

WATER RESOURCES

REPORT NO. 80-4

HYDROGEOLOGY OF THE PECOS NATIONAL MONUMENT

WELL NO. 2

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Southwest Region
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HYDROGEOLOGY OF THE PECOS NATIONAL MONUMENT WELL NO. 2

by

Paul K. Christensen

ABSTRACT

Pecos National Monument is located in north central New Mexico. Pecos National Monument well no. 2 has a total depth of 350 feet and penetrates two upper Paleozoic formations: the Pennsylvanian Madera limestone and the Pennsylvanian-Permian Sangre de Cristo formation.

The Sangre de Cristo formation comprises the upper 200 foot section of the hole. Well cuttings show that the formation is comprised of 150 feet of reddish-brown to light brown shale and siltstone which rests on 50 feet of sandstone. A minor perched water zone occurs in a sandy portion of the siltstone unit at approximately 60 feet BSL.

The Madera limestone which comprises the remainder of the hole appears as limestone interbedded with gray and reddish-brown shales. The producing water zone occurs in a fractured limestone with solution cavities in the interval between 315 to 340 feet BSL. Another water producing zone was encountered between 500 to 560 feet BSL.

Originally, the hole was drilled to a depth of 560 feet BSL. Water-swelling shale zones encountered in the hole from the surface to total depth required casing from the surface to the screen and sealing off of the hole at 350 BSL. The screen was emplaced in the interval of 330 to 340 feet BSL.

The producing water zone is an artesian perched reservoir. Static water level is 120 feet BSL (195 feet above the reservoir). The aquifer test revealed a coefficient of transmissibility of 216 gpd/ft with a drawdown of 75.8 feet in 24 hours at a discharge of 42.8 gpm. No stabilization occurred. The specific capacity is 0.57 gpm/ft drawdown. A recovery of 80 per cent occurred 110 minutes after pumping ceased.

Water quality testing shows the water to be safe for human consumption. Aesthetically, the water is pleasing.

INTRODUCTION

This report describes the hydrogeology of the Pecos National Monument well no. 2 and is intended to summarize the stratigraphy and groundwater hydrology of the rocks penetrated by the well. Pecos National Monument is located in north central New Mexico, about 25 miles west of Santa Fe, New Mexico. See figure 1 for locations.

The methodology behind this report is three-fold:

- 1) a microscopic analysis of the well cuttings taken at 10 foot intervals,
- 2) an aquifer test dated August 9 and 10, 1979, and 3) literature research.

The written sources consulted are Geology and Ground-Water Resources of San Miguel County, New Mexico (1951), by R.L. Griggs and G.E. Henderickson, the New Mexico Bureau of Mines and Mineral Resources Ground-Water Report 2, and Pecos National Monument New Mexico: Its Geological Setting (1969) by Ross B. Johnson, U.S. Geological Survey Bulletin 1271-E.

STRATIGRAPHY

Pecos National Monument well no. 2 penetrates two formations, the Sangre de Cristo formation, and the Madera limestone of the Magdalena group. The Sangre de Cristo formation which is Pennsylvanian-Permian in age has a thickness of 600-1000 feet in San Miguel County and consists of alternating dark-maroon shale and coarse pink feldspathic sandstone. A mantle of thick red soil covers much of the formation on the monument and is derived from the formation itself. The contact between the Sangre de Cristo formation and the older Madera limestone appears conformable or gradational regionally but may be disconformable locally. The Madera limestone, Pennsylvanian in age, consists of two limestone members. The upper member may be 1000 feet thick and consists of medium

