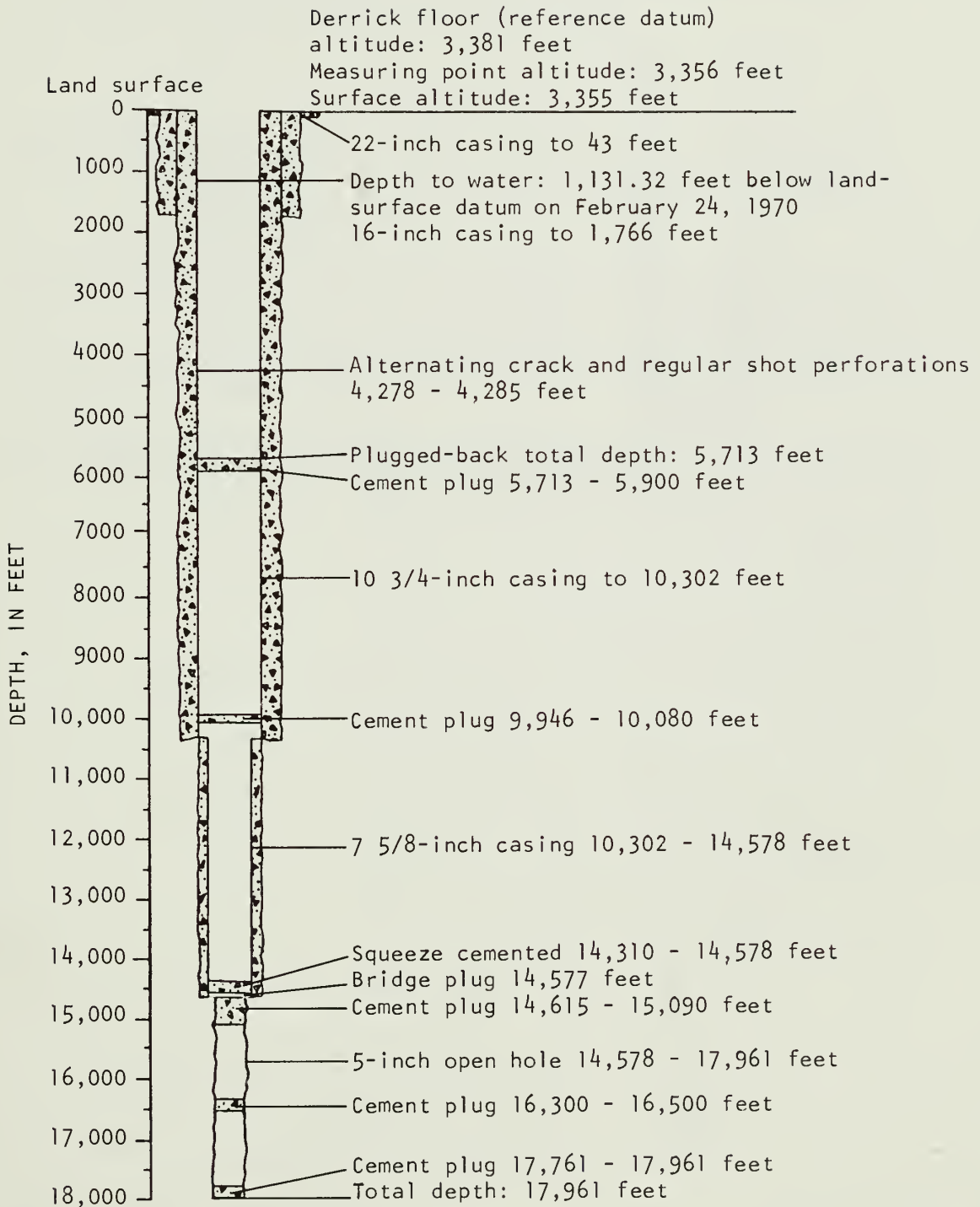
North Custer Mountain Unit 1



Appendix J.--Well-construction details for North Custer Mountain Unit 1, 660 feet from north line and 1,980 feet from west line of sec. 28, T. 23 S., R. 35 E., Lea County, New Mexico.

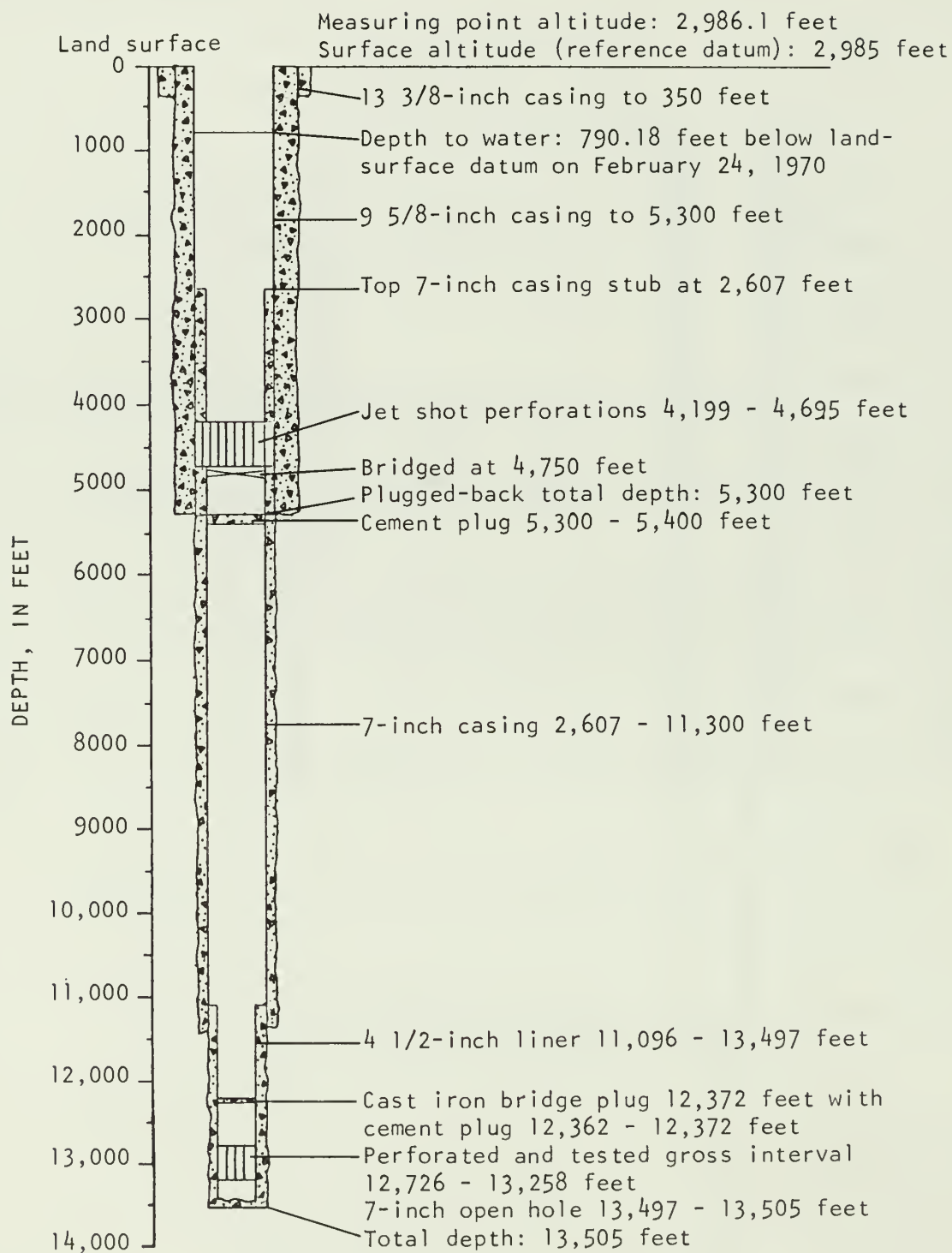


## Federal Davison 1



Appendix K.--Well-construction details for Federal Davison 1,  
660 feet from north line and 1,980 feet from east  
line of sec. 20, T. 24 S., R. 36 E., Lea County,  
New Mexico.

Southwest Jal Unit 1



Appendix L.--Well-construction details for Southwest Jal Unit 1,  
 1,980 feet from north line and 1,980 feet from east line  
 of sec. 4, T. 26 S., R. 36 E., Lea County, New Mexico.

Appendix M.--Drilling and completion records of observation  
wells in the Capitan aquifer

EXPLANATION

Location: Distance in feet from north line (FNL), from south line (FSL), from east line (FEL), or from west line (FWL) of a section in the given township (T) and range (R) or to nearest 10-acre tract.

Altitude: Feet above mean sea-level datum. Water levels are given in depth from the land-surface datum. All other depths are measured from the reference-datum altitude unless otherwise specified. Names in parentheses refer to individual oil operators.

