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HYDRAULIC CHARACTERISTICS OF AQUIFERS PENETRATED BY IRRIGATION WELLS IN THE VICINITY OF OROVADA, HUMBOLDT COUNTY, NEVADA, 1953

By

Omar J. Loeltz

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Introduction

During the period April 21-23, 1953, a pumping test was made on several irrigation wells penetrating alluvium about a mile southwest of Orovada, Nev., in order to determine the hydraulic characteristics of the aquifers commonly penetrated by wells in that vicinity. The test was made by the writer, engineer, and J. L. Poole, geologist, United States Geological Survey, as part of an investigation of the ground-water resources of Nevada being by the U. S. Geological Survey in cooperation with the State Engineer. Much recent interest in the development of underground water by pumping in the Orovada area made it desirable to make the pumping test in order to obtain data that might be helpful in the proper planning of future development.

The locations of the wells for which data were obtained are shown in figure 1. The data collected during the pumping test, together with other data pertinent to the wells, are listed in table 1 at the end of this report.

Conditions for conducting the pumping test were not ideal. A. E. Hosack, owner of well 43/37-34C3, was forced to begin pumping the well at 2:00 p. m. on April 16, 1953, five days before the date scheduled for the beginning of the test. Fortunately, according to Mr. Hosack, the well was pumped at a rather constant rate of about 800 gallons per minute until 6:00 a. m. on April 18, after which time the well was pumped at an essentially constant rate which during the pumping test was determined to be 885 gallons per

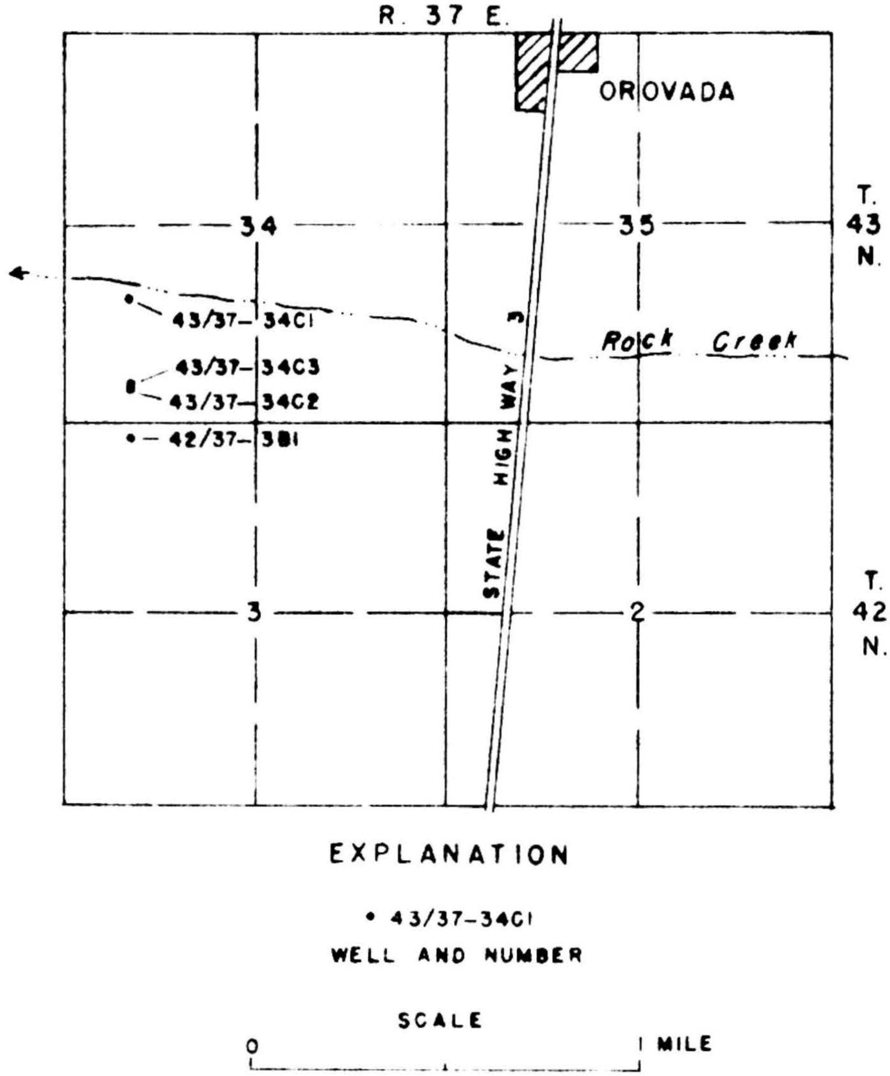

Figure 1. Sketch map showing the location of wells for which data were collected during a pumping test near Orovada, Humboldt County, Nev., during the period April 21-23, 1953.

