SEASONAL CHANGES IN GROUND-WATER LEVELS IN THE SHALLOW AQUIFER NEAR HAGERMAN AND THE PECOS RIVER, CHAVES COUNTY, NEW MEXICO

By Herbert S. Garn

U.S. GEOLOGICAL SURVEY
Open-File Report 88-197

Prepared in cooperation with the
PECOS RIVER COMMISSION

Albuquerque, New Mexico
1988

DEPARTMENT OF THE INTERIOR

DONALD PAUL HODEL, Secretary

U.S. GEOLOGICAL SURVEY

Dallas L. Peck, Director

For additional information
write to:

District Chief
U.S. Geological Survey
Water Resources Division
Pinetree Office Park
4501 Indian School Rd. NE, Suite 200
Albuquerque, New Mexico 87110

Copies of this report can
be purchased from:

U.S. Geological Survey
Books and Open-File Reports Section
Federal Center
Box 25425
Denver, Colorado 80225

CONTENTS

FIGURES

TABLES

CONVERSION FACTORS

In this report, measurements are given in inch-pound units. The following table contains factors for converting to metric (SI) units.

Multiply inch-pound unit	By	To obtain metric (SI) unit
foot	0.3048	meter
mile	1.609	kilometer
square mile	2.590	square kilometer
cubic foot per second	0.02832	cubic meter per second

Sea level: In this report, "sea level" refers to the National Geodetic Vertical Datum of 1929 (NGVD of 1929) -- a geodetic datum derived from a general adjustment of the first-order level nets of both the United States and Canada, formerly called "Mean Sea Level."

SEASONAL CHANGES IN GROUND-WATER LEVELS IN THE SHALLOW AQUIFER NEAR HAGERMAN AND THE PECOS RIVER, CHAVES COUNTY, NEW MEXICO

By Herbert S. Garn

ABSTRACT

The Pecos River near Hagerman in Chaves County, New Mexico, historically has been a gaining stream. In 1938, the slope of the water table in the shallow alluvial aquifer near Hagerman was toward the Pecos River. By 1950, a large water-table depression had formed in the alluvial aquifer southwest of Hagerman. The depression enlarged from 1950 to 1975.

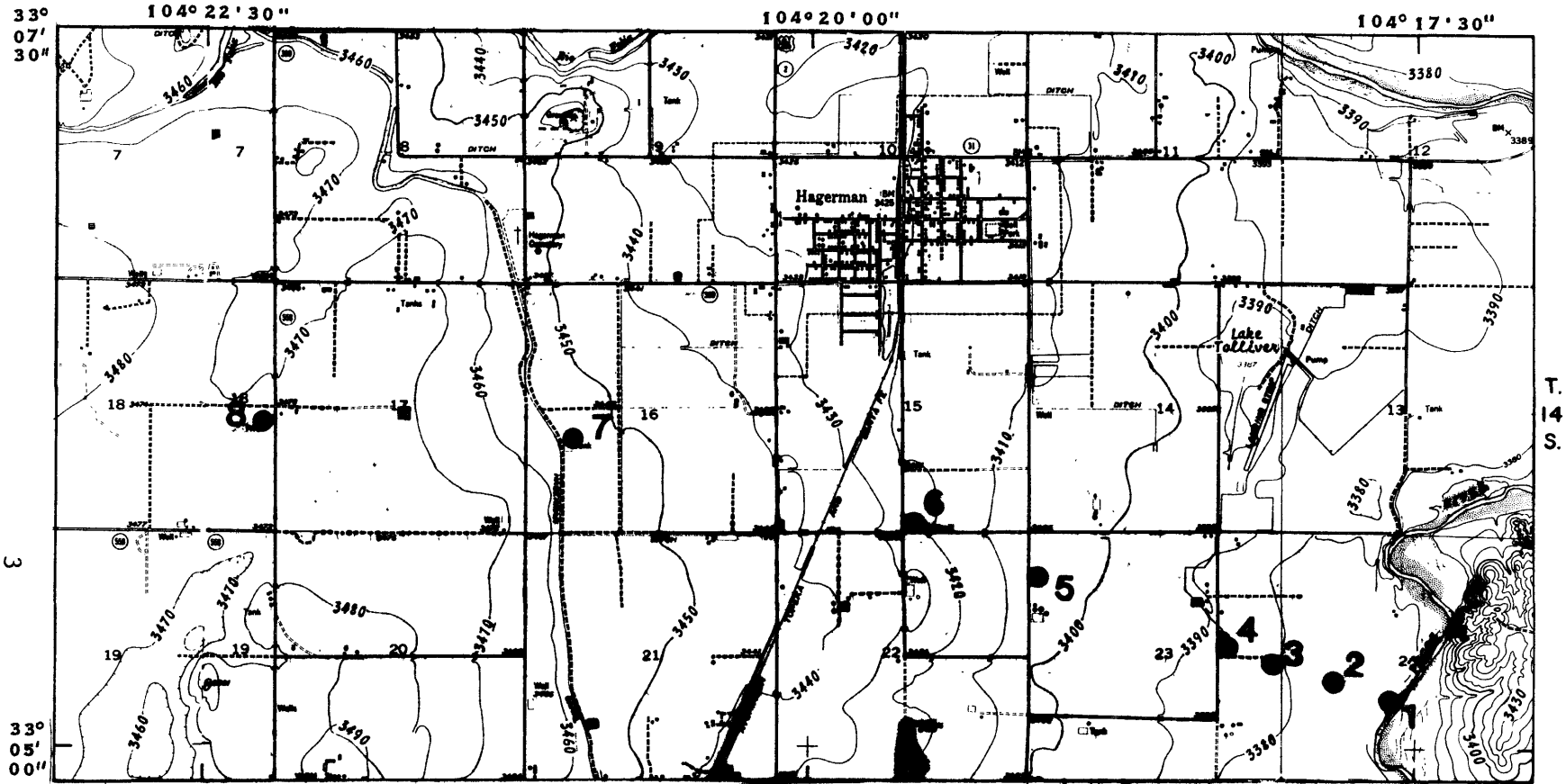
Continued enlargement of this depression could reverse the direction of ground-water flow to the Pecos River. Water levels were measured during 1981-85 along a line of wells extending from the Pecos River to a point within the depression to document seasonal water-level changes. Winter water levels indicated a water-level high about 2 miles west of the Pecos River. In summer, the high is not as distinct, and the water-level gradient is away from the Pecos River toward the depression for at least 1.5 miles.