OMNIANA Data File No.: Data sets in the computer-based data file used in the New Mexico District are identified by unique reference codes that incorporate standard identifiers recommended by the American Petroleum Institute and (or) the American National Standards Institute (Peterson and Hiss, 1970; American Petroleum Institute, 1966 and 1968; and American National Standards Institute, 1972). The word "OMNIANA" was chosen as a name for this general purpose modular data file by combining the prefix "OMNI-" meaning "all, universal, or without restriction" with the suffix "-ANA" indicating a "collection of items of information". The reference identifier is composed of the elements NN, MMM, PPP, XXXXX, and YY where NN and MMM are numbers for the state and county codes, respectively; PPP represents a code indicating the source of the unique reference number; and XXXXX and YY are the unique reference number and sidetrack number, respectively.

Latitude and longitude: Expressed in degrees and the decimal fraction of a degree.

Water rights: File number of New Mexico State Engineer Office for a limited and nontransferable water right.

Depth to water from land-surface datum: The wetted steel-tape method was generally used to determine depths to water of less than 500 feet whereas a wireline logger was employed in determining depths to water of more than 500 feet.

Appendix M.--Drilling and completion records of observation  
wells in the Capitan aquifer - Continued

Depth to water from land-surface datum: - Concluded

Depth-to-water measurements were made before and after remedial operations on an observation well and whenever a mechanical recorder failed to function properly.

Formation tops and bases: In feet below reference datum given and in feet above, +, or below, -, mean sea-level datum.

Tops and bases for formations older than the Delaware Mountain Group were picked by the operator.

Appendix M.--Drilling and completion records of observation  
wells in the Capitan aquifer - Continued

City of Carlsbad Well 10  
(Dark Canyon Well 1)

Location: SW $\frac{1}{4}$ NW $\frac{1}{4}$ NE $\frac{1}{4}$  sec. 24, T. 23 S., R. 25 E., Eddy County,  
New Mexico.

Altitude: Measuring point (reference datum) 3,502.87; ground level 3,501.70.

Latitude: 32.28910°N Longitude: 104.34660°W

OMNIANA Data File No.: 35015G000070204

Owner: City of Carlsbad

Land owner: City of Carlsbad

Surface lease holder: Unknown

Water rights: Unknown

Depth to water from land-surface datum: 401.53 ft on August 13, 1963.

Measuring-point description: Top of collar on 16-inch casing.

Date acquired by USGS: Well loaned to USGS in 1963.

Borehole geophysical logs: Gamma-ray-neutron 0-887 ft.

Casing and cement record: Approximately 20 ft of 16-in casing  
set in top of 18-in open hole.

Total depth: Reported as drilled to depth of 900 feet.

Formation tops and bases: Eroded Capitan Limestone at the surface.  
No other formations encountered.

Other owner records: Well drilled in March(?) 1958.

USGS work record: Installed water-level recorder on August 13, 1963.

Production rate: Unknown

Total water produced: Unknown

Special conditions: Well still owned by the city of Carlsbad. Also  
known as Dark Canyon Well 1.



Appendix M.--Drilling and completion records of observation  
wells in the Capitan aquifer - Continued

City of Carlsbad Well 13  
(La Huerta East Well)

Location: NW $\frac{1}{4}$ NE $\frac{1}{4}$ NE $\frac{1}{4}$  sec. 36, T. 21 S., R. 26 E., Eddy County, New Mexico.

Altitude: Ground level 3,121.84; top of casing (reference datum) 3,122.54;  
measuring point 3,125.98.

Latitude: 32.26875°N

Longitude: 104.14312°W

OMNIANA Data File No.: 35015G000070209

Owner: City of Carlsbad

Land owner: City of Carlsbad

Surface lease holder: City of Carlsbad

Water rights: Unknown

Depth to water from land-surface datum: 22.17 ft on April 17, 1962.

Measuring-point description: Top edge of recorder shelf.

Date acquired by USGS: Well loaned to USGS on April 17, 1962.

Borehole geophysical logs: Gamma-ray-neutron 0-318 ft.

Casing and cement record: 20-in casing set to depth of 40 ft.  
16-in casing set to a depth of 290 ft.

Total depth: Approximately 500 ft reported by engineer with city of Carlsbad.

Plugged-back total depth: 327 ft reported in Bjorklund and Motts (1959)  
(319 ft indicated by borehole geophysical  
log run on November 28, 1961).

Formation tops and bases: Tansill Fm. 130 (+2,992)  
Capitan Limestone 254 (+2,868)

Other owner records: Well drilled in 1951.

USGS work record: Installed water-level recorder on April 17, 1962.

Production rate: Reported to be 5,000 gpm at reported total depth;  
900 gpm at plugged-back depth of 327 ft.

Total water produced: Unknown

Special conditions: Well owned by the city of Carlsbad. Also known  
as La Huerta East Well.

Appendix M.--Drilling and completion records of observation  
wells in the Capitan aquifer - Continued

North Cedar Hills Unit 1

Location: 1,993 FEL 3,060 FNL, sec. 5, T. 21 S., R. 27 E.,  
Eddy County, New Mexico.

Altitude: Derrick floor 3,296; kelly bushing (reference datum) 3,297;  
ground level 3,280; measuring point 3,281.5.

Latitude: 32.50972°N

Longitude: 104.21388°W

Permian Basin Well Data System No: MH 10817 (temporarily assigned MH 70131).

OMNIANA Data File No.: 35015API10817

Original owners as joint operators: Humble Oil and Refining Co. (unit  
operator); Mr. Edward R. Hudson, Jr.;  
Atlantic Refining Co.; Superior Oil  
Co.; Texas Pacific Oil Co.; Yates  
Brothers; Mobil Oil Co.; Ampex  
Petroleum Corp.; and Martin,  
Williams and Judson.

Land owner: U.S. Government. Drilled under Federal Oil and Gas Lease  
No. NM-01119.

Grazing lease: Mr. Gerald Elmore, Box 696, Carlsbad, New Mexico 88220.

U.S. Bureau of Land Management special land use permit: No. NM-791. Dated  
October 24, 1966. Permit expires  
October 24, 1971, unless renewed.

Water rights: File No. C-1348. Granted September 23, 1966.

Depth to water from land-surface datum: 195.80 ft on March 3, 1967.

Measuring-point description: Top of 8 5/8-inch casing.

Date acquired by USGS: August 29, 1966.

Borehole geophysical logs: Gamma-ray-neutron 0-2,700 ft  
Induction log 2,546-11,627 ft  
Microlaterolog 2,546-11,626 ft  
Sonic 0-11,618 ft  
Gamma-ray 0-11,618 ft

Casing and cement record: 13 3/8-in, 48-lb/ft casing set to depth  
of 602 ft with 1,650 sacks of cement  
circulated to the surface.  
8 5/8-in, 32-lb/ft casing set to depth of  
2,548 ft with 775 sacks of cement  
circulated to 250 ft from the surface.

Appendix M.--Drilling and completion records of observation

wells in the Capitan aquifer - Continued

North Cedar Hills Unit 1 - Continued

Total depth: 11,629 ft

Plugged-back total depth: 2,500 ft

Formation tops and bases:

Rustler Fm. (eroded top at surface)		
Yates Fm.	506	(+2,791)
Capitan Limestone	748	(+2,549)
Base of Capitan Limestone	2,677	(+620)
Delaware Mountain Gp.	2,677	(+620)
Bone Spring Limestone	5,024	(-1,727)
Wolfcamp Series	8,030	(-4,733)
Strawn Series	10,176	(-6,879)
Mississippian System	11,541	(-8,244)

Other former owner record: Spudded on May 20, 1966; completed August 31, 1966.

Plugging record: Plugs, each consisting of 40 sacks of cement, were set at depths of 11,629 to 11,530, 11,000 to 10,900, 10,250 to 10,150, 8,570 to 8,470, 6,500 to 6,400, 5,000 to 4,900, and 3,800 to 3,700 ft. Cement plugs consisting of 100 and 70 sacks of cement were set at depths of 10,700-10,400 and 2,630-2,500 ft, respectively.

Five drill-stem tests were run at various intervals from 8,938 to 11,603 ft.

Lost circulation: None reported in Capitan Limestone.

USGS work record: Ran perforating depth control (gamma-ray-neutron collar) log on July 30, 1966, during well abandonment.

Perforated casing on August 10, 1966, with total of 50 jet shots at 4 shots/ft. Perforated intervals 1,007-1,014, 1,024-1,025, 1,042-1,044, 1,059-1,060, and 1,167-1,170 ft with alternating crack and regular jet shots.

On August 11, 1966, treated Capitan aquifer with 3,000 gal 15 percent regular HCl acid injected through casing. Used 60 7/8-in ball sealers to divert acid during injection.

Swabbed approximately 207 bbl of water through casing at rate of approximately 6 gpm on August 12, 1966.