minute. Measurements of water level immediately prior to pumping and during the first five days of pumping were almost wholly lacking. Water-level measurements were made only in wells 43/37-34C1 and 43/37-34C2. No other measurements of water level were obtained until the afternoon of April 21. Consequently, any of the drawdown data that normally are obtained during a pumping test were not available and it was necessary to rely almost entirely on recovery data in the determination of the hydraulic characteristics of the aquifers. Another unfavorable aspect was the large difference in the depth of the wells. In order to obtain reliable results all the wells should tap the same water-bearing beds. The probability that the wells used in this test tapped the same beds seemed somewhat remote, considering the differences in the depths of the wells and the distances between them.

The formulas used in determining the hydraulic characteristics of an aquifer are based on the assumption that the aquifer is areally extensive and isotropic. The wells used in this pumping test were drilled near the lower margin of the alluvial apron fronting the west side of the Santa Rosa Range. Thus, the likelihood that the beds penetrated by the wells would meet the ideal conditions upon which the formulas are based seems somewhat remote. However, in the past, values for the hydraulic characteristics of aquifers obtained as a result of controlled pumping tests have been rather constant, even for areas where aquifers were neither extensive nor isotropic, provided that the individual water-bearing beds were freely connected hydraulically and that the anisotropic properties of the aquifer were not too pronounced. Therefore, in spite of the unfavorable conditions, both known and surmised, the pumping test was made in the hope that it would at least indicate the order of magnitude of the principal hydraulic properties of the aquifer.

Pumping Tests

Measurements of water level were made in the wells shown in figure 1, beginning in the afternoon of April 21 and continuing until the afternoon of April 23. Measurements given to hundredths of a foot were made with a steel tape, and those to tenths of a foot were obtained by means of a pressure gage attached to an air line of known length. A circular orifice was installed at the end of the discharge pipes to measure the rates of pumping. A microbarograph recorded changes in air pressure. These changes are shown in figure 8 at the end of this report.

Well 43/37-34C3 was pumped at an essentially uniform rate until 1:05 p. m., April 22, at which time the pump was stopped. Measurements of water level were continued in all the wells in order to observe the effects of stopping the pump. At 1:26 p. m., April 23, after about 24 hours had elapsed, well 43/37-34C1, 1,200 feet north of well 43/37-34C3, was pumped for about 2 hours in order to obtain additional data for computing the transmissibility of the aquifer penetrated by the wells.

Interpretation of Data

The recovery data obtained for well 43/37-34C3 after the pump was stopped at 1:05 p. m. on April 22 are shown in figure 2. The depths to water, in feet below land-surface datum, are plotted as ordinates on a linear scale against the time, in minutes, after pumping stopped as abscissas on a logarithmic scale. It will be noted that the pattern of the plotted points, except in the upper right-hand portion of the graph, approximates a straight line. It is the slope of this straight line that is used in the determination of the coefficient of transmissibility of the aquifer penetrated by the well. This