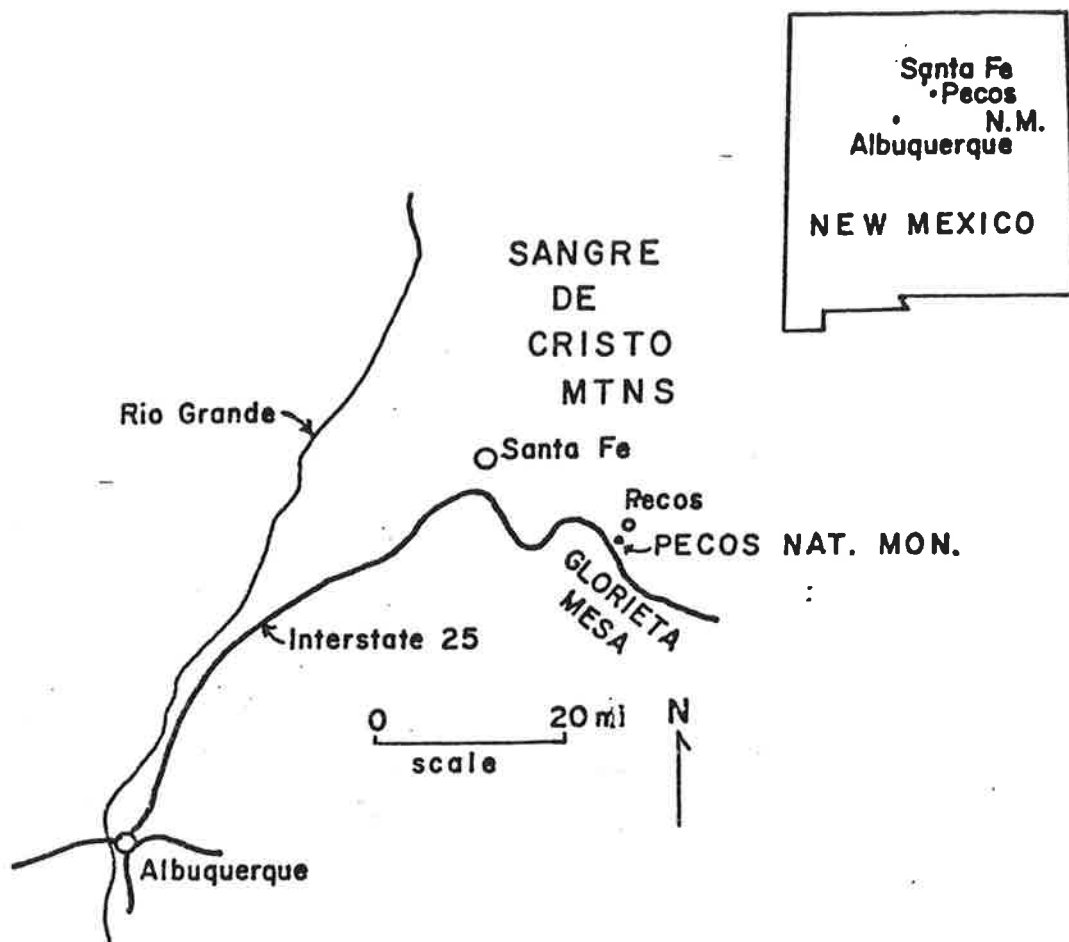


FIGURE 1. Location map for Pecos National Monument, north-central New Mexico

to coarsely crystalline light-gray commonly feldspathic limestone interbedded with coarse feldspathic sandstone. Near the top of the member, in places, some maroon shale is present. The lower member may be as much as 800 feet thick and consists of tan to light-gray to dark-gray fine-grained cherty limestone interbedded with dark-gray to black shale.

Pecos National Monument well no. 2 was drilled by the air rotary method to a depth of 560 feet below land surface. The generalized lithologic descriptions of the well cuttings which follow are from the microscopic analysis of the samples. The analysis is presented in Appendix I.

The upper 200 foot section of the hole stands in the lower portion of the Sangre de Cristo formation. The cuttings show that this section consists of 150 feet of reddish-brown to light brown shale and siltstone which rests on 50 feet of sandstone. The sandstone is light-brown, friable to soft, feldspathic, and poorly sorted with a clay and silt matrix. In part, it is coarse-grained and contains pebble gravel. This basal sandstone of the Sangre de Cristo formation becomes muddier near the contact with the Madera limestone.

The lower 360 foot section of the hole stands in the upper member of the Madera limestone. In the interval between 200 and 280 feet, the samples consist of a white to gray very fine- to fine-grained limestone interbedded with gray shale. The interval between 280 and 330 feet consists of very fine- to coarse-grained quartz limestone. Calcite is very common, which suggests fracture and cavity filling. The lower 350 to 560 foot interval consists of light gray to light brown very fine- to coarse-grained feldspathic limestone and gray to reddish-brown shales.

No coarse feldspathic sands were found in the samples of the interval between 200 and 560 feet. The reddish-brown shales that are found in places in the upper member of the Madera limestone are present. The hole does not penetrate the lower member of the Madera limestone.

GROUND WATER HYDROLOGY

Ground water withdrawn by the Pecos National Monument well no. 2 is derived from the upper member of the Madera limestone. In the upper member, ground water occurs in fractures and solution cavities. Large calcite crystals in the cuttings from interval 280 to 340 suggest that along zones of fracturing, circulating ground water has dissolved large openings in the limestone and redeposited the calcium carbonate in other zones of fracturing and previously open cavities.