Appendix M.--Drilling and completion records of observation  
wells in the Capitan aquifer - Continued

North Cedar Hills Unit 1 - Concluded

USGS work record - Concluded

Installed water-level recorder on  
September 20, 1966.  
Swabbed approximately 95 bbl water on  
October 27, 1966, prior to second acid  
treatment.  
Acidized Capitan aquifer with 500 gal regular  
and 2,500 gal retarded 15 percent HCl on October 27,  
1966. Used 60 7/8-in ball sealers to divert  
acid. Injected acid through casing.  
Swabbed approximately 700 bbl water through  
casing in 11 hours on October 28, 1966. Could  
not lower fluid level below depth of 700 ft.  
Moved in work-over rig on December 2, 1968, in an  
attempt to run an aquifer performance test.  
Swabbed approximately 1,300 bbl water from  
December 3 to 6, 1968. Lost swab in hole.  
Fished for swab from December 6 to December 10,  
1968. Recovered swab on December 10, 1968.  
Swabbed approximately 600 bbl of water on  
December 11, 1968. Collected approximately 15  
gal water for radio-carbon dating on last swab  
run.  
Ran aquifer performance pulse test on August 12,  
1969.

Production rate: Approximately 6 gpm after the first acid treatment.  
Approximately 45 gpm after the second acid treatment.

Total water produced: Approximately 2,900 bbl water produced.

Appendix M.--Drilling and completion records of observation  
wells in the Capitan aquifer - Continued

Humble State 1

Location: 660 FSL, 660 FWL, sec. 23, T. 21 S., R. 27 E., Eddy County,  
New Mexico.

Altitude: Kelly bushing 3,244; derrick floor 3,243 (reference datum);  
ground level 3,230.2; measuring point 3,232.0.

Latitude: 32.46000°N                      Longitude: 104.16660°W

Permian Basin Well Data System No: MH20012 (temporarily assigned MH70188).

OMNIANA Data File No.: 35015API20012

Original owners: J. M. Huber Corp. (operator) and Pierce and Davis.

Land owner: State of New Mexico. Drilled under New Mexico State Oil  
and Gas Lease No OG-1420.

Surface lease: Mr. Gerald Elmore, Box 696, Carlsbad, New Mexico 88220.

Water rights: C-1376. Granted October 24, 1967.

Depth to water from land-surface datum: 170.12 ft on February 1, 1968.

Measuring-point description: Top of 9 5/8-inch casing.

Date acquired by USGS: September 27, 1967.

Borehole geophysical logs:

Gamma-ray	0-10,648 ft
Acoustic	3,020-10,652 ft
Contact caliper	8,600-10,652 ft
Induction electric	3,030-10,649 ft
Perforating depth control	0-2,938 ft

Casing and cement record: 60.5 ft of 13 3/8-in, 54.5 lb/ft, J-55  
and 643 ft of 48-lb/ft, H-40 casing set to  
depth of 700 ft. Circulated 700 sacks of  
cement to surface behind casing.  
9 5/8-in, 40 lb/ft, J-55 casing set to depth  
of 3,035 ft. Cemented casing in two  
stages with 580 sacks of cement. DV tool  
located at depth of 1,679 ft. Top of  
cemented casing located by temperature  
survey at depth of 1,160 ft.

Total depth: 10,652 ft

Plugged-back total depth: 2,850 ft



Appendix M.--Drilling and completion records of observation

wells in the Capitan aquifer - Continued

Humble State 1 - Continued

<u>Formation tops and bases:</u>	Capitan Limestone	812	(+2,432)
	Base of Capitan Limestone	2,565	(+679)
	Delaware Mountain Gp.	2,565	(+679)
	Bone Spring Limestone	5,349	(-2,105)
	Wolfcamp Series	9,149	(-5,905)
	Strawn Series	10,313	(-7,069)

Other former owner record: Hole spudded on January 28, 1967; temporarily abandoned on March 19, 1967; abandoned and assigned to USGS on September 27, 1967.

Plugs, each consisting of 50 sacks of cement, were set over the following intervals: 10,350-10,220, 9,650-9,520, 5,400-5,270, and 3,100-2,970 ft.

A 75-sack cement plug was set from 9,000 to 9,200 ft depth.

Five drill-stem tests were run at selected intervals from 9,114 to 10,608 ft depth.

Lost circulation: Started losing circulation at 900 ft. Lost all circulation between depths of 1,775 and 3,035 ft before intermediate casing was set. Lost 400 bbl water in 24 hours at 7,420 ft.

USGS work record: Moved in work-over rig in October 30 and 31, 1967.  
 (Depths measured Reversed rotary drilling mud out of 9 5/8-in casing.  
 from ground level) Set cast iron bridge plug at depth of 2,850 ft above the top of the cement plug in base of 9 5/8-in casing on October 31, 1967.  
 Perforated intervals 1,538-1,540, 1,559-1,561, 1,691-1,693, 1,704-1,710, 1,743-1,745, and 1,773-1,775 ft with two hyperjet shots/ft on October 31, 1967. Total of 44 jet shots.  
 Perforations measured from ground level.  
 Swabbed well through casing. Lowered fluid level to depth of 1,638 ft. Very little fluid entering well.  
 Treated Capitan aquifer with 1,000 gal regular and 2,250 gal retarded 15 percent HCl acid on October 31, 1967. Washed perforations with regular acid. Then injected 1,000 gal regular acid followed by injection of jelled retarded acid in 3 stages. Used 500 lbs of rock salt between stages as a diverting agent.

Appendix M.--Drilling and completion records of observation  
wells in the Capitan aquifer - Continued

Humble State 1 - Concluded

USGS work record - Concluded

Well still under pressure when treatment swage removed on November 1, 1967. Swabbed well through casing. Lowered fluid level very rapidly to depth of perforations. Ran swab to depth of 1,800 ft and pulled rapidly to surface. Held vacuum for 30 min. Repeated in attempt to develop well.

Perforated intervals 1,705-1,710, 1,743-1,745, 1,773-1,775, and 1,929-1,936 ft with 4 alternating crack and regular jet shots/ft on November 2, 1967. Total of 64 shots. Perforations measured from ground level.

Swabbed well through casing after perforating on November 2, 1967. Lowered fluid level very rapidly to depth of perforations. Only 20 ft of fill-up in 15 min.

Swabbed fluid level to depth slightly below lower perforations on November 3, 1967.

Treated Capitan aquifer with 4,000 gal regular 15 percent HCl acid injected through the casing on November 3, 1967.

Started swabbing well 30 min after over-flush of acid treatment was completed. Recovered acid during swab runs at depth of lower perforations. Lowered fluid level to depth of 1,900 ft. Well recovering approximately 150 ft/hr.

Installed water-level recorder on February 1, 1968. Ran aquifer performance pulse test on September 5, 1969. Test failed.

Bailed nine samples from fluid column and reinstalled recorder on December 30, 1971.

Production rate: Swabbed approximately 8 gpm on November 3, 1967.

Total water produced: Did not recover all of the water injected during acid treatment.

Appendix M.--Drilling and completion records of observation  
wells in the Capitan aquifer - Continued

City of Carlsbad Test Well 3  
(Miller Nix-Yates Federal 1)

Location: 1,650 FNL, 1,650 FWL, sec. 30, T. 21 S., R. 28 E.,  
Eddy County, New Mexico.

Altitude: Kelly bushing (reference datum) 3,194; ground level 3,181.71;  
measuring point 3,183.35. (Ground level of 3,184 reported on  
borehole geophysical logs.)

Latitude: 32.45272°N Longitude: 104.12747°W

OMNIANA Data File No.: 35015G000070183

Owner: Forrest Miller, Alpine, Texas.

Land owner: U.S. Government. Drilled under Federal Oil and Gas Lease  
No. LC-059365.

Surface lease holder: Mr. Paul Bond, Box 961, Nogales, Arizona 85621.

Water rights: None

Depth to water from land-surface datum: 91.94 ft on April 16, 1967.

Measuring-point description: Top of 5 1/2-inch casing.

Date acquired by USGS: Well is on loan and has not been formally acquired.

Borehole geophysical logs: Gamma-ray-neutron 0-1,059 ft  
Microlog 93-1,057 ft  
Induction electric log 93-1,061 ft

Casing and cement record: 8 5/8-in, 24.7-lb/ft, used casing set to depth  
of 94 ft from kelly bushing. Cemented with  
50 sacks of cement circulated to the surface  
on June 23, 1961.  
5½-in, 14-lb/ft, used casing set to depth of  
640 ft from kelly bushing. Set casing on  
Halliburton formation packer shoe after drill-  
ing to total depth of 1,060 ft. Cemented  
casing with 17 sacks of cement on June 27,  
1961. Checked condition of open hole below  
packer hole after cementing casing and found  
no cement below 640 ft.