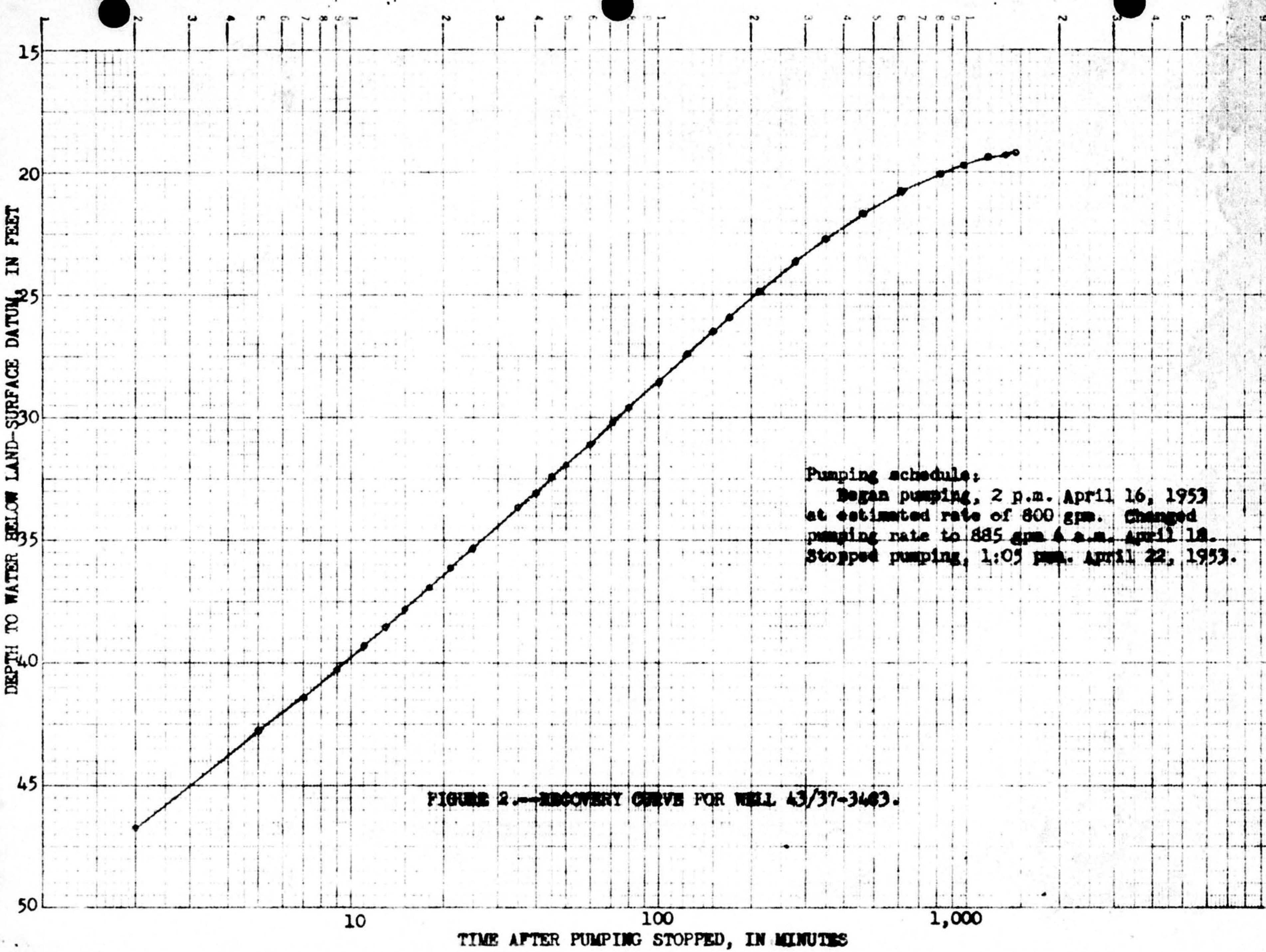

FIGURE 2.--RECOVERY CURVE FOR WELL 43/37-3463.

important hydraulic characteristic is a measure of the ability of the aquifer to transmit water. It may be defined as the number of gallons per day that will be transmitted through each mile-wide section of the water-bearing material being investigated, measured normal to the direction of flow of the water, for each foot per mile of hydraulic gradient, and at the prevailing temperature of the ground water. The slope of the plotted points was determined by using the depth-to-water level measurements noted during the first 2 hours after pumping had stopped. If all the theoretical conditions had been met, and if adjustments of the observed water level had been made for the continuation of the pumping effects and the fluctuations due to changes in atmospheric pressure, the pattern of all the plotted points would have been a straight line. The slope of this straight line would be essentially the same as the slope of the straight-line portion of the curve defined by the unadjusted plot of observed water-level measurements shown on figure 2. Therefore, using a method similar to the one used by Jacob,1/ the transmissibility of the aquifer penetrated by the well was computed by multiplying the average rate of discharge of the well, in gallons per minute, by 264 and dividing this product by the change in water level, in feet, during one log cycle of time. The average rate of discharge of the well during the latter part of the pumping period was 885 gallons per minute. Figure 2 indicates that the change in water level per log cycle of time is about 11.0 feet. The coefficient of transmissibility, according to these data, therefore, is 21,200 gallons per day per foot.

1/ Jacob, C. E., 1946, Drawdown test to determine effective radius of an artesian well: Am. Soc. Civil Eng. Proc., V. 72, no. 5, p. 636.