A perched water table was encountered in the siltstone interval between 40 and 70 feet at approximately 60 feet BSL. This zone produced little water. The main ground water reservoir lies about 315 feet BSL at Pecos National Monument well no. 2. After tapping the reservoir, the water table rose to a level of 122.0 feet BTC (120.0 BSL). Confined ground water conditions exist. The main ground water reservoir is capped by a layer of limestone in which the fractures and cavities have been filled by calcite deposition, restricting upward movement. The reservoir is bound beneath by a shale unit which separates the reservoir tapped by the well from ground water beneath this water-producing zone. Some leakage from the artesian aquifer probably occurs.

From the water reservoir encountered between 315 and 340 feet, a discharge of approximately 35 to 40 gpm of water occurred during air rotary drilling. Flow steadily increased through this interval. No further increase in flow was observed until final interval, 500 to 560, when discharge out of the hole increased to 40-65 gpm. The water was muddy in the interval 315-350 and became gray when water from the lower interval 500-560 was tapped. The color was derived from shales encountered in drilling. The change in color and the increase in flow of the interval 500-560 further suggest that the tapped aquifer is confined on both lower and upper surfaces.

Between the intervals 0-280 and 340-560, the shales are water swelling. The hole was partially filled by the caving of these shales. To avoid the problem the hole was backfilled to 350 feet and sealed and casing was emplaced to 330 feet. The screen sits in the interval between 330 340 upon 10 more feet of casing. The casing and screen have an outer diameter of $5\frac{1}{2}$ inches. During the pump test performed August 9 and 10 after completion, water was slightly muddy initially but soon became clear and tasted good.

The pump test performed without an observation well, August 9 and 10, 1979, showed a drawdown of 75.8 feet in 24 hours at an average discharge of 42.8 gpm with no stabilization. Appendix II contained the data from the aquifer test and the time-drawdown, residual-drawdown, and calculated time-recovery curves. Specific capacity was 0.57 gpm/ft drawdown. A recovery of 65.0 feet (80% of total drawdown) occurred 110 minutes after pumping ceased. From the residual drawdown curve, the approximate calculated coefficient of transmissibility is 216 gpd/ft.

Pumping records on two wells at Rowe and Pecos which also withdraw water from the upper member of the Madera limestone show specific capacities of 4.5 and 2.0 gpm/ft drawdown, respectively. Drilling logs indicate the water comes from the arkosic sandstone beds, which were not penetrated or are absent at the Pecos National Monument well no. 2.

Water Chemistry

Table 1 compares the maximum permissible concentration limits of certain constituents as set by health criteria with well water from the Pecos well. Water from the well is clear and bears a good taste. The water contains no inorganic constituents in any harmful amount.

SUMMARY

Groundwater at Pecos National Monument well no. 2 is withdrawn from an artesian perched reservoir in the upper member of the Madera limestone. The water producing unit consists of a limestone, whose porosity and permeability is due to fractures and solution cavities. The coefficient of transmissibility is 216 gpd/ft. A drawdown of 75.8 feet was observed after 24 hours of pumping from a static water level of 122.0 feet BTC at an average pumping rate of 42.8 gpm. Specific capacity is 0.57 gpm/ft drawdown. A recovery of 80 per cent occurred 110 minutes after pumping ceased. Water from the well is clear, bears a good taste, and is fit for human use.

Table 1. Pecos well chemistry and EPA health standards

<u>Constituent</u>	<u>Maximum permissible Concentration (mg/l)</u>	<u>Pecos well water (mg/l)</u>
Arsenic	0.05	<0.01
Barium	1.0	0.1
Cadmium	0.01	<0.001
Chromium +6	0.05	<0.01
Fluoride	1.4-2.4	1.7
Lead	0.05	0.001
Mercury	0.002	<0.0004
Nitrogen Nitrate	45	1.1
Selenium	0.01	0.01
Silver	0.05	0.01