Total depth: 1,060 ft

Plugged-back total depth: 906 ft

Formation tops and bases: Rustler Fm. 80 (+3,114)  
Salado Fm. 154 (+3,040)  
Tansill Fm. 646 (+2,548)  
Capitan Limestone 775 (+2,419)

Appendix M.--Drilling and completion records of observation  
wells in the Capitan aquifer - Continued

City of Carlsbad Test Well 3 - Concluded

- Other former owner record: Spudded on June 23, 1961; completed and temporarily abandoned on September 17, 1961.  
 Drilled 7 7/8-in hole to 1,060 ft before setting 5½-in casing at 640 ft.  
 Produced approximately 168 gpm of water from open-hole interval 640-1,060 ft by air jet method.  
 Aquifer performance test with a short recovery period conducted during August 9 to 11, 1961.  
 Plugged hole back to 906 ft. Set Halliburton basket at 937 ft on September 16, 1961. Dumped 18 gallons of pea gravel on basket with dump bailer followed by 5 sacks of Calseal.  
 Set inflatable packer at 860 feet and tested interval 860-640 ft by swabbing for 2½ hr.  
 Swabbed formation water from interval 860-906 ft for 1½ hr.
- Lost circulation: Lost circulation while drilling interval 880-890 ft.  
 Level of drilling fluid dropped to 90 ft from surface.
- USGS work record: Installed digital recorder October 5, 1965.  
 Ran aquifer performance pulse test on September 3, 1969. Test failed.
- Production rate: Air jet test at 168 gpm.
- Total water produced: Estimated total of 4,700 gal water produced during tests in August and September 1961.
- Special conditions: Well still owned by Mr. Forrest Miller. Well is also known as Miller Nix-Yates Federal 1 stratigraphic test.

Appendix M.--Drilling and completion records of observation  
wells in the Capitan aquifer - Continued

Yates State 1

Location: 660 FSL, 1,650 FWL, sec. 32, T. 20 S., R. 30 E., Eddy  
County, New Mexico.

Altitude: Ground level 3,365; derrick floor 3,380; kelly bushing  
(reference datum) 3,381.2; measuring point 3,367.

Latitude: 32.52260°N

Longitude: 103.99170°W

Permian Basin Well Data System No: MH10895 (temporarily assigned MH70187).

OMNIANA Data File No.: 35015API10895

Original owners: Pennzoil Co. and Stoltz and Co.

Minerals owner: State of New Mexico. Drilled under New Mexico State Oil  
and Gas Lease No. K-4278.

Land surface owner: Mr. Wayne Cowden, 702 North Halagueno, Carlsbad,  
New Mexico 88220.

Water rights: CP-438. Granted August 4, 1967.

Depth to water from land-surface datum: 309.84 ft on September 20, 1967.

Measuring-point description: Top of 8 5/8-inch casing.

Date acquired by USGS: July 12, 1967

Borehole geophysical logs: Perforating depth control (gamma-ray-  
neutron collar) 1,500-3,914 ft  
Sonic-caliper 4,040-12,371 ft  
Induction-laterolog-gamma-ray 4,103-12,376 ft  
Microlog-caliper 4,103-12,378 ft  
Gamma-ray 0-12,371 ft  
Gamma-ray-neutron 10,204-12,517 ft

Casing and cement record: 16-in, 65-lb/ft, H-40 casing set to depth  
of 556 ft with 300 sacks of cement  
circulated to the surface.  
11 3/4-in, 42-lb/ft, H-40 casing set to  
depth of 1,575 ft with 850 sacks of  
cement circulated to the surface.  
8 5/8-in, 32-lb/ft, N-80 casing set to depth  
of 4,100 ft with 1,150 sacks of cement  
circulated to the surface. Casing tested  
at 5,000 psi pressure at the well head.  
4½-in, 11.6 and 13.5-lb/ft casing set to depth  
of 11,392 ft with 475 sacks of cement. Pro-  
duction string was cut at approximately 6,600  
ft depth and removed at time of abandonment.



Appendix M.--Drilling and completion records of observation  
wells in the Capitan aquifer - Continued

Yates State 1 - Continued

Total depth: 12,603 ft

Plugged-back total depth: 2,550 ft

<u>Formation tops and bases:</u>	Rustler Fm.	210	(+3,171)
	Salado Fm.	487	(+2,894)
	Base of Salado Fm.	1,572	(+1,809)
	Yates Fm.	1,642	(+1,739)
	Capitan Limestone	1,755	(+1,626)
	Base of Capitan Limestone	3,492	(-111)
	Delaware Mountain Gp.	3,492	(-111)
	Bone Spring Limestone	6,562	(-3,181)
	Wolfcamp Series	9,905	(-6,524)
	Strawn Series	11,120	(-7,739)
	Atoka Series	11,555	(-8,174)
	Morrow Series	12,062	(-8,681)

Other former owner record:

Hole spudded on December 3, 1966; completed by Stoltz and Co. on February 26, 1967.

Re-entered by Pennzoil Co. and subsequently abandoned July 3, 1967.

Plugging record. A cast iron bridge plug was set at a depth of 10,200 ft. Twenty-five sacks of cement were placed on top of the bridge plug. A plug consisting of 40 sacks of cement was set at the top of the 4½-in casing stub at 6,680 to 6,480 ft. A 60-sack cement plug was placed at the base of the intermediate casing (9 5/8 in) at a depth of 4,194 to 3,915 ft.

Rotary mud reversed out with fresh water from depth of 3,915 ft to the surface.

Oil and gas produced from interval 10,240-10,261 ft in the Wolfcamp Series. Unknown number of drill-stem tests taken. Drill-stem test tool left in hole at 12,525 ft.

USGS work record:

Ran perforating depth control logs on July 31, 1967 and perforated the casing with one jet shot at each of the following selected depths: 2,239, 2,270, 2,287, 2,327, 2,329, 2,335, 2,337, 2,339, 2,369, 2,401, 2,449½, 2,498, 2,499, 2,500, 2,502, 2,506, and 2,515 ft.

Swabbed approximately 240 bbl water through casing on August 29, 1967 prior to acid treatment.

Treated aquifer through casing on August 30 and 31, 1967 with 3,500 gal of 15 percent HCl acid under pressures as high as 3,000 psi.



Appendix M.--Drilling and completion records of observation

wells in the Capitan aquifer - Continued

Yates State 1 - Concluded

USGS work record - Concluded

Swabbed approximately 1,850 bbl fluid from aquifer during August 31, 1967, to September 2, 1967.  
Installed water-level recorder on September 19, 1967.  
Ran pulse type aquifer performance test on September 4, 1969. Test failed.  
Bailed approximately 75 feet of oil from borehole on October 22, 1971.  
Set wire line bridge plug at depth of 2,550 feet and dumped 1 cubic foot of cement on top of bridge plug on December 28, 1971.  
Swabbed approximately 275 bbl fluid from aquifer after bridge plug was set during December 28, 1971 to December 29, 1971.

Production rate: Swabbed at approximately 45 gpm on August 31, 1967.

Total water produced: Swabbed a total of approximately 2,365 bbl of fluid during periods August 29 to September 2, 1967 and December 28 and 29, 1971.

Special conditions: Small amount of oil seeping into borehole from September 19, 1967, to December 28, 1971. Oil seep was stopped with installation of cast iron bridge plug.

Appendix M.--Drilling and completion records of observation  
wells in the Capitan aquifer - Continued

Hackberry Deep Unit 1

Location: 1,650 FNL, 990 FWL, sec. 31, T. 19 S., R. 31 E., Eddy  
County, New Mexico.

Altitude: Kelly bushing 3,414 (Sweeney), 3,409 (Strake - reference  
datum); derrick floor 3,407 (Strake); ground level 3,397;  
casing head flange 3,393; measuring point 3,398.6.

Latitude: 32.61920°N Longitude: 103.91330°W

Permian Basin Well Data System No: MH10385

OMNIANA Data File No.: 35015API10385

Original owners: Mr. G. W. Strake. Subsequently assigned to Mr. H. N. Sweeney.

Land owner: U.S. Government. Drilled under Federal Lease No NM-06815A;  
grazing lease held by John Lusk, 304 North Corral, Carlsbad,  
New Mexico 88220.

U.S. Bureau Land Management Use Permit: Assigned Serial No. NM-0559838 and  
noted under 44 L.D. 513.

Water rights: CP-362 assigned on May 9, 1966. Originally assigned CP-363  
in error. Granted on May 9, 1966.

Depth to water from land-surface datum: 610.78 ft on March 2, 1967.

Measuring-point description: Top of 8 5/8-inch casing.

Date acquired by USGS: March 26, 1966.