Figure 3 was drawn by using data obtained from well 42/37-3B1 after well 43/37-34C3 had been shut down. The circles represent unadjusted depth-to-water-level measurements whose pattern is an elongated "s". The points enclosed by triangles are depth-to-water-level measurements adjusted for the carryover effects due to pumping, and the points enclosed by squares are measurements adjusted both for the effects due to the previous pumping and the changes in water level caused by changes in atmospheric pressure, assuming that the water level in the well responded fully to these changes. Under ideal conditions the pattern of the points after proper adjustments for the carryover effects of the previous pumping and for changes in atmospheric pressure are made, should be a concave-upward line asymptotic to a horizontal line (in the lower left-hand part of the graph) indicating the depth to water when pumping was stopped and asymptotic to a line of constant slope in the right-hand part of the graph. The plot of the points enclosed by squares in the right half of figure 3 has a somewhat variable slope of about 2.3 feet per log cycle of time. The transmissibility of the water-bearing beds penetrated by the well is therefore 264 times the rate of discharge of well 43/37-34C3, which was 885 gallons per minute, divided by 2.3, or about 100,000 gallons per day per foot.

On figure 4 are shown plots of unadjusted and adjusted depth-to-water-level measurements made in well 43/37-34C1 after the pumping of well 43/37-34C3 was stopped. The pattern of the plots is similar to that for well 42/37-3B1. The centers of the circles represent unadjusted observations, whereas the points enclosed by triangles represent observations adjusted both