APPENDIX I

Sample analysis of Pecos National Monument Well no. 2 cuttings

<u>Interval</u>	<u>Sample Description</u>
SANGRE DE CRISTO FORMATION	
0-10	SHALE - Light reddish-brown, earthy, hard, calcareous, micaceous, water swelling, blocky.
10-20	SHALE - Light brown, earthy, moderately hard, non-calcareous, micaceous, water swelling, blocky.
20-30	SHALE - Light reddish-brown, a/a.
30-40	SHALE - Light gray, earth, moderately hard, calcareous, micaceous, water swelling, blocky, silty.
40-50	SILTSTONE - Light brown, waxy, hard, slightly calcareous, very micaceous, flaky.
50-60	SILTSTONE - Light brown, earthy, soft, calcareous, slightly sandy, water swelling, blocky.
60-70	SILTSTONE - Light brown, earthy, moderately hard to hard, micaceous, very sandy, clayey, water swelling, blocky, calcareous.
70-80	SHALE - Light brown, earthy, moderately hard to hard, noncalcareous, micaceous, water swelling, blocky, occasional clasts of mud and limestone, sand grains of quartz and lithic composition.
80-90	SHALE - Light brown, calcareous, a/a.
90-100	SHALE - Light brown, very calcareous, a/a.
110-120	SHALE - Light brown, calcareous, a/a.
120-150	SHALE - Light brown, mottled with gray, earthy,

- 150-70 SANDSTONE - Moderately hard, calcareous, micaceous,
water swelling, flaky to blocky, occasional
limestone and mud clasts.
- 150-70 SANDSTONE - Light brown, very fine- to medium-grained,
angular to subrounded, friable to soft,
grain composition - feldspar, quartz,
lithic, muddy calcareous matrix.
- 170-80 SANDSTONE - a/a, occasional coarse grains and pebble
gravel.
- 180-200 SANDSTONE - a/a, matrix becoming very muddy.
- MADERA LIMESTONE
- 200-10 LIMESTONE - Light brown, very fine to fine-grained, very
hard, slightly silty, dolomitic, white
calcite fill, with some medium- to dark gray
very micaceous calcareous moderately hard
shale.
- 210-30 LIMESTONE - Light gray, a/a.
- 230-40 LIMESTONE - Light to medium gray, a/a, with some medium
to dark gray carbonaceous calcareous micaceous
shale.
- 240-50 SHALE - Light to medium gray, earthy, hard, calcareous,
slightly carbonaceous, nonswelling, blocky.
- 250-60 LIMESTONE - Light to medium gray, reddish gray, micro-
crystalline to very fine-grained, dolomitic,
very hard. Reddish-gray limestone, muddy.

- 260-70 SHALE - Medium gray, earthy, moderately hard,
 calcareous, water swelling, micaceous,
 block, with some limestone, a/a.
- 270-80 SHALE - Medium gray, a/a, with some limestone, a/a.
- 280-300 LIMESTONE - Light brown, light gray, very fine to fine
 grained, very hard, abundant white calcite
 fill, dolomitic.
- 300-10 LIMESTONE - White, very fine-grained, dolomitic, very
 hard, clear quartz grains common, abundant
 white calcite fill.
- 310-20 LIMESTONE - White, a/a, with abundant white calcite fill.
- 320-30 LIMESTONE - Light gray, coarse-grained, dolomitic, very
 hard, sandy, white calcite fill common, some
 coarse-grained dolomitic rhombs.
- 330-40 LIMESTONE - White. a/a, with abundant white calcite fill
 and some glauconite, and SANDSTONE - Dark gray,
 fine- to coarse-grained, angular, soft to
 moderately hard, poor sorting, slightly
 micaceous carbonaceous slightly calcareous
 muddy matrix, very limy in parts.
- 340-50 SHALE - Dark reddish-brown, earthy, slightly calcareous,
 silty, micaceous, water swelling, blocky.
- 350-60 SHALE - Dark reddish-brown, a/a, sandy in parts, and
 LIMESTONE - Light brown, light gray, very fine-
 to fine-grained, coarser grained in parts,
 oolitic in parts, very hard, dolomitic.

360-70	LIMESTONE - Light brown, light gray, a/a.
370-80	LIMESTONE - Light gray. light brown, dark gray, very fine- to medium-grained, very hard, micaceous, muddy, dolomitic, some pyrite.
380-90	SHALE - Medium to dark reddish-gray, earthy, moderately hard to hard, micaceous, water swelling, blocky.
390-410	LIMESTONE - Light brown, light gray, very fine- to fine- grained, occasionally coarsely grained, dolomitic, very hard, pyritic, micaceous.
410-20	LIMESTONE - Light brown, very fine-to fine-grained, white calcite fill, muddy, orange feldspar common, dolomitic, very hard.
420-40	SHALE - Medium gray, earthy, hard, micaceous, carbonaceous, slightly calcareous, blocky, nonswelling, some pyrite.
440-50	SHALE - Medium gray, earthy, moderately hard, micaceous, blocky, water swelling, calcareous, orange feldspar common.
450-60	SHALE - Medium gray, light reddish brown, a/a.
460-80	SHALE - Light gray, earthy, hard, very micaceous, orange feldspar common, nonswelling, calcareous with some light brown to light gray limestone.
480-90	LIMESTONE - Light brown, light gray, very fine to fine- grained, very hard, dolomitic, micaceous,

muddy with medium gray calcareous nonswelling shale.