Borehole geophysical logs: Gamma-ray-neutron 1,700-4,024 ft  
Acoustic 4,450-11,544 ft  
Guard-gamma-ray-forxo-caliper-density  
11,500-12,523 ft  
Focus-gamma-ray 6,750-11,541 ft  
Minifocused-caliper 6,700-11,549 ft  
Acoustic-velocity-gamma-ray 11,500-12,518 ft  
Gamma-ray 0-11,544 ft

Other logs: Drill cuttings 1,700-4,200 ft; Penetration rate 1,750-4,850 ft.

Casing and cement record: 13 3/8-in, 48-lb/ft casing set to 583 ft with  
610 sacks of cement. Top of cement located  
by temperature survey at 230 ft. Cemented  
to surface with 100 sacks using line pipe.  
8 5/8-in, J-55, 32 and 24-lb/ft casing set to  
4,131 ft. Cemented bottom of casing with  
200 sacks. Cemented through DV tool set  
at 2,402 with 1,000 sacks. Temperature  
survey indicates top of cement at 1,115 ft.

Appendix M. --Drilling and completion records of observationwells in the Capitan aquifer - Continued

## Hackberry Deep Unit 1 - Continued

Total depth: 12,524 ftPlugged-back total depth: 4,050 ft

<u>Formation tops and bases:</u>	Rustler Fm.	510	(+2,899)
	Yates Fm.	1,955	(+1,454)
	Capitan Limestone	2,193	(+1,216)
	Base of Capitan Limestone	4,103	(-694)
	Delaware Mountain Gp.	4,103	(-694)
	Bone Spring Limestone	6,625	(-3,216)
	Morrow Series	11,558	(-8,149)
	Barnett Shale	12,473	(-9,064)

Other former owner record:

Spudded January 31, 1965; temporarily abandoned on March 2, 1965. Re-entered hole on August 13, 1965; temporarily abandoned August 24, 1965.

Drill-stem tests in formations of lower Permian and Pennsylvanian age.

Plugging record (Mr. H. N. Sweeney). Eight cement plugs, varying from 35 to 55 sacks of cement, were set at 12,400-12,250, 11,550-11,450, 11,200-11,050, 10,200-10,100, 8,480-8,380, 6,850-6,750, 5,330-5,230, and 4,200-4,050 ft, respectively, to plug open hole. Rotary mud circulated below, between, and above plugs.

<u>Lost circulation:</u>	<u>Depth, feet</u>	<u>Percent lost</u>
	1,893	100
	2,505	40
	2,585	100
	2,800	100
	2,828	40
	3,559-3,987	10-50

USGS work record:

Rigged up work-over rig on March 29, 1966. Bailed rotary mud from casing. Rigged down March 31, 1966. June 6, 1966, ran perforating depth control logs and perforated casing with shaped charges (torpedo jets) designed to cut 1½-in hole in casing and penetrate approximately 23 inches into formation. Perforated the intervals 3,736-3,749 with 8 shots; 3,830-3,833 with 4 shots; and 3,928-3,939 with 8 shots. No indication of fluid entering hole immediately after perforating casing.

Appendix M.--Drilling and completion records of observation  
wells in the Capitan aquifer - Continued

Hackberry Deep Unit 1 - Concluded

USGS work record - Concluded

Treated Capitan aquifer with 2,000 gallons of regular 15 percent HCl in June 17, 1966. Acidized through casing.

Swabbed through casing from June 17 to June 20, 1966. Could not lower fluid level below 2,300 ft depth. Swabbed into test tank. Ran aquifer recovery test. Test failed.

Injected 3,000 gal retarded HCl acid in 3 stages through casing in second acid treatment on December 12, 1966. Each stage separated by jelled water and rock salt.

Swabbed through casing from December 12 to December 15, 1966. Sampled fluid in borehole at 3,005, 3,746, 3,832, and 3,936 ft using bailer. Installed water-level recorder on September 12, 1966. Ran aquifer performance pulse test on September 4, 1969. Test failed.

Bailed approximately 95 feet of oil from borehole on October 21, 1971.

Production rate: 28 to 35 gpm on June 20, 1966, 12 gpm on June 22, 1966, and 43 gpm on December 15, 1966.

Total water produced: Approximately 2,170 bbl produced from June 17 to December 15, 1966.

Special conditions: Approximately 1,100 feet of 8 5/8-in, J-55, 24-lb/ft salvable casing remaining in the hole. Small amount of oil seeping into borehole.

Appendix M.--Drilling and completion records of observation  
wells in the Capitan aquifer - Continued

Middleton Federal B 1

Location: 660 FNL, 660 FWL, sec. 31, T. 19 S., R. 32 E., Lea County,  
New Mexico. Abandoned test in Lusk Strawn field.

Altitude: Derrick floor (reference datum) 3,528; ground level 3,518;  
measuring point 3,519.1.

Latitude: 32.62200°N Longitude: 103.81160°W

Permian Basin Well Data System No: MN20161

OMNIANA Data File No.: 35025API20161

Original owner: Shell Oil Co. Well was temporarily assigned to  
Mr. H. N. Sweeney. Acquired from Shell Oil Company.

Land owner: U.S. Government. Drilled under Federal Lease No. LC-064198.

U.S. Bureau of Land Management use permit: Noted under 44 L.D. 513.  
Assigned Serial No. NM-0559276  
in letter dated February 15, 1966.

Water rights: CP-386. Granted on September 23, 1966.

Depth to water from land-surface datum: 520.98 ft on October 7, 1966.

Measuring-point description: Top of 8 5/8-inch casing.

Date acquired by USGS: January 20, 1966.

Borehole geophysical logs:

Gamma-ray	0-12,959 ft
Sonic	3,705-12,959 ft
Proximity-microlog-detail	7,100-12,962 ft
Induction-laterolog-gamma-ray	7,100-12,959 ft
Gamma-ray-neutron	2,600-3,100 ft
Gamma-ray-neutron	1,850-2,200 ft

Casing and cement record: 13 3/8-in, 48-lb/ft casing set to 845 ft. 350 sacks  
of cement circulated to depth of 290(?) ft.  
8 5/8-in, J-55, 32-lb/ft casing set to 3,705 ft with  
3,350 sacks of cement in two stages. Stage 1 -  
3,600 to 3,705 ft. Stage 2 - 2,100 to 2,900 ft.  
No cement behind casing from 2,900 to 3,705 ft.  
Annulus filled with pea gravel from 823 to 2,100 ft.  
Casing parted at 2,039 ft in casing collar. Casing  
repaired with 4½-in casing liner set 2,032-2,040 ft.

Total depth: 12,976 ft

Appendix M.--Drilling and completion records of observation

wells in the Capitan aquifer - Continued

Middleton Federal B 1 - Concluded

Plugged-back total depth: 3,650 ft

<u>Formation tops and bases:</u>	Rustler Fm.	827	(+2,701)
	Yates Fm.	2,645	(+833)
	Capitan Limestone	2,947	(+581)
	Base Capitan Limestone	4,190	(-662)
	Delaware Mountain Gp.	4,190	(-662)
	Bone Spring Limestone	7,218	(-3,690)
	Wolfcamp Series	10,530	(-7,002)
	Des Moines Series	11,352	(-7,824)
	Atoka Series	11,584	(-8,056)

Other former operator record: Hole spudded April 8, 1963; completed July 2, 1963. Re-entered by H. N. Sweeney during July-October 1963 who tested Capitan aquifer for water. Plugging record: Seven cement plugs, each consisting of 30 sacks of cement, were set at 11,900-11,800, 11,400-11,300, 10,600-10,500, 8,700-8,600, 7,250-7,150, 5,400-5,300, and 3,750-3,650 ft, respectively, to plug 7 7/8-in open hole. Drill-stem tests and cores taken in formations of Pennsylvanian age. Perforated at 2,923, 2,928, 2,932, 2,937, 2,953, 2,956, and 2,957 ft. Acidized with 200 gal retarded 27 percent HCl acid through tubing. Perforations measured from ground level. Swabbed and pumped unknown quantity of water during summer and fall 1963.

USGS work record: Installed water-level recorder on September 13, 1965. Swabbed 245 bbl water in 5 hours on October 26, 1966. Lowered fluid level to depth of approximately 1,700 ft.

Lost circulation: Unknown. Drilled Capitan Limestone with aerated water.

Production rate: Unknown. Inadequate test of well capacity.

Total water produced: Unknown

Special conditions: Casing patched. Casing not cemented to surface. Approximately 1,700 ft of 8 5/8-in, J-55, 32-lb/ft casing is salvable.



Appendix M.--Drilling and completion records of observation  
wells in the Capitan aquifer - Continued

South Wilson Deep Unit 1

Location: 1,980 FSL, 660 FWL, sec. 23, T. 21 S., R. 34 E., Lea County,  
 New Mexico.

Altitude: Ground level 3,717 (reference datum); measuring point 3,719.