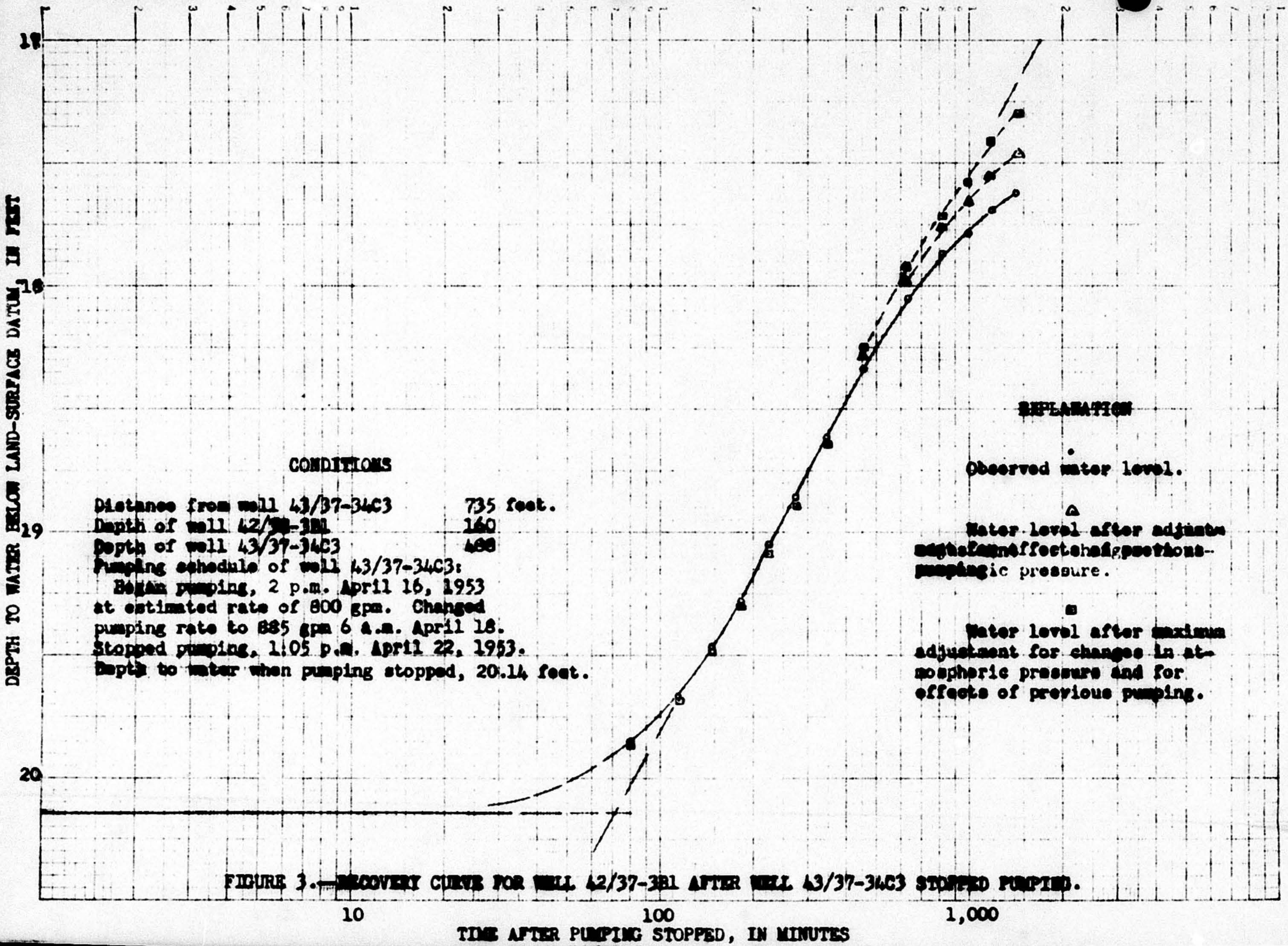

FIGURE 3.—RECOVERY CURVE FOR WELL 42/37-3B1 AFTER WELL 43/37-34C3 STOPPED PUMPING.