INTRODUCTION

The relation between the Pecos River and water levels in the shallow alluvial aquifer near Hagerman, N. Mex. (fig. 1), has been of concern to water users and managers. The configuration of the water table in the aquifer west of the Pecos River has changed considerably since 1938 (Welder, 1983). A water-level map of the shallow aquifer in the Roswell Basin did not show any closed cones of depression in the water table in 1938 (Morgan, 1938, pl. 2). By 1950, a mappable depression greater than 10 feet in depth had formed in the shallow aquifer west of Hagerman (fig. 2). By 1975, this depression had grown to enclose an area of 15 square miles extending eastward to within 2 miles of the Pecos River (Welder, 1983). Continued enlargement of this depression could reverse the direction of the water-level gradient and cause water to seep from the Pecos River into the alluvium and flow westward.

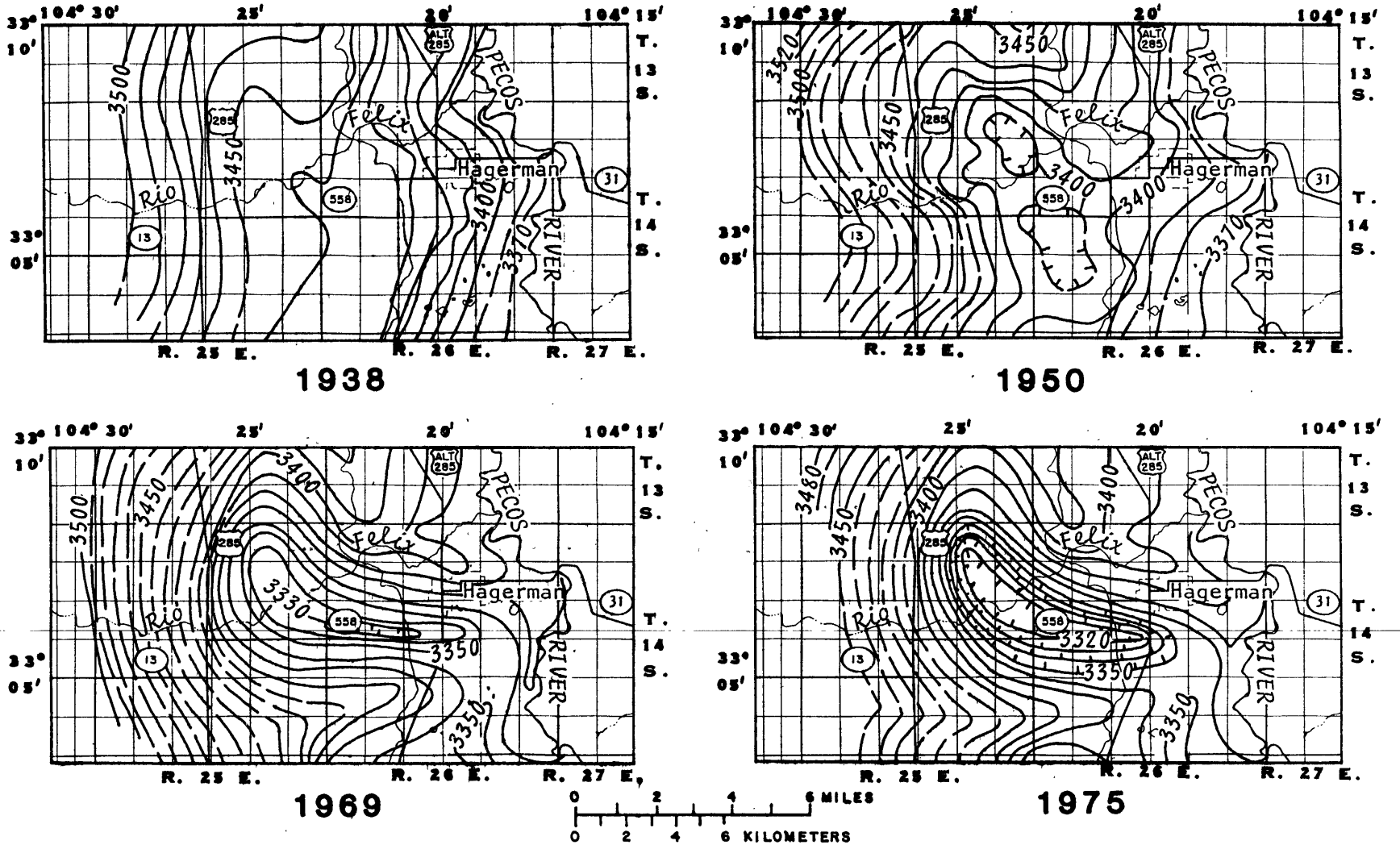
Purpose and Scope

In 1981, the U.S. Geological Survey began a study of water levels in the aquifer southwest of Hagerman in cooperation with the Pecos River Commission. The purpose of the study was to document seasonal water-level changes in the area between the Pecos River and the ground-water depression. This report presents results of water-level measurements taken from July 1981 through April 1985 from eight wells completed in the shallow aquifer along a line from the Pecos River to a point within the depression. This line of wells was used to define the existence and persistence of a ground-water high between the depression and the Pecos River. The location of the wells is shown in figure 1.



Base from U.S. Geological Survey, 1:24,000, Hagerman, 1951; and Hagerman SW, 1952

Figure 1.--Location of the study area and selected wells.



EXPLANATION

——3550— — WATER-LEVEL CONTOUR--Shows altitude of water level. Contour interval 10 feet. Dashed where approximate. Datum is sea level

Figure 2.--Configuration of the water-level surface in the shallow aquifer near Hagerman in January 1938, 1950, 1969, and 1975 (modified from Welder, 1983).