Latitude: 32.46110°N                      Longitude: 103.44700°W

Permian Basin Well Data System No: MN20849

OMNIANA Data File No.: 35025API20849

Original owners as joint operators: Sinclair Oil and Gas Co. (unit operator),  
 Cities Service Oil Co., El Paso Natural Gas Co., Humble Oil and  
 Refining Co., Pan American Petroleum Corp., Pure Oil Co., Socony  
 Mobil Oil Co., Sun Oil Co., Tidewater Oil Co., Wilson Oil Co.,  
 Wyoming Oil Co., and Mr. Raymond Lamb.

Land owner: State of New Mexico. Drilled under New Mexico State Oil and Gas  
 Lease No. E-229, Unit L.

Water rights: CP-320. Granted on March 4, 1966.

Depth to water from land-surface datum: 1,042.85 ft on November 7, 1967.

Measuring-point description: Top of 9 5/8-inch casing.

Date acquired by USGS: January 6, 1966.

Borehole geophysical logs:                      Perforating depth control 3,750-4,300 ft  
     Gamma-ray 0-14,368 ft  
     Sonic 900-14,369 ft  
     Microlog-caliper 5,603-14,368 ft  
     Induction electric-gamma-ray 13,987-14,367 ft  
     Induction-laterolog-gamma-ray 5,603-13,550 ft

Casing and cement record:                      13 3/8-in casing set to 923 ft depth with  
     cement circulated to the surface.  
     9 5/8-in, 40-lb/ft, N-80 casing set from surface  
     to 1,303 ft; 9 5/8-in, 36-lb/ft, J-55  
     casing set from 1,303 to 3,182; and 9 5/8-  
     in, 40-lb/ft, J-55 casing set from 3,182 to  
     5,601 ft. Cement circulated to surface in  
     two stages with total of 3,642 sacks of  
     cement. DV tool set at depth of 3,680 ft.  
     7-in casing set at 13,992 with cement to  
     10,695 ft from surface. 7-in casing string  
     cut off at 10,695 and removed during  
     abandonment. Open hole from 5,601 to 10,695  
     ft. 6-in open hole from 13,992 to 14,368 ft.

Appendix M.--Drilling and completion records of observation

wells in the Capitan aquifer - Continued

South Wilson Deep Unit 1 - Continued

Total depth: 14,368 ft

Plugged-back total depth: 5,390 ft

<u>Formation tops and bases:</u>	Chinle Fm.	220	(+3,497)
	Rustler Fm.	1,686	(+2,031)
	Salado Fm.	1,910	(+1,807)
	Base Salado Fm.	3,410	(+307)
	Yates Fm.	3,620	(+97)
	Capitan Limestone	3,945	(-228)
	Base Capitan Limestone	5,500	(-1,783)
	Delaware Mountain Gp.	5,500	(-1,783)
	Bone Spring Limestone	8,090	(-4,383)
	Strawn Series	11,488	(-7,749)
	Atoka Series	11,853	(-8,114)
	Morrow Series	12,560	(-8,821)
	Barnett Shale	13,256	(-9,517)

Other former owner record: Hole spudded on November 8, 1963; completed March 16, 1964.  
 Plugging record. Three plugs, each consisting of 25 sacks of cement, were set at 10,795-10,695, 8,100-8,000, and 5,600-5,500 ft respectively, to plug open hole. One 10-sack cement plug was set in top of the 7-in casing stub. A cast iron bridge plug with 10 sacks of cement was set at 12,640 ft. One 10-sack cement plug was set at the top of the 9 5/8-in casing in the cellar.  
 Eight drill-stem tests run at selected intervals from 7,810 to 14,365 ft.  
 Non-commercial gas production from Pennsylvanian Morrow Series at 12,642-12,895 ft.

USGS work record: March 3 to 15, 1966. Bailed mud out of 9 5/8-in casing with work-over rig. Lost bailer when sand line broke. Recovered bailer and sand line.  
 Attempted to perforate casing on September 16, 1966, but could not lower perforating gun into hole below depth of 3,446 ft because of heavy mud. Cement plug at base of 9 5/8-in casing had failed, allowing rotary mud and cement fragments to move upward into casing under hydraulic pressure.

Appendix M.--Drilling and completion records of observation

wells in the Capitan aquifer - Continued

South Wilson Deep Unit 1 - Concluded

USGS work record - Concluded

During October 14 to 19, 1966, bailed rotary mud to depth of approximately 4,000 ft. Could not lower fluid level with bailer. Reverse circulation method then was employed to remove rotary drilling mud and cement fragments from casing. Ran wire-line gauge ring to depth of 5,708 ft. Bottom of 9 5/8-in casing at 5,601 ft. Set wire-line bridge plug at depth of 5,390 (above collar located at depth of 5,401 ft) on October 19, 1966. Dumped 1 sack of cement on top of bridge plug. Ran pressure test on casing. Maintained a pressure of 1,000 psi at well head for 15 minutes. Ran perforating depth control log. Perforated interval 4,169 to 4,171.5 and 4,181 to 4,187 ft with four jet shots per ft on October 19, 1966. Alternated crack and regular jet shots. Swabbed through casing on October 24 and 25, 1966. Recovered approximately 700 bbl fluid including fluid left in well after reversing out mud. Adequate production rate attained without acid treatment. Installed water-level recorder on February 1, 1967.

Production rate: Approximately 50 gpm on October 26, 1966.

Total water produced: Approximately 400 bbl water produced from Capitan aquifer.

Special conditions: USGS has agreed not to perforate above a depth of 4,050 ft.

Appendix M.--Drilling and completion records of observation  
wells in the Capitan aquifer - Continued

North Custer Mountain Unit 1

Location: 660 FNL, 1,980 FWL, sec. 28, T. 23 S., R. 35 E., Lea County,  
New Mexico.

Altitude: Kelly bushing (reference datum) 3,406.20; ground level 3,387;  
derrick floor 3,405; measuring point 3,388.7.

Latitude: 32.27890°N Longitude: 103.37850°W

Permian Basin Well Data System No: MN21601 (temporarily assigned MN70371).

OMNIANA Data File No.: 35025API21601

Original owners as joint operators: Bass Brothers Enterprises (unit  
operator), Pan American Petroleum  
Corp., Sunray DX Oil Co., Gulf Oil  
Corp., and Mobil Oil Corp.

Land owner: State of New Mexico. Drilled under New Mexico State Oil  
and Gas Lease No. M-605.

Surface lease holder: Mr. Lawrence B. Merchant, Box 1270, Carlsbad,  
New Mexico 88220.

Depth to water from land-surface datum: 847.50 ft on February 2, 1967.

Measuring-point description: Top 9 5/8-inch casing.

Water rights: CP-385. Granted on September 20, 1966.

Date acquired by USGS: July 18, 1966.

Borehole geophysical logs:

- Gamma-ray-microlog-caliper 8,600-14,700 ft
- Borehole compensated sonic-gamma-ray-caliper  
5,800-15,981 ft
- Dual induction-laterolog 5,800-12,224 ft
- Induction electric-gamma-ray 3,900-5,796 ft
- Acoustic-gamma-ray-caliper 3,902-5,797 ft
- Gamma-ray-epithermal neutron 0-5,800 ft
- Amplitude log 10,000-11,500 ft
- Velocity survey 12,175-16,000 ft
- Perforating depth control (gamma-ray-neutron-  
collar) 4,350-5,400 ft
- Gradiomanometer 930-5,298 ft

Appendix M.--Drilling and completion records of observation  
wells in the Capitan aquifer - Continued

North Custer Mountain Unit 1 - Continued

Casing and cement record:

- 20-in, 94-lb/ft casing set to 439 ft depth with 750 sacks of cement circulated to surface through shoe.
- 16-in, 75-lb/ft casing set to 3,902 ft depth. 5,650 sacks of cement circulated to 1,400-ft depth through shoe and collar.
- 13 3/8-in, J-55 and N-80, 61, 68, 72 and 77-lb/ft casing set to depth of 5,784 ft. Cemented casing string with 2,900 sacks of cement in three stages from total depth to surface. Temperatures survey indicated lack of cement from 3,930 to 4,065 and only probable cement in the interval from 4,065-4,475 ft. Cement behind casing elsewhere.
- 9 5/8-in, N-80, 43.5-lb/ft casing set to 6,016 ft, 9 5/8-in, N-80, 47-lb/ft casing set from 6,016 ft to 7,437 ft, 9 5/8-in, N-80, 53.5-lb/ft casing set from 7,437 to 10,703 ft, and 9 5/8-in, P-110, 53.5-lb/ft casing set from 10,703 to 12,175 ft. Cement circulated to the surface in three stages.