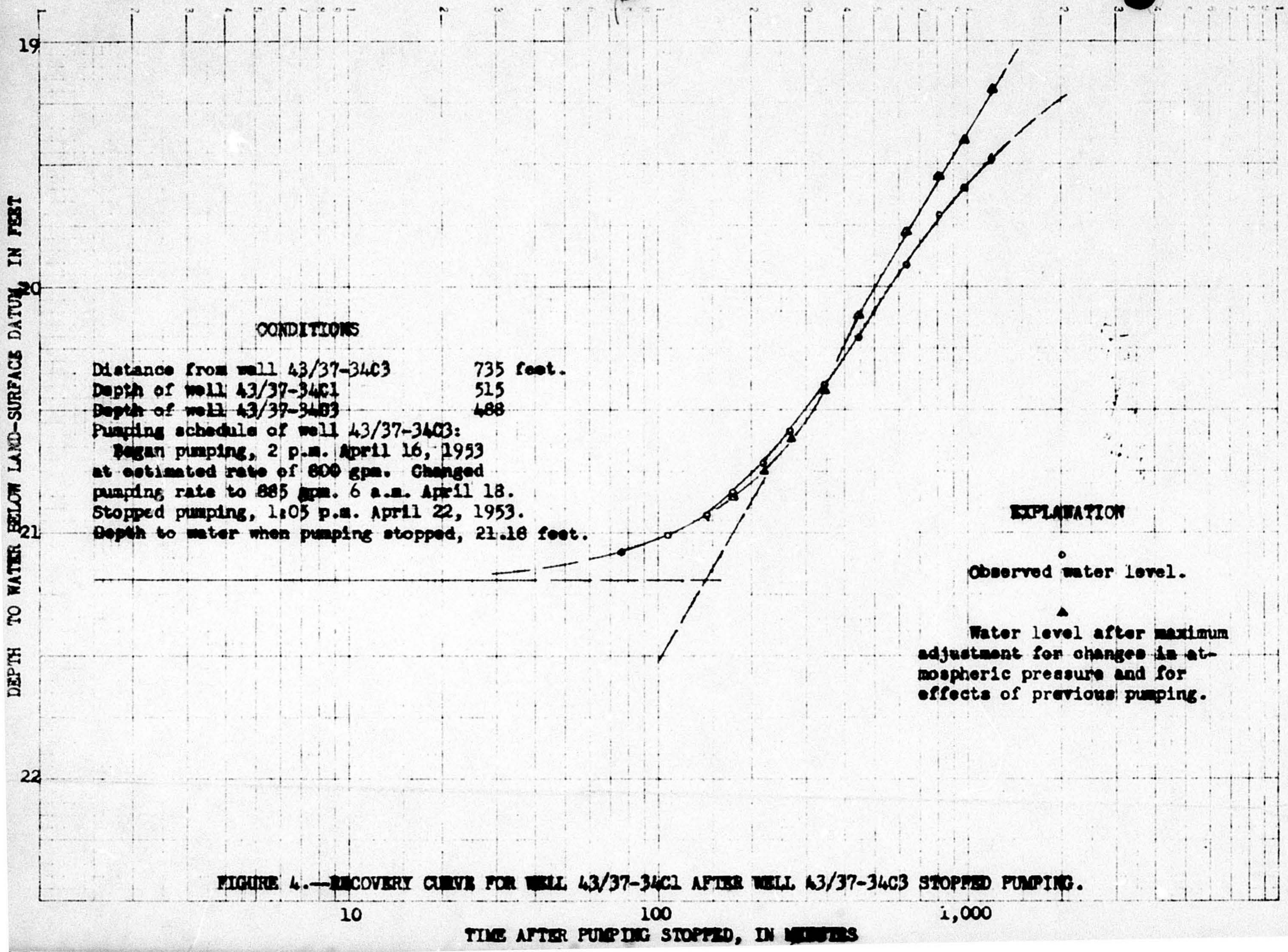

FIGURE 4.—RECOVERY CURVE FOR WELL 43/37-34C1 AFTER WELL 43/37-34C3 STOPPED PUMPING.

for the effects of the previous pumping of well 43/37-34C3 and for the changes in water level caused by changes in atmospheric pressure, assuming that the water level in the wells responded fully to these changes. The straight line which best fits the plot of adjusted observations on the right half of the curve indicates a change in water level of about 2.1 feet per logarithmic cycle of time. The transmissibility, therefore, is computed as 264 times 885 gallons per minute, divided by 2.1 feet, or about 110,000 gallons per day per foot.

There are several explanations for the wide range in values of the coefficients of transmissibility noted at the three wells. One is that the water-transmitting properties of the aquifer change as much as the coefficients indicate. If that were true, the formulas used to determine the transmissibility do not apply and consequently the transmissibility figures are of little or no value. Another possible explanation for the apparently large differences in the coefficients of transmissibility is that the wells do not tap essentially the same water-bearing beds. This is a possibility, inasmuch as the wells are drilled on an alluvial fan built in large part by an ephermeral stream. Under these conditions the areal extent of many of the water-bearing beds would tend to be limited and the hydraulic connection between beds might be poor. Thus only a part of the yield of a discharging well might influence the rate of change of water level in an observation well. ~~might enter the observation well.~~ Also, water from a water-bearing bed or beds not common to the discharging well might enter the observation well and thus reduce the rate of change of water level in it. Similarly, even though the water-bearing beds are extensive, if the water in some is confined and in others it is not confined, pumping effects in the artesian beds are transmitted to an observation well some distance from the pumped well in but a small fraction of the time that such effects are transmitted through beds where the water is unconfined. Under these conditions, especially for short periods of pumping, the water in the unconfined beds tapped by the observation well would tend to reduce the rate of change of water level in the well caused by the transmission of pumping effects through the artesian beds. It will be noted that the formula used to determine the coefficient of transmissibility involves only a constant, 264; the rate at which the pumped well is discharging; and the changes in water level during one log cycle of time. Any decrease in the rate of change of water level in the observation well thus causes a corresponding increase in the computed coefficient of transmissibility. Likewise, if only part of the yield of the discharging well affects the water level in the observation well, the computed transmissibility will be too large unless only that part of the yield of the discharging well affecting the observation well is used in computing it.

In order to have some basis for the supposition that the large values of the coefficients of transmissibility computed for wells 43/37-34C1 and 42/37-4B1 as compared with well 43/37-34C3 were due to one or a combination of two or more of the conditions just noted, a drawdown-time relationship was established for well 43/37-34C1 by means of a short, rather loosely controlled pumping test. The well was not fully developed and little was known about the ability of the engine to pump the well at a constant rate. However, after well 43/37-34C3 had been shut down for about 24 hours, well 43/37-34C1 was pumped for 2 hours at a rate that varied somewhat at the beginning of the test but which was maintained at about 720 gallons per minute during the last hour of the test. As might be expected, the plot of the observed water-level measurements versus time, shown in figure 5, is somewhat erratic. However, by lending more weight to the observations made during the second hour of pumping, when the rate of pumping was more nearly constant, it will be noted that the points fall reasonably close to a straight line whose slope indicates a change in water level of about 9.4 feet per log cycle of time. The coefficient of transmissibility, using a discharge of 720 gallons per minute, thus is computed as about 20,200 gallons per day per foot.