- 490-500 SHALE - Medium gray, earthy, moderately hard to hard, micaceous, calcareous, blocky, nonswelling.
- 500-10 SHALE - Light reddish-brown, earthy, moderately hard, micaceous, occasional mud clust, blocky, calcareous, water swelling.
- 510-40 LIMESTONE - Light brown, light gray, a/a, interbedded with SHALE - Light reddish-brown, a/a.
- 540-50 SHALE - Medium to dark gray, earthy, calcareous, moderately hard to hard, micaceous, water swelling, blocky.
- 550-60 LIMESTONE - Dark gray, very fine to fine grained very hard, dolomitic, blocky.

APPENDIX II

RECOVERY DATA

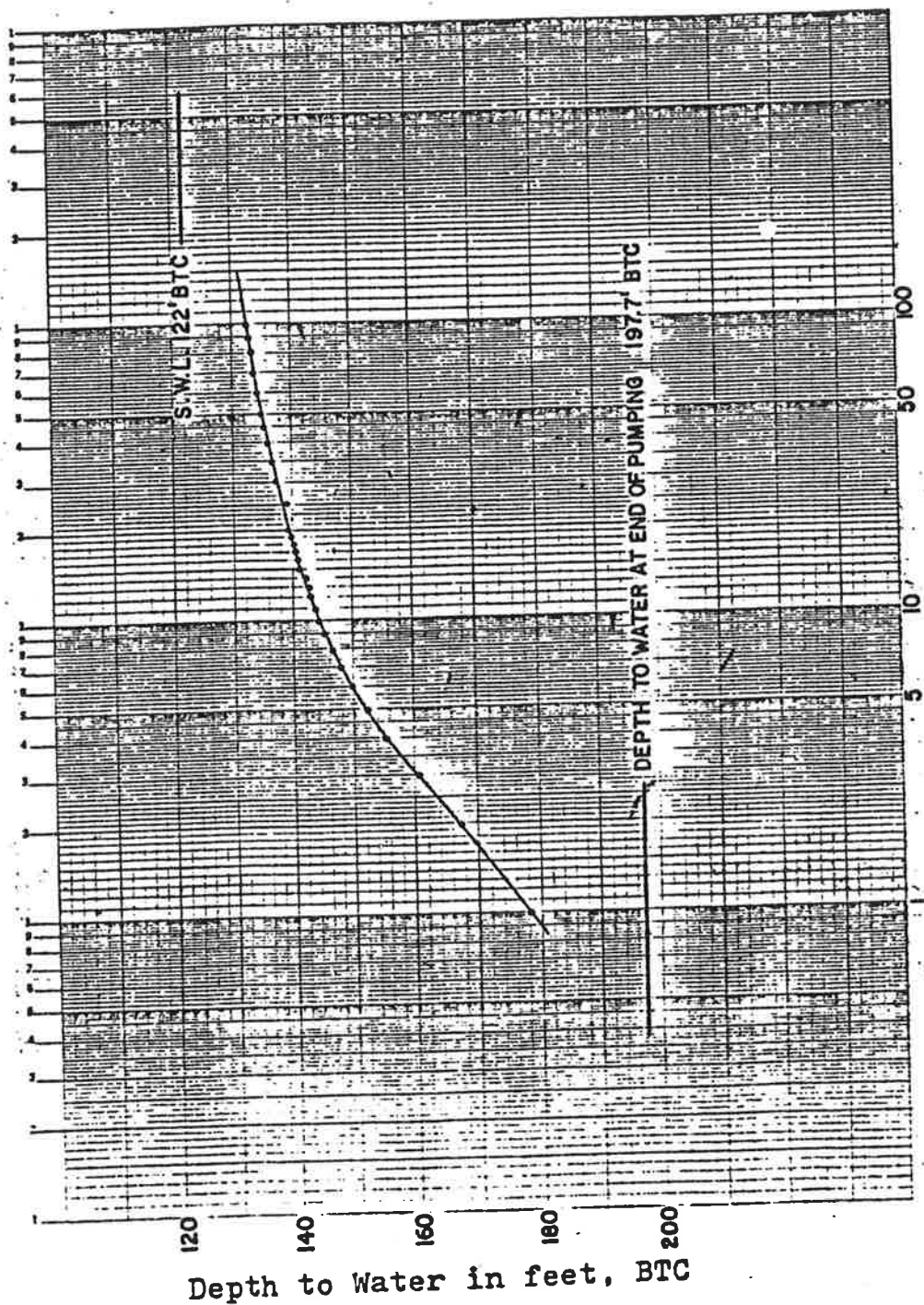
Clock Time (hour)	Time, Pump Start (t, min)	Time, Pump Stop (t', min)	Ratio (t/t')	Water Level (BTC, ft.)	Drawdown from Pumping Curve	Calculated Recovery
10 August 1979						
0935	1444	0	-	197.70	197.70	0
		1.0	1445	177.98	197.70	19.73
		2.0	723	167.39	197.70	30.31
		3.0	482	160.22	197.69	37.47
		4.0	362	155.69	197.69	42.00
		5.0	290	152.47	197.69	45.22
		6.0	240	150.10	197.69	47.59
		7.0	207	148.00	197.68	49.68
		8.0	182	146.80	197.68	50.88
		9.0	161	145.60	197.68	52.08
		10.0	145	144.90	197.68	52.78
		11.0	132	144.05	197.68	53.68
		12.0	121	143.40	197.68	54.28
		13.0	112	142.84	197.67	54.83
		14.0	104	142.14	197.67	55.53
0945	1454	15.0	97.3	141.60	197.67	56.07
		16.0	91.3	141.23	197.67	56.44
		17.0	85.9	140.80	197.67	56.87
		18.0	81.2	140.50	197.67	57.17
		19.0	77.0	140.21	197.66	57.45
		20.0	73.2	139.81	197.66	57.85
		25.0	58.8	139.65	197.65	58.00
		30.0	49.1	137.75	197.65	59.90
		35.0	42.3	136.95	197.64	60.69
		40.0	37.1	136.20	197.63	61.43
		45.0	33.1	135.68	197.62	62.37
		50.0	29.9	135.25	197.61	62.36
		60.0	25.1	134.55	197.59	63.04
		70.0	21.6	133.90	197.57	63.67
		80.0	19.1	133.53	197.56	64.03
0955	1464	90.0	17.0	132.92	197.54	64.62
		100.0	15.4	132.54	197.52	64.98
1035	1504					
1045	1514					
1055	1524					
1105	1534					
1115	1544					