Well-Numbering System

The system of numbering wells in New Mexico is based upon the common subdivision of public lands into sections. The well location number, in addition to designating the well, locates its position in the land network. The well number is divided by periods into four segments. The first segment denotes the township north or south of the New Mexico Base Line, and the second denotes the range east or west of the New Mexico Principal Meridian. Because all wells in this report are south of the base line and east of the meridian, the letters S. and E. are not included in the location number. The third segment denotes the section. The fourth segment of the number, which consists of three digits, denotes the 160-, 40-, and 10-acre tracts, respectively, in which the well is situated in the section. For this purpose, the section is divided into four quarters, numbered 1, 2, 3, and 4 in the normal reading order, for the northwest, northeast, southwest, and southeast quarters, respectively. The first digit of the fourth segment gives the quarter section, which is a tract of 160 acres. Similarly, the 160-acre tract is divided into four 40-acre tracts numbered in the same manner, and the second digit denotes the 40-acre tract. The 40-acre tract is divided into four 10-acre tracts, and the third digit denotes the 10-acre tract. Thus, well 14.26.36.142 is in the NE¼ SE¼ NW¼ sec. 36, T. 14 S., R. 26 E. (fig. 3). In this report, a well reference number, as in figure 1 and table 1, also is used.

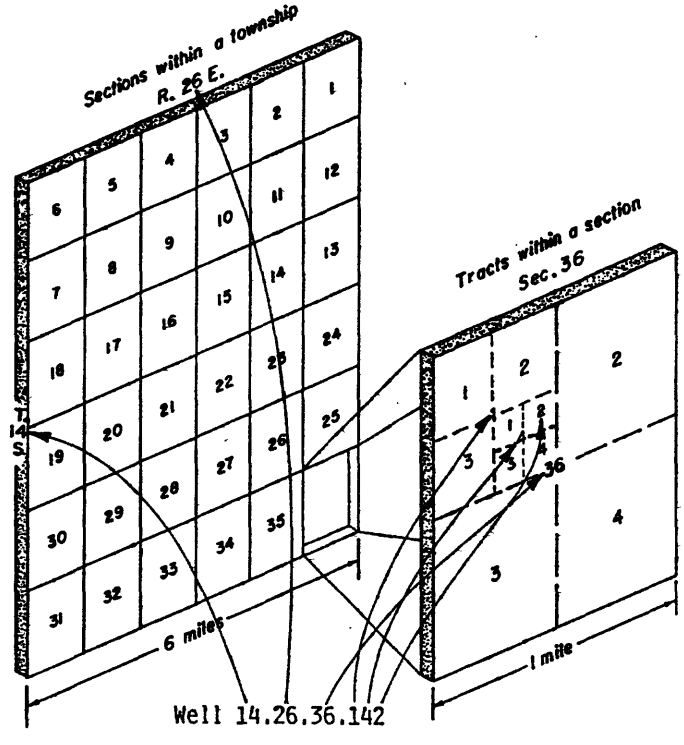


Figure 3.--System of numbering wells in New Mexico.

GEOHYDROLOGIC SETTING

The study area is within the Roswell ground-water basin as defined by Welder (1983, fig. 1). The eastern limit of the ground-water basin generally follows the Pecos River; the western limit is about 30 to 40 miles from the river. The basin consists of an eastward-dipping artesian aquifer and an overlying alluvial water-table aquifer in the east, separated by a leaky confining bed. The alluvial, or shallow, aquifer is hydraulically connected with the Pecos River along most of the eastern boundary (Welder, 1983).

The shallow aquifer primarily is composed of valley-fill alluvial deposits of clay, silt, sand, and gravel. Lyford (1973) described three units in the valley fill: a clay unit, a carbonate gravel unit, and a quartzose unit that is the principal water-bearing unit. The shallow aquifer extends about 15 to 20 miles west of the Pecos River and generally is less than 250 feet thick. In the study area, the saturated thickness ranged from approximately 50 to 150 feet in 1975 (Welder, 1983, fig. 8).

Ground-water flow in the shallow aquifer generally is eastward toward the Pecos River and then southward. The river historically has been a gaining stream from Acme to Artesia (fig. 1), including the reach near Hagerman, for most of the period of record (Welder, 1983, p. 17).

The principal means of discharge from the shallow aquifer is through wells. Additional discharge occurs by seepage to the Pecos River and by evapotranspiration where the water table is shallow. Some discharge by downward leakage to the artesian aquifer may occur if ground-water withdrawals lower artesian water levels below the shallow water levels. Recharge to the shallow aquifer occurs from precipitation, surface runoff, return flow from irrigation, and upward leakage from the artesian aquifer. Additional information on the geohydrologic characteristics of the shallow aquifer may be obtained from reports by Morgan (1938), Hantush (1957), Mower and others (1964), and Lyford (1973).

SEASONAL CHANGES IN ALTITUDE OF THE SHALLOW WATER-LEVEL SURFACE

The water table in the shallow aquifer is defined by water levels in wells that penetrate the upper few feet of the aquifer. Not all water-level measurements obtained for this study are representative of the water table as defined in this sense. The study used existing wells (wells 3-8 in table 1 and fig. 1) that penetrate a substantial thickness of the shallow aquifer. Water levels in these wells represent a composite hydraulic head of the shallow aquifer; the water levels generally are useful, however, for documenting seasonal changes.

The water table of the shallow aquifer represents the energy head of the aquifer. Ground water flows from areas of high hydraulic head to areas of low hydraulic head. The direction of ground-water flow is perpendicular to lines of equal water-table altitudes (Driscoll, 1986, p. 79). The direction of ground-water movement in the study area is determined by the presence or absence of a water-table high between the depression and the Pecos River.

Water-level data collected during 1981-85 from selected wells along a line east of the Pecos River (fig. 1) are presented in table 1. Water-level measurements were made monthly during the first 2 years to establish short-term changes in water levels and seasonally thereafter. Other miscellaneous measurements are available at other well locations.