It seems reasonable to assume, therefore, that the transmissibility of the beds in the vicinity of wells 43/37-34C1 and -34C3 is in the neighborhood of 20,000 gallons per day per foot. The transmissibility of the beds tapped by well 42/37-3B1 likewise is believed to be in the neighborhood of 20,000 gallons per day per foot rather than 100,000 gallons per day per foot,

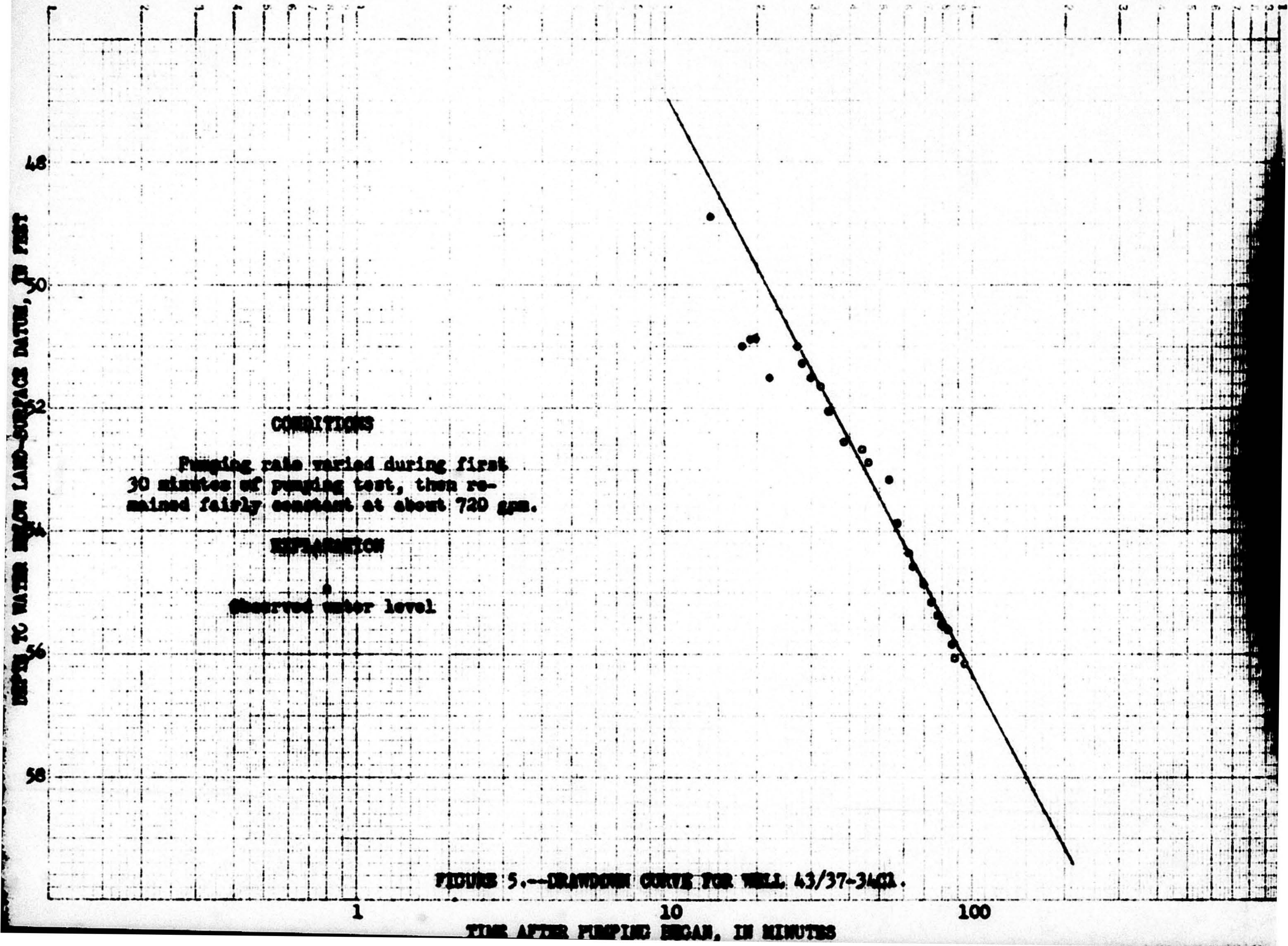

FIGURE 5.--DRAWDOWN CURVE FOR WELL 43/37-34C1.

especially in view of the fact that the specific capacity of this well is much less than the specific capacities of either of the wells that were pumped in the test.