Park: Visitor Center Well #2, Pecos National Monument
 Elevation: 6890 ft. MSL
 Date: August 9 and 10, 1979
 Observers: Alan Bengtson, Paul Christensen, Garland Moore

DRAWDOWN DATA

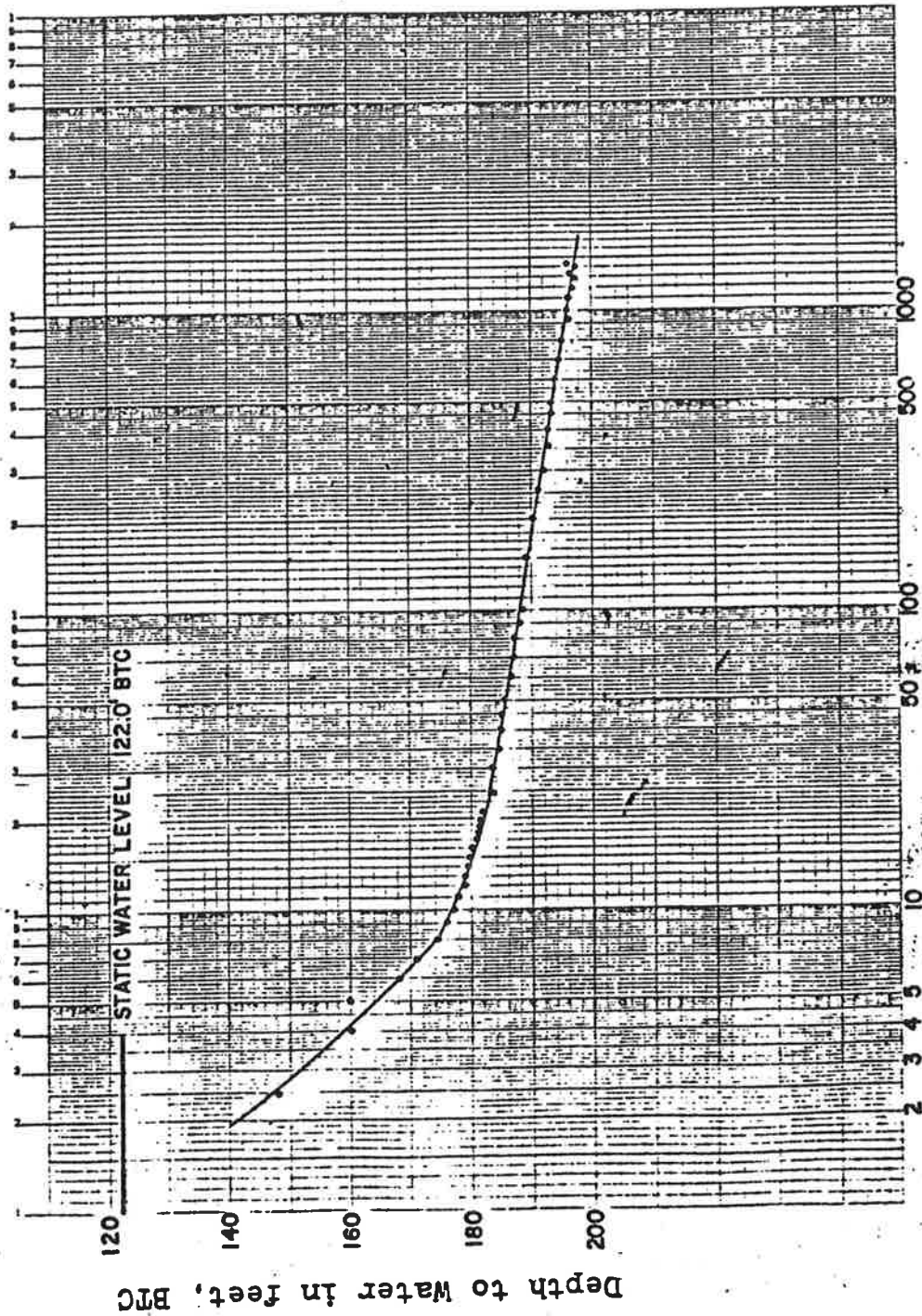
Clock Time (hour)	Pumping Time (min)	Water Level BTC (feet)	Drawdown (feet)	Specific Capacity	Remarks
9 August 1979					
0931	0	121.95	0		SWL
	2.5	148.10	26.15	1.91	5 gal/6 sec Q=50gpm
	4.0	160.18	38.23	1.31	
	5.0	160.13	38.18	1.31	
	6.0	168.35	46.40	1.08	
	7.0	171.02	49.07	1.02	
	8.0	174.87	52.92	.94	
	9.0	176.11	54.16	.92	
	10.0	177.15	55.20	.91	
	11.0	177.90	55.95	.89	
	12.0	178.78	56.83	.88	
	13.0	179.15	57.20	.87	
	14.0	179.64	57.69	.87	
	15.0	180.08	58.03	.86	
	16.0	180.60	58.65	.85	
	17.0	181.04	59.09	.85	
	18.0	181.41	59.46	.84	
	19.0	181.78	59.83	.84	
	20.0	182.02	61.07	.83	
	21.0	182.25	61.30	.82	
	25.0	183.60	61.65	.81	
	30.0	183.89	61.94	.81	
	35.0	184.60	62.65	.80	
	40.0	185.10	63.15	.79	
0945					
0956					

1016	45.0	185.28	63.33	.79	
	50.5	186.02	64.07	.78	