Water levels in the line of wells have a definite seasonal variation. Winter and summer water levels from the Pecos River to the ground-water depression during the 4 years of study are shown in figure 4 (well 8 is not shown in the figure because of its much lower water level). Winter water levels indicate the presence of a water-level high at well 6, approximately 2 miles west of the Pecos River. Little or no ground water is withdrawn for irrigation during the winter, and water levels recover to their highest annual altitude at this time. In the summer, however, when irrigation withdrawals are the greatest, the water-level high is not as distinct, and the water-level gradient is away from the Pecos River toward the depression for at least 1.5 miles adjacent to and west of the river (fig. 4).

Water levels of wells within the ground-water depression (wells 7 and 8) show little recovery from summer pumping during the winter. Water levels in these wells varied less than 4 feet during the period of study (table 1). In wells 7 and 8, the mean water levels were 3,349.8 and 3,318.9 feet above sea level, respectively. In well 8, the water level was about 30 feet lower than that in well 7, indicating the persistence of the ground-water depression noted by Welder (1983) in his water-level map for 1975 (fig. 2). Well 8 is near the deepest part of the depression mapped for 1975.

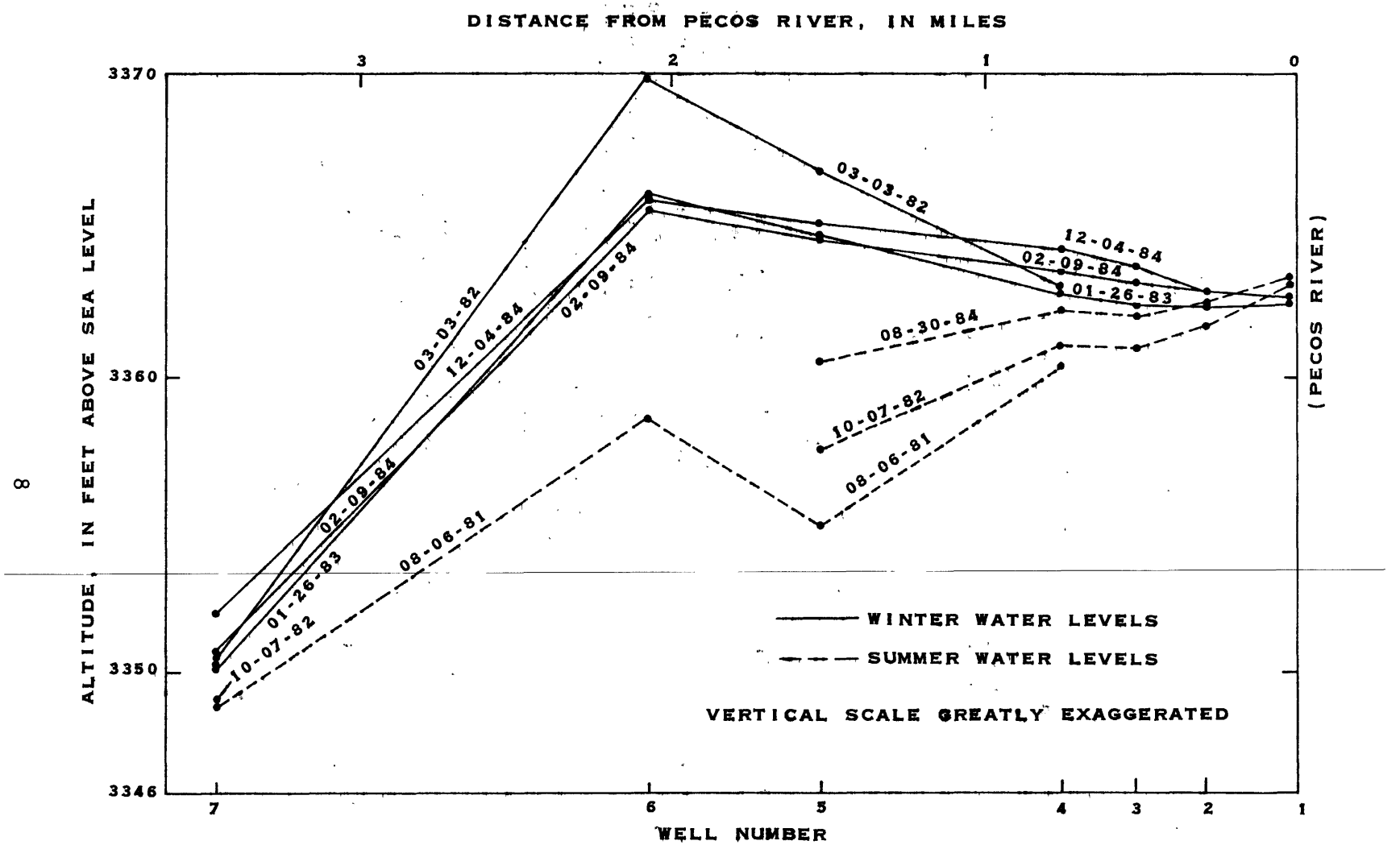


Figure 4.--Winter and summer water levels in selected wells, 1981-84.

See figure 1 for location of wells.

Intensive water-level measurements of wells in the Roswell Basin were repeated during January and February 1984. A number of the wells with winter 1975 measurements were remeasured in the winter of 1984. The change in water-level altitudes from winter 1975 to winter 1984 measurements is given in table 2 and shown in figure 5. Water-level declines have occurred in the northeastern part of T. 14 S., R. 25 E. and the southwestern part of T. 14 S., R. 26 E., near the deepest part of the depression and to the west. Declines in this area ranged from 2 to 21 feet. The area immediately west of the river (Tps. 13 and 14 S., R. 26 E.) between the depression and the Pecos River, including the line of wells, has experienced a rise in winter water levels between 1975 and 1984 measurements. Hudson and Borton (1983, p. 122) presented a ground-water level change map for the Roswell-Artesia area based on winter 1974 and winter 1979 measurements. They also found a rise in water levels in the shallow aquifer in Tps. 13 and 14 S., R. 26 E. and a decline in water levels in Tps. 13 and 14 S., R. 25 E.