Total depth: 16,000 ft

Plugged-back total depth: 5,300 ft

<u>Formation tops and bases:</u>		
Rustler Fm.	1,555	(+1,851)
Salado Fm.	1,695	(+1,711)
Base Salado Fm.	3,705	(-299)
Yates Fm.	3,947	(-541)
Capitan Limestone	4,397	(-991)
Base Capitan Limestone	5,635	(-2,229)
Delaware Mountain Gp.	5,635	(-2,229)
Bone Spring Limestone	8,997	(-5,591)
Wolfcamp Series	11,585	(-8,179)
Strawn Series	12,502	(-9,096)
Atoka Series	12,725	(-9,319)
Barnett Shale	14,159	(-10,753)
Woodford Fm.	15,570	(-12,164)
Devonian System	15,846	(-12,440)

Appendix M.--Drilling and completion records of observation

wells in the Capitan aquifer - Continued

North Custer Mountain Unit 1 - Concluded

- Other former owner record: Hole spudded January 14, 1966; abandoned July 17, 1966.  
 Plugging record. Three plugs, each consisting of 100 sacks of cement, were set at 16,000-15,700, 15,200-14,900, 13,100-12,800 ft.  
 Ran 10 drill-stem tests from 8,690 to 15,550 ft.  
 Left hole filled with fresh water.
- Lost circulation: Lost about 500 bbl water/hr at depth of 4,438 ft from February 3 to 6, 1966, and February 18 to 23, 1966, in top of Capitan aquifer. No returns while drilling Capitan Limestone.
- USGS work record: Well headed and blew out. Ran gradiomanometer on September 9, 1966. Set wire-line cast iron bridge plug at 5,300 ft. Dumped one sack of cement on top of bridge plug with wire-line dump bailer. On October 10, 1966, ran perforating depth control log and perforated casing at 4,470, 4,473, 4,485, 4,490 to 4,491, 4,501 to 4,507 in Capitan aquifer. Total of 22 shots spaced at 2 shots per ft. Perforated from carrier gun. Alternated regular and crack jet shots.  
 Swabbed approximately 330 bbl water through casing on September 13 to 15, 1966. Unloaded hole. Little or no water entering well.  
 Swabbed and bailed approximately 330 bbl water through casing on October 11 to 12, 1966.  
 Treated Capitan aquifer with 1,000 gal regular 15 percent HCl acid.  
 Swabbed approximately 540 bbl water through casing on October 13 and 14, 1966, at rate of 42 gpm.  
 Installed water-level recorder on February 2, 1967.
- Production rate: 42 gpm during swab test October 13 to 14, 1966.
- Total water produced: 1,200 bbls during September and October 1966.
- Special conditions: Left 625 ft of 8 3/8-in open hole 12,175-12,800 ft. Well headed and blew out under fresh-water hydrostatic head. Small amount of gas and condensate produced from open-hole zone during blow out.



Appendix M.--Drilling and completion records of observation  
wells in the Capitan aquifer - Continued

Federal Davison 1

Location: 660 FNL, 1,980 FEL, sec. 20, T. 24 S., R. 36 E., Lea County,  
New Mexico.

Altitude: Derrick floor 3,381 (reference datum); ground level 3,355;  
measuring point 3,356.

Latitude: 32.20720°N

Longitude: 103.28490°W

Permian Basin Well Data System No: MN21725 (temporarily assigned MN70368).

OMNIANA Data File No.: 35025API21725

Original owners as joint operators: Humble Oil and Refining Co. (operator);  
Gulf Oil Corp., Atlantic Richfield  
Co., Standard Oil of Texas, and Aztec  
Oil and Gas Co.

Land owner: U.S. Government. Drilled under Federal Oil and Gas Lease  
NM-040763, Unit B.

Water rights: CP-424. Granted February 8, 1967.

Depth to water from land-surface datum: 1,071 ft on December 29, 1966.

Measuring-point description: Top of the 10 3/4-inch casing 0.6 ft above  
tee connection.

Date acquired by USGS: September 15, 1966.

Borehole geophysical logs:

Gamma-ray-neutron-caliper	50-14,589 ft
Acoustic	150-14,589 ft
Induction-gamma-ray	10,308-17,956 ft
Epithermal neutron	0-10,301 ft
Laterolog-gamma-ray	1,770-10,307 ft
Microlaterolog-caliper	7,050-17,959 ft
Perforating depth control	3,600-4,400 ft

Casing and cement record:

22-in conductor pipe set to depth of 43 ft with 27 sacks of cement.
16-in, 65-lb/ft, R-40 casing set to 1,766 ft with 1,900 sacks of cement circulated to the surface.

Appendix M.--Drilling and completion records of observation  
wells in the Capitan aquifer - Continued

Federal Davison 1 - Continued

Casing and cement record - Concluded

Various grades and weights of 10 3/4-in casing listed below set to depth of 10,302 ft with 5,900 sacks of cement circulated to surface in three stages.

<u>Depth</u>			
<u>From</u>	<u>To</u>	<u>lb/ft</u>	<u>Grade</u>
0	1,283	60.7	N-80
1,283	6,992	55.5	N-80
6,992	6,016	55.5	P-110
9,016	10,302	60.7	P-110

7 7/8-in, 39 and 33.7-lb/ft, P-110 and N-80 casing liner set to 14,578-ft depth with top at 10,028 ft inside 10 3/4-in casing. 900 sacks of cement circulated to top of liner.

Total depth: 17,961 ft

Plugged-back total depth: 5,713 ft

<u>Formation tops and bases:</u>			
Rustler Fm.	1,698	(+1,683)	
Salado Fm.	1,958	(+1,423)	
Base halite in the Salado Fm.	3,447	(-66)	
Tansill Fm.	3,496	(-115)	
Yates Fm.	3,638	(-257)	
Capitan Limestone	3,945	(-564)	
Base Capitan Limestone	5,620	(-2,239)	
Delaware Mountain Gp.	5,620	(-2,239)	
Bone Spring Limestone	8,042	(-4,661)	
Wolfcamp Series	10,055	(-6,674)	
Pennsylvanian System	10,794	(-7,413)	
Morrow Series	11,460	(-8,079)	
Woodford Fm.	14,016	(-10,635)	
Devonian System	14,444	(-11,063)	
Fusselman Dolomite	16,329	(-12,948)	
Montoya Dolomite	17,011	(-13,630)	

Appendix M.--Drilling and completion records of observation  
wells in the Capitan aquifer - Continued

Federal Davison 1 - Concluded

Other former owner record:

Hole spudded on July 7, 1965; completed and assigned to the USGS on September 30, 1966.

Plugging record: Plugs, each consisting of 50 sacks of cement, were set at 17,761-17,961 and 16,300-16,500 ft, respectively. A cement plug fills the interval 14,615-15,090 ft. Permanent wire-line bridge set at depth of 14,577 ft in base of 7 7/8-in casing liner.

Interval 14,310-14,578 was squeezed with 80 sacks of cement. A 50-sack cement plug was placed in interval 10,080-9,946 ft. A 90-sack cement plug was set in the interval 5,900-5,713 ft near the top of the Delaware Mountain Gp. Borehole left full of salt water.

Four drill-stem tests run at various intervals between depths of 10,674 and 12,269 ft. Gas and condensate were produced non-commercially from rocks of Devonian age from the interval 14,532 to 14,555 ft.

USGS work record:

Ran perforating depth control log and then perforated interval 4,278 to 4,285 ft with 28 alternating crack and regular jet shots spaced 4 shots/ft on November 11, 1966.

Bailed fluid from borehole from November 2 to 5, 1966. Did not use casing swab because of borehole size. Could not lower fluid level below 2,234-ft depth. Caught spot samples of fluid in borehole at 5,500, 4,000, 2,134 and 1,073 ft.

Installed water-level recorder on February 2, 1967.

Production rate: Produced approximately 8 gpm on bailer test November 4, 1966.

Total water produced: 296 bbls.

Appendix M.--Drilling and completion records of observation  
wells in the Capitan aquifer - Continued

Southwest Jal Unit 1

Location: 1,980 FNL, 1,980 FEL, sec. 4, T. 26 S., R. 36 E., Lea County,  
New Mexico.

Altitude: Ground level 2,985 (reference datum); measuring point 2,986.1;  
kelly bushing 3,004.

Latitude: 32.07350°N

Longitude: 103.26810°W

Permian Basin Well Data System No: MN20843

OMNIANA Data File No.: 35025API20843

Original owner: Sinclair Oil and Gas Co.

Land owner: U.S. Government. Drilled under Federal Oil and Gas Lease No. LC-069025

U.S. Bureau of Land Management use permit: Noted under 44 L.D. 513 in  
letter dated January 5, 1966.

Water rights: CP-321. Granted on March 11, 1966.

Depth to water from land-surface datum: 743.00 ft on September 14, 1966.

Measuring-point description: Top of 9 5/8-inch casing.

Date acquired by USGS: January 4, 1966.