1031	60.0	186.70	64.75	.77	
	70.0	187.20	65.25	.77	
	80.0	187.55	65.60	.76	
1101	90.0	188.11	66.16	.76	5 gal/6 sec Q=50gpm
	100.0	188.62	66.67	.75	
	150.0	189.16	67.21	.64	5 gal/6 sec Q=42.8gpm (throughout rest of test)
1348	200.0	190.25	68.30	.63	
	257.0	191.30	69.35	.61	
	300.0	192.15	70.20	.61	
1526	355.0	192.75	70.80	.60	
1611	400.0	192.90	70.95	.60	
1701	450.0	193.18	71.23	.60	580 mhos @ 12°C
1751	500.0	193.50	71.55	.60	
1931	600.0	194.10	72.15	.59	
2111	700.0	194.80	72.85	.59	
2251	800.0	195.40	73.45	.58	
10 August 1979					
0101	930.0	196.20	74.25	.58	
0211	1000.0	196.40	74.45	.57	
0351	1100.0	196.80	74.85	.57	
0541	1210.0	197.25	75.30	.57	
0711	1300.0	197.42	75.47	.57	
0740	1329.0	197.20	75.25		Engine sputtered due to change of fuel tanks
0851	1400.0	197.49	75.54	.57	Pump off; adjusted value from graph: measured value 196.61 ft. BTC to water level not valid because of measurement taken just seconds after pump was turned off, allowing recovery.
0935	1444.0	197.70	75.75	.57	