Changes in the altitude of water levels in well 4 for the duration of this study are shown in figure 6. The hydrograph shows the seasonal variation of water levels and a rising trend of winter water levels during the study, as is also indicated by the 1975 and 1984 mass water-level measurements. Summer water levels in well 4 commonly may decline below the riverbed altitude of 3,362 feet.

The monthly recovery of water levels after summer ground-water withdrawals in 1982 and the development of a ground-water divide are shown in figure 7. A significant recovery of water levels appears to occur in wells 5 and 6. A ground-water high is well established by December. The data indicate that water-level gradients reverse direction from winter to summer in wells 1-5 adjacent to the Pecos River.

Three winter seepage measurements (April 7, 1982, February 28, 1983, and February 9, 1984) made on a 2.5-mile reach of the Pecos River along the area of the ground-water depression confirmed that the river was a gaining stream in the reach at those times. The river gained about 1.5 cubic feet per second in the reach. Seepage measurements are not available during the summer irrigation season to identify seepage gains or losses.

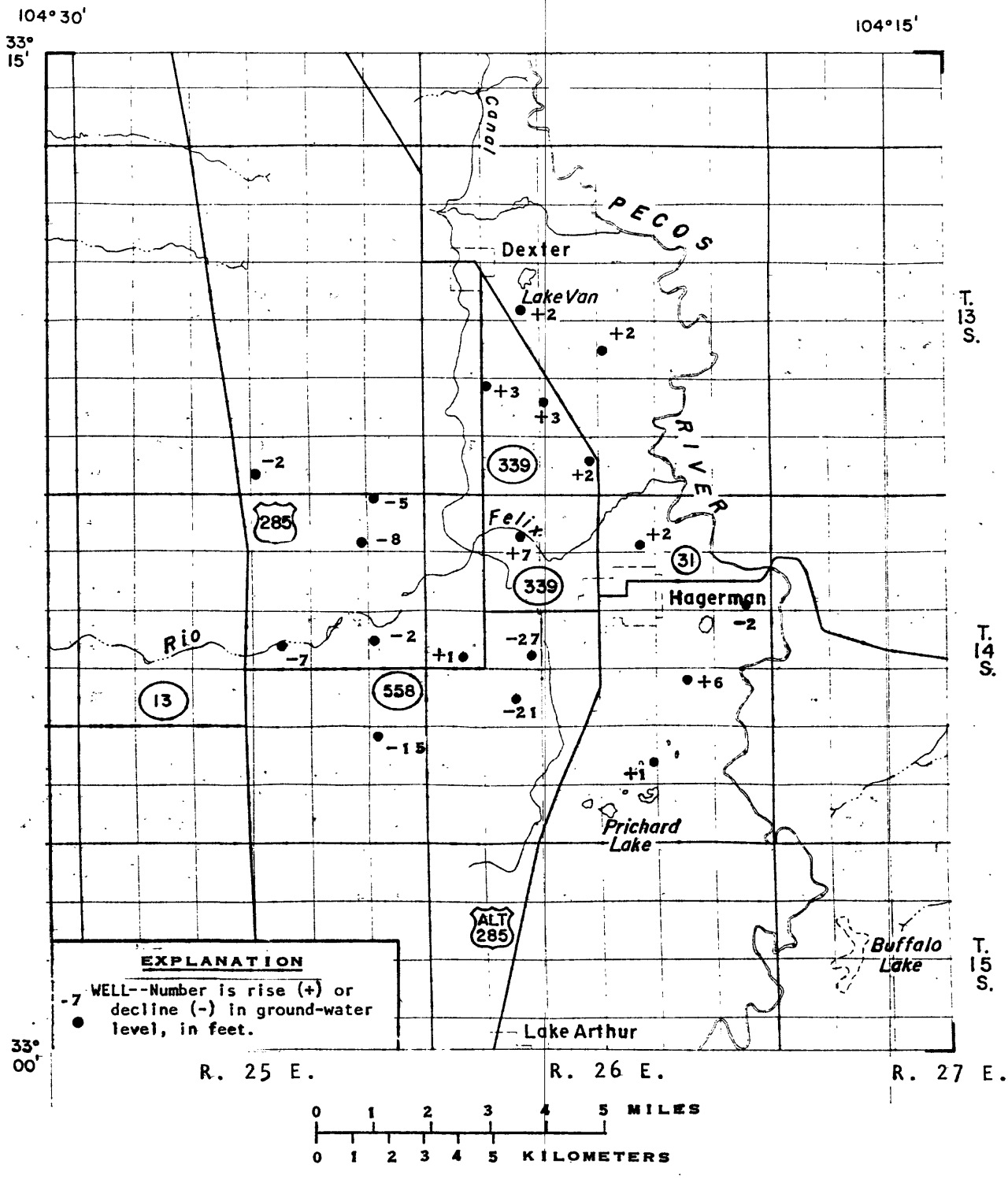


Figure 5.--Change in water levels in the shallow aquifer near Hagerman between winter 1975 and winter 1984.