Borehole geophysical logs: Perforating depth control 4,150-4,650 ft  
Sonic 360-13,489 ft  
Gamma-ray 0-13,489 ft  
Microlaterolog 5,005-11,296 ft  
Induction-laterolog-gamma-ray 5,305-13,496 ft

Casing and cement record: 13 3/8-in, 48-lb/ft casing set at 350 ft with  
400 sacks of cement circulated to the  
surface.  
3,365 ft of 36-lb/ft, 1,013 ft of 40-lb/ft  
J-55 and 924 ft of 40-lb/ft, N-80 9 5/8-in  
casing set to 5,300 ft with 3,500 sacks of  
cement circulated to 1,920 ft from surface.  
Cemented behind casing to surface through  
1-in tubing with 600 sacks of cement.  
11,300 ft of 7-in, 23, 26, 29 and 32-lb/ft,  
N-80 casing set to 11,300 ft and cemented  
to 2,220 ft from the surface with 1,150  
sacks of cement.  
4½-in casing set as liner from 11,096-13,497  
ft. Cement circulated behind liner.  
7-in casing cut at depth of 2,607 ft and removed.

Appendix M.--Drilling and completion records of observation  
wells in the Capitan aquifer - Continued

Southwest Jal Unit 1 - Continued

Total depth: 13,505 ft

Plugged-back total depth: 5,300 ft (bridged at 4,750 ft)

<u>Formation tops and bases:</u>	Rustler Fm.	1,275	(+1,710)
	Salado Fm.	1,540	(+1,445)
	Base halite in Salado Fm.	3,250	(-265)
	Tansill Fm.	3,312	(-327)
	Yates Fm.	3,480	(-495)
	Capitan Limestone	3,908	(-923)
	Base of Capitan Limestone	5,335	(-2,350)
	Delaware Mountain Gp.	5,335	(-2,350)
	Bone Spring Limestone	7,808	(-4,823)
	Wolfcamp Series	10,603	(-7,618)
	Strawn Series	12,420	(-9,435)
	Atoka Series	13,310	(-10,325)

Other former owner record:

Spudded on April 21, 1964; abandoned on January 4, 1966.

Plugging record: A 20-ft plug consisting of 2 sacks of cement was placed on top of a cast iron bridge plug set at a depth of 12,372 ft. A plug composed of 25 sacks of cement was set in 7-in casing at depths of 5,400-5,300 ft. Heavy drilling mud left between plugs.

Ten drill-stem tests run in selected intervals from 5,270 to 13,109 ft. Tested gross interval 12,726 to 13,258 through pipe. Non-commercial gas flow from this interval.

USGS work record:

Moved in work-over rig and cleaned rotary drilling mud from borehole with bailer during March 21-26, 1966.

May 17, 1966, ran perforating depth control log from depth of 4,150 to 4,650 feet. Perforated with Tornado jet shots 4,508, 4,509, 4,642, 4,643, 4,221 and 4,222; glass jet shots 4,690-4,695, 4,622-4,628, 4,590-4,594, 4,598-4,603 and 4,199-4,204; and glass and Titan jet shots 4,506-4,518, 4,476-4,488, 4,400-4,420, 4,382-4,390 and 4,360-4,368 ft. No indication of fluid entering well after perforations.

Appendix M.--Drilling and completion records of observation

wells in the Capitan aquifer - Concluded

Southwest Jal Unit 1 - Concluded

USGS work record - Concluded

Moved in work-over rig on June 9, 1966 and swabbed well through casing. Lowered fluid level to casing stub at approximately 2,220 ft, then bailed well. Swabbed and bailed June 9-13, 1966.

Treated with 1,500 gals 15 percent HCl acid injected through casing on June 13, 1966.

Swabbed well through casing June 14-15, 1966.

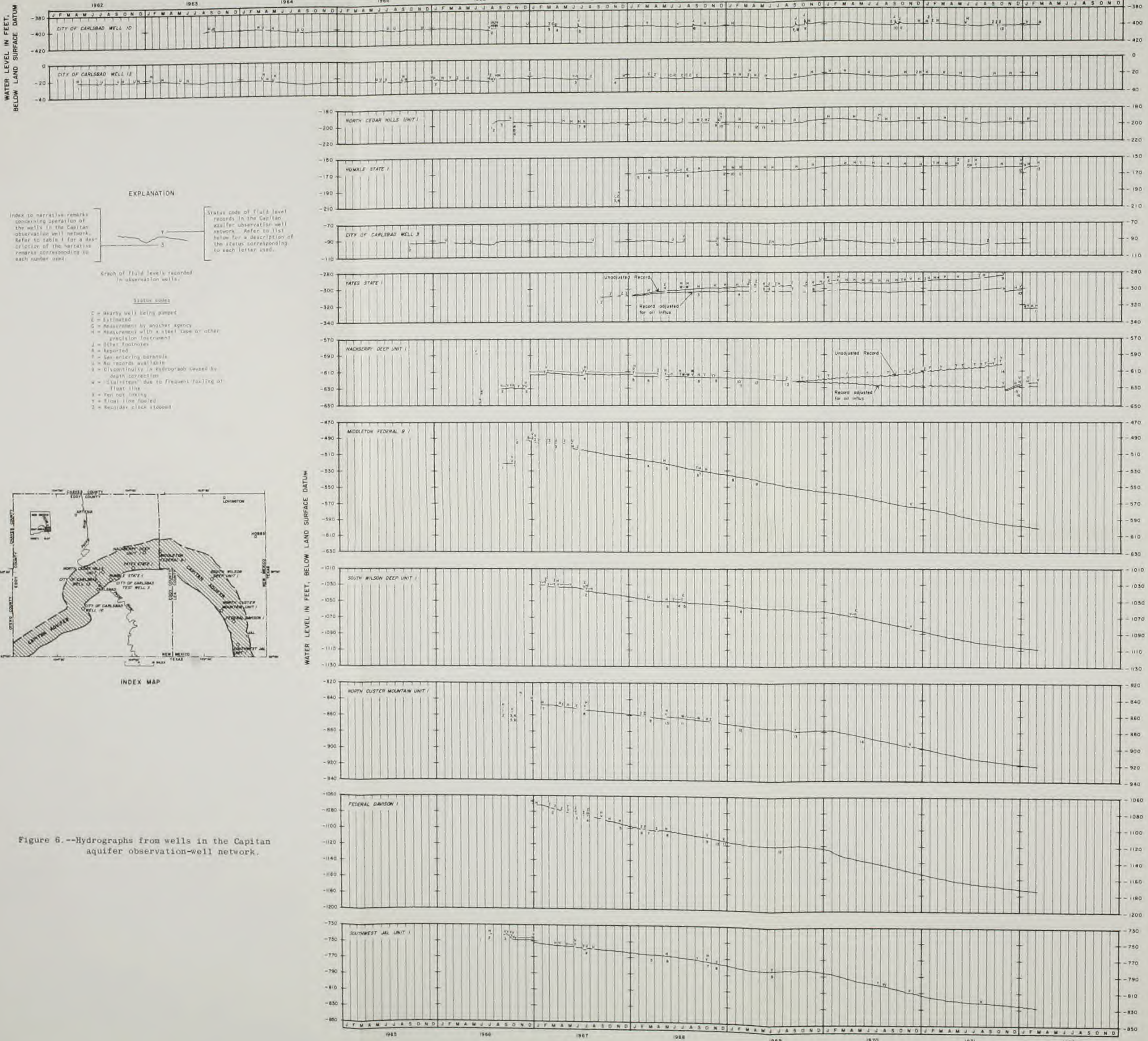
Installed water-level recorder on September 14, 1966.

Production rate: Fluid produced at rate of 6 gpm before acid treatment.  
Well swabbed at rate of 28 gpm after acid treatment.

Total water produced: Approximately 1,900 bbl.

Special conditions: Unable to go below depth of 4,750 with equipment due to bridge. Permission required from El Paso Natural Gas Co. prior to using heavy equipment on road from Jal to well.





**EXPLANATION**

Index to narrative remarks concerning operation of the wells in the Capitan aquifer observation well network. Refer to table 1 for a description of the narrative remarks corresponding to each number used.

Status code of fluid level records in the Capitan aquifer observation well network. Refer to list below for a description of the status corresponding to each letter used.

Graph of fluid levels recorded in observation wells.

**Status codes**

- C = Nearby well being pumped
- E = Estimated
- S = Measurement by another agency
- H = Measurement with a steel tape or other precision instrument
- J = Other footnotes
- R = Reported
- T = Day entering borehole
- U = No records available
- V = Discontinuity in hydrograph caused by depth correction
- W = "Saltwater" due to frequent fouling of float line
- X = Pen not working
- Y = Float line fouled
- Z = Recorder clock stopped



**INDEX MAP**

Figure 6.--Hydrographs from wells in the Capitan aquifer observation-well network.