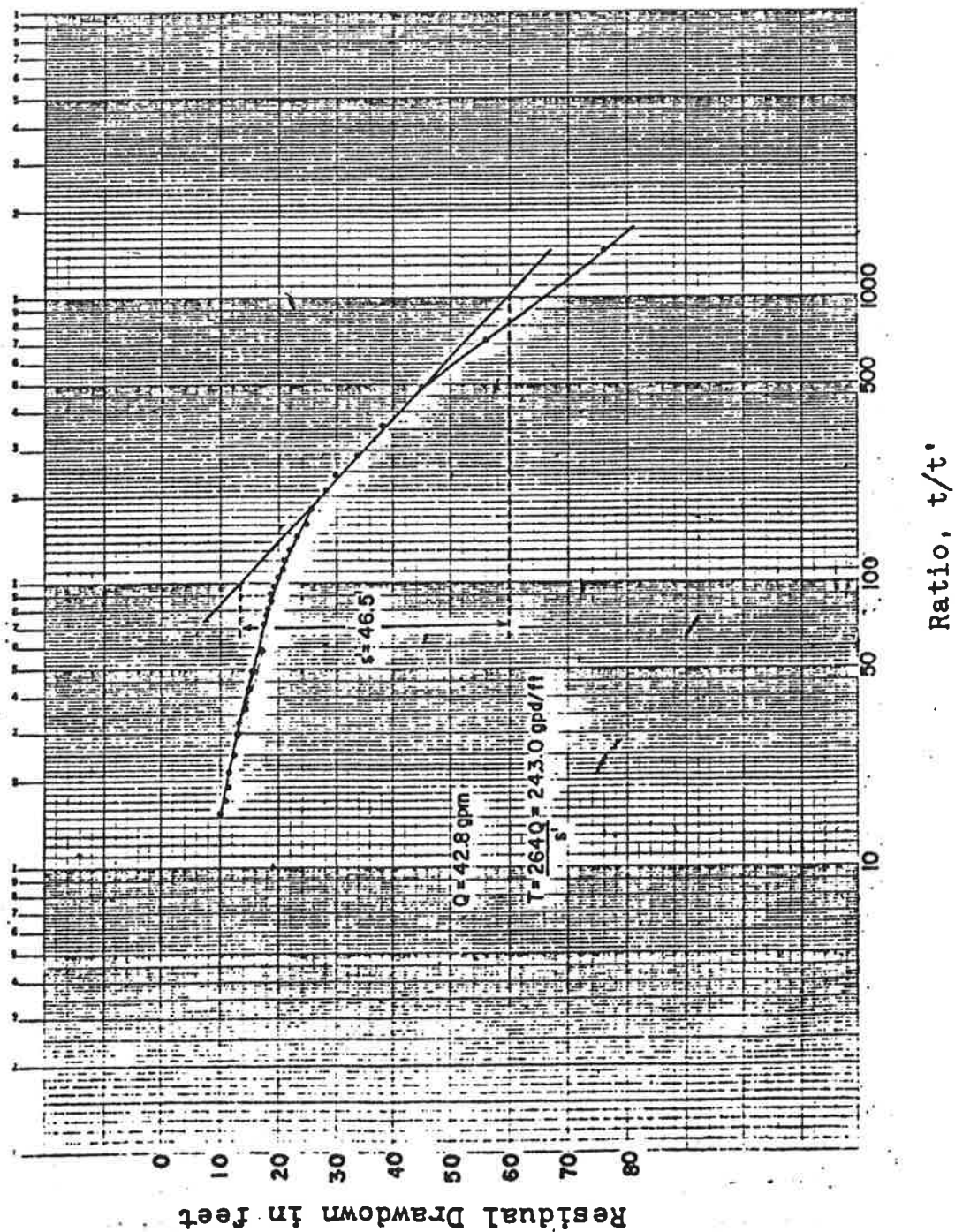
Time (t) elapsed since pumping ceased in minutes

TIME-RECOVERY CURVE, Pecos National Monument well #2
August 8 and 9, 1979



Time (t) elapsed since pumping started in minutes

TIME-DRAWDOWN CURVE, Pecos National Monument well #2
August 8 and 9, 1979



RESIDUAL DRAWDOWN CURVE, Pecos National Monument well #2