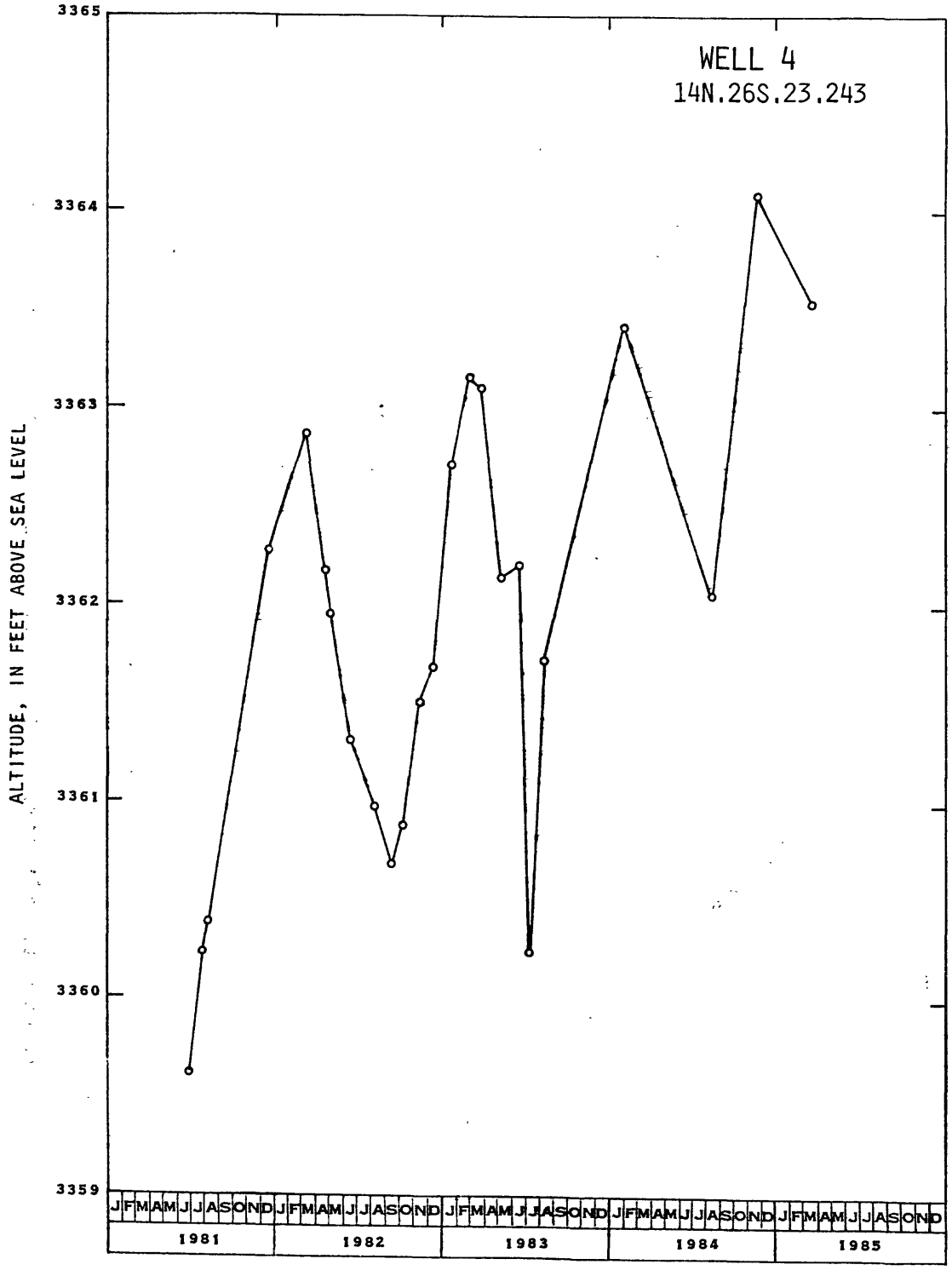


Figure 6.--Water levels in well 4, 1981-85.

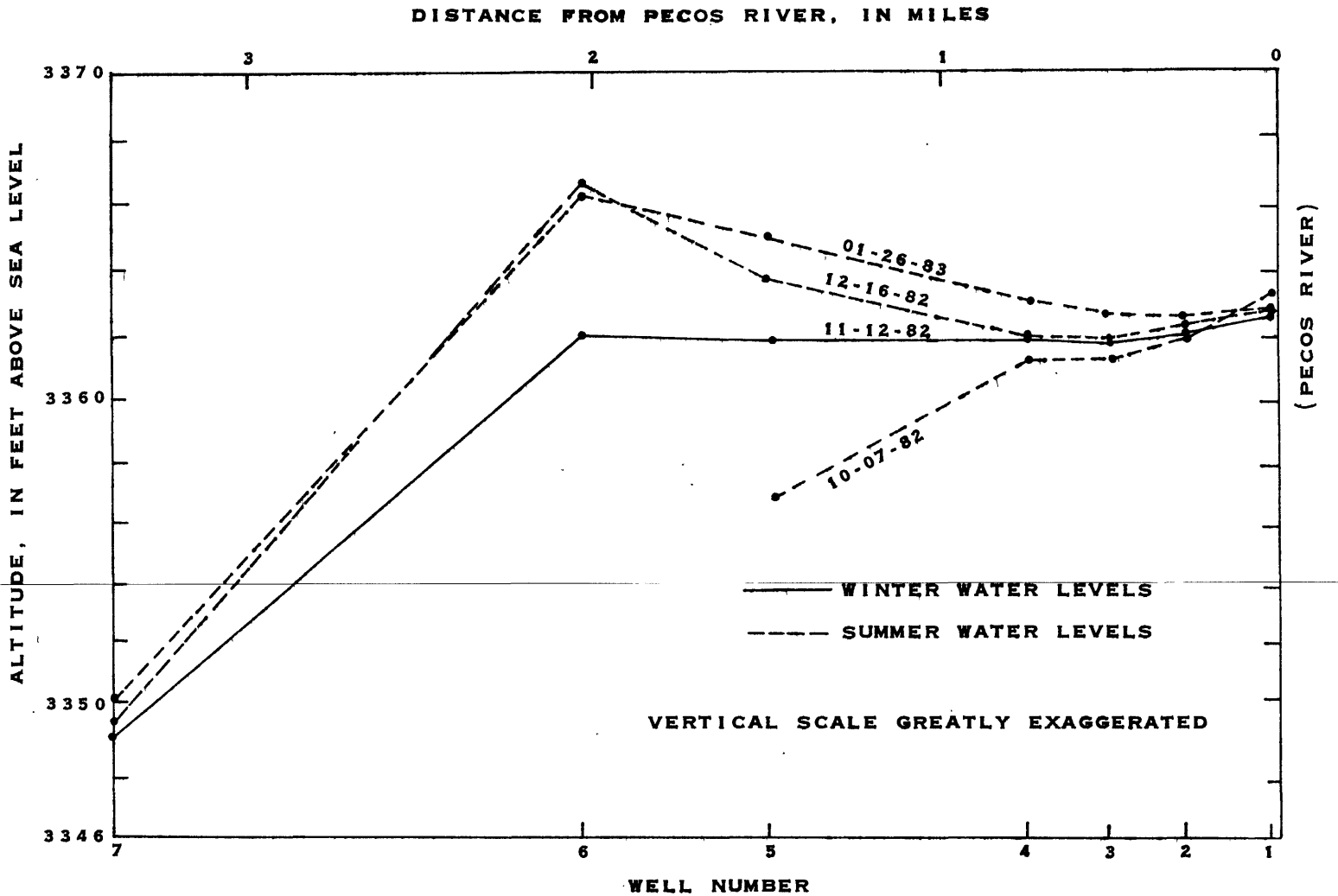


Figure 7.--Monthly recovery of water levels in selected wells after summer ground-water withdrawals, 1982. See figure 1 for location of wells.

SUMMARY

Water levels in a line of wells completed in the shallow alluvial aquifer from the Pecos River to a ground-water depression southwest of Hagerman have a definite seasonal variation, based on measurements made during 1981-85. During the winter, a water-level high exists between the depression and the river. During the summer, when ground-water withdrawals are greatest, the water-level high is less distinct and the gradient is away from the river for about 1.5 miles west of the river. These seasonal changes in the water-level gradient may have been taking place since 1975. Since 1975, ground-water levels have been rising in the area between the depression and the Pecos River.

REFERENCES

Driscoll, F.G., 1986, Groundwater and wells (2d ed.): St. Paul, Johnson Division, 1108 p.

Hantush, M.S., 1957, Preliminary quantitative study of the Roswell ground-water reservoir, New Mexico: New Mexico Institute of Mining and Technology, State Bureau of Mines and Mineral Resources Division, 118 p.

Hudson, J.D., and Borton, R.L., 1983, Ground-water levels in New Mexico, 1978-1980: New Mexico State Engineer Basic Data Report, 283 p.

Lyford, F.P., 1973, Valley fill in the Roswell-Artesia area, New Mexico: U.S. Geological Survey open-file report, 26 p.

Morgan, A.M., 1938, Geology and shallow-water resources of the Roswell artesian basin, New Mexico: New Mexico State Engineer Bulletin 5, 95 p.

Mower, R.W., Hood, J.W., Cushman, R.L., Borton, R.L., and Galloway, S.E., 1964, An appraisal of potential ground-water salvage along the Pecos River between Acme and Artesia, New Mexico: U.S. Geological Survey Water-Supply Paper 1659, 98 p.

Welder, G.E., 1983, Geohydrologic framework of the Roswell ground-water basin, Chaves and Eddy Counties, New Mexico: New Mexico State Engineer Technical Report 42, 28 p.

Table 1. Records of selected wells

[Altitude above sea level]

Well number (figure 1)	Well location number	Depth of well (feet)	Altitude of land surface (feet)	Water level		Remarks
				Altitude (feet)	Date measured	
1	14.26.24.324	15	3,370	3,361.70	06-11-82	Auger
				3,362.26	08-02-82	hole near
				3,364.10	09-13-82	Pecos River.
				3,362.97	10-07-82	2-inch-diameter
				3,362.32	11-12-82	PVC pipe.
				3,362.45	12-16-82	
				3,362.46	01-26-83	
				3,362.25	02-28-83	
				3,362.20	03-28-83	
				3,363.82	05-10-83	
				3,361.88	06-21-83	
				3,364.32	07-12-83	
				3,361.88	08-19-83	
				3,362.38	02-09-84	
				3,363.26	08-30-84	
				3,362.62	12-04-84	
				3,363.54	04-01-85	
2	14.26.24.312	19	3,376	3,361.52	06-11-82	Auger hole.
				3,361.54	08-02-82	2-inch-diameter
				3,361.36	09-13-82	PVC pipe.
				3,361.58	10-07-82	
				3,361.66	11-12-82	
				3,361.98	12-16-82	
				3,362.16	01-26-83	
				3,362.39	02-28-83	
				3,362.30	03-28-83	
				3,361.42	05-10-83	
				3,361.51	06-21-83	
				3,361.68	07-12-83	
				3,361.93	08-19-83	
				3,362.68	02-09-84	
				3,362.32	08-30-84	
				3,362.66	12-04-84	
				3,362.75	04-01-85	

Table 1. Records of selected wells - Continued

Well number (figure 1)	Well location number	Depth of well (feet)	Altitude of land surface (feet)	Water level		Remarks
				Altitude (feet)	Date measured	
3	14.26.23.422	104	3,386	3,361.73	04-13-82	Abandoned.
				3,361.36	04-30-82	7-inch-diameter
				3,361.26	06-11-82	steel
				3,361.16	08-02-82	pipe.
				3,360.75	09-13-82	
				3,360.94	10-07-82	
				3,361.41	11-12-82	
				3,361.57	12-16-82	
				3,362.27	01-26-83	
				3,362.67	02-28-83	
				3,362.63	03-28-83	
				3,361.28	05-10-83	
				3,361.37	06-21-83	
				3,359.41	07-12-83	
				3,361.92	08-19-83	
				3,363.08	02-09-84	
				3,361.85	08-30-84	
				3,363.53	12-04-84	
				3,363.55	04-01-85	
4	14.26.23.243	-	3,389	3,356.82	07-14-81	Unused.
				3,359.53	07-24-81	16-inch-
				3,360.28	08-06-81	diameter steel
				3,360.44	08-14-81	pipe.
				3,362.28	12-10-81	
				3,362.87	03-03-82	
				3,362.18	04-13-82	
				3,361.96	04-30-82	
				3,361.33	06-11-82	
				3,361.00	08-02-82	
				3,360.71	09-13-82	
				3,360.89	10-07-82	
				3,361.52	11-12-82	
				3,361.69	12-16-82	
				3,362.73	01-26-83	
				3,363.16	02-28-83	
				3,363.10	03-28-83	
				3,362.15	05-10-83	
				3,362.22	06-21-83	
				3,360.26	07-12-83	
				3,361.74	08-19-83	
				3,363.42	02-09-84	

Table 1. Records of selected wells - Continued

Well number (figure 1)	Well location number	Depth of well (feet)	Altitude of land surface (feet)	Water level		Remarks
				Altitude (feet)	Date measured	
4	14.26.23.243	-	3,389	3,362.07	08-30-84	Unused.
				3,364.09	12-04-84	16-inch-
				3,363.54	04-01-85	diameter steel pipe.
5	14.26.23.113	203	3,403	3,307.62	07-14-81	Irrigation
				3,349.26	07-24-81	well.
				3,353.45	07-31-81	16-inch-
				3,354.38	08-06-81	diameter pipe.
				3,356.06	08-14-81	
				3,365.26	12-10-81	
				3,366.69	03-03-82	
				Pumping	04-13-82	
				3,349.58	04-30-82	
				Pumping	06-11-82	
				Pumping	08-02-82	
				Pumping	09-13-82	
				3,357.41	10-07-82	
				3,361.46	11-12-82	
				3,363.35	12-16-82	
				3,364.63	01-26-83	
				Pumping	02-28-83	
				Pumping	03-28-83	
				Pumping	05-10-83	
				Pumping	06-21-83	
				Pumping	07-12-83	
				Pumping	08-19-83	
				3,364.45	02-09-84	
				3,360.43	08-30-84	
				3,364.96	12-04-84	
				Pumping	04-01-85	
6	14.26.15.433	245	3,423	3,357.36	07-31-81	Irrigation
				3,358.46	08-06-81	well.
				Pumping	08-14-81	16-inch-
				3,367.41	12-10-81	diameter pipe.
				3,369.82	03-03-82	
				3,365.54	04-13-82	
				Pumping	06-11-82	
				Pumping	08-02-82	
				Pumping	09-13-82	
				Pumping	10-07-82	

Table 1. Records of selected wells - Continued

Well number (figure 1)	Well location number	Depth of well (feet)	Altitude of land surface (feet)	Water level: Altitude (feet)	Water level: Date measured	Remarks
6	14.26.15.433	245	3,423	3,361.59	11-12-82	Irrigation well. 16-inch-diameter pipe.
				3,366.34	12-16-82	
				3,365.87	01-26-83	
				3,367.26	02-28-83	
				Pumping	03-28-83	
				Pumping	05-10-83	
				Pumping	06-21-83	
				Pumping	07-12-83	
				Pumping	08-19-83	
				3,365.35	02-09-84	
				Pumping	08-30-84	
				3,365.64	12-04-84	
				Pumping	04-01-85	
7	14.26.16.314	190	3,456	3,348.92	07-14-81	Unused. 16-inch-diameter pipe.
				3,349.03	07-24-81	
				3,348.90	07-31-81	
				3,348.86	08-06-81	
				3,348.93	08-14-81	
				3,349.16	12-10-81	
				3,350.43	03-03-82	
				3,350.43	04-13-82	
				3,349.83	06-11-82	
				3,349.56	08-02-82	
				3,349.07	09-13-82	
				3,349.01	10-07-82	
				3,348.91	11-12-82	
				3,349.27	12-16-82	
				3,350.02	01-26-83	
				3,350.32	02-28-83	
				3,350.78	03-28-83	
				3,350.48	05-10-83	
				3,350.02	06-21-83	
				3,349.80	07-12-83	
				3,349.01	08-19-83	
				3,350.65	02-09-84	
				3,350.16	08-30-84	
				3,351.95	12-04-84	
				3,352.86	04-01-85	

Table 1. Records of selected wells - Concluded

Well number (figure 1)	Well location number	Depth of well (feet)	Altitude of land surface (feet)	Water level		Remarks
				Altitude (feet)	Date measured	
8	14.26.18.422	212	3,475	3,318.25	07-14-81	Unused.
				3,318.17	07-24-81	16-inch-
				3,318.10	07-31-81	diameter pipe.
				3,318.03	08-06-81	
				3,317.96	08-14-81	
				3,317.89	12-10-81	
				3,318.86	03-03-82	
				3,319.48	04-13-82	
				3,320.17	06-11-82	
				3,319.87	08-02-82	
				3,319.42	09-13-82	
				3,319.15	10-07-82	
				3,318.50	11-12-82	
				3,318.52	12-16-82	
				3,318.89	01-26-83	
				3,319.24	02-28-83	
				3,319.76	03-28-83	
				3,320.19	05-10-83	
				3,320.28	06-21-83	
				3,316.45	07-12-83	
				3,319.84	08-19-83	
				3,318.91	02-09-84	
				3,317.68	08-30-84	
				3,319.10	12-04-84	
				3,319.99	04-01-85	

Table 2. Comparison of 1975 and 1984 winter water-level altitudes in the shallow aquifer near Hagerman

[(est), estimated]

Well location number	Water-level altitude in feet above sea level		Change in water level, feet
	1975	1984	
13.25.34.314	3,401	3,399	-2
13.26.05.331	3,441	3,440	-1
13.26.10.112	3,400	3,400	0
13.26.17.443	3,402	3,404	+2
13.26.22.313	3,392	3,394	+2
13.26.28.311	3,399	3,402	+3
13.26.29.113	3,405	3,408	+3
13.26.33.421	3,397	3,399	+2
14.24.32.333	3,524	3,530	+6
14.25.01.111	3,365	3,360	-5
14.25.02.444	3,323	3,315	-8
14.25.13.311	3,320	3,318	-2
14.25.15.413	3,389	3,382	-7
14.25.25.111	3,377(est)	3,362	-15
14.26.03.433	3,393	3,395	+2
14.26.05.433	3,389	3,396	+7
14.26.12.433	3,378	3,376	-2
14.26.17.444	3,318	3,345	+27
14.26.18.431	3,316	3,317	+1
14.26.20.411	3,413	3,392	-21
14.26.23.232	3,355	3,361	+6
14.26.27.424	3,354	3,355	+1