The fluctuations of water level in well 43/37-34C2 indicated a poor hydraulic connection with well 43/37-34C3, which was only 20 feet distant. The poor hydraulic connection probably is due to the fact that well 43/37-34C2 is 80 feet deep, whereas well 43/37-34C3 is 488 feet deep. The reasons why the water level in well 43/37-34C2 dropped temporarily when pumping of well 43/37-34C3 was stopped were not determined. It is possible that the temporary lowering was due to an increase in the storage capacity of the water-bearing beds tapped by well 43/37-34C2 as a result of a sudden decrease in the load on the beds when the pump on well 43/37-34C3 was stopped. Such apparently anomalous changes in water levels are not uncommon. Because of the poor hydraulic connection between well 43/37-34C2 and the other wells, the data obtained for it were not used to compute hydraulic coefficients.

The other important hydraulic characteristic of an aquifer is its storage capacity. It is commonly expressed as a coefficient of storage, which has been defined by Theis 2/ as the volume of water, measured in cubic feet, released from storage in each column of the aquifer having a base 1 foot square and a height equal to the thickness of the aquifer, when the water table or other piezometric surface is lowered 1 foot. The coefficient of storage is important as it governs the time that will elapse before a given lowering of the water table or artesian head will occur at various distances from a discharging well. When the water in an aquifer is unconfined -- that is, when it occurs under water-table conditions, the coefficient of storage

2/ Theis, C. V., 1938, The significance and nature of the cone of depression in ground-water bodies: Econ. Geology, v. 33, no. 8, p. 894.

thousand times as large as it would be were the water under artesian pressure. Thus at a given distance from a discharging well a comparable lowering of water level would occur several hundred to several thousand times faster in an artesian aquifer than in an aquifer where the water was unconfined.

Determinations of the coefficient of storage were made by using a modification of the method described by Cooper and Jacob 3/. The modified method consists of extending the straight-line section of the recovery-versus-time graph until it intersects a horizontal line representing the water level in the well at the time pumping stopped. The time at which this intersection occurs is noted. The coefficient of storage then is computed by multiplying the coefficient of transmissibility in gallons per day per foot by the time, expressed in minutes, at which the intersection occurs, by a constant 2.1 X 154, and then dividing this product by the square of the distance, expressed in feet, between the well in which the observations were made and the well that had been pumped. Obviously, at a given site the only variables for determining the coefficient of storage are the time of zero recovery and the transmissibility. Both are directly proportional to the coefficient of storage. It follows, therefore, that if the value selected for the coefficient of transmissibility is several times too large, the value of the coefficient of storage likewise will be several times too large, and vice versa. Earlier in this report, it was pointed out that the coefficient of transmissibility determined as a result of the pumping test varied from about 20,000 to more than 100,000. It was also pointed out why the most weight should be given to the coefficients of transmissibility computed from observations made in a well that is discharging or that is recovering rather than observations made

3/ Cooper, H. H. Jr., and Jacob, C. E., 1946, A generalized graphical method for evaluating formation constants and summarizing well-field history: Am. Geophys. Union Trans., vol. 27, no. 4, pp. 526-534.

that is recovering rather than observations made in a well some distance away. The coefficient of transmissibility used to compute the coefficient of storage was therefore arbitrarily taken as 21,200 gallons per day per foot, the same as that determined for the aquifer tapped by well 43/37-34C3. The time at which the extension of the straight-line portion of the recovery curve intersects the horizontal line indicating the water-level stage in the well at the time the pumped well was shut down is not necessarily correct. If the slope of the recovery curve in figure 3 were increased sufficiently to make the computed transmissibility at well 42/37-3B1 equal to 21,200 gallons per day per foot it would have to be increased about five times and this in turn might cause the intersection to lie at a point as much as 150 minutes after pumping stopped instead of about 70 minutes, thus somewhat more than doubling the value of the coefficient of storage. About the same ratio would be obtained for the data shown in figure 4. However, in order to obtain the order of magnitude of the coefficient of storage the points of intersection as shown on figures 3 and 4 were used. The coefficient of storage thus obtained was 0.00059 at well 42/37-3B1 and 0.00044 at well 43/37-34C1. Because of the uncertain value of the true coefficient of transmissibility and the point of intersection of the extension of the straight-line portion of the corresponding recovery curves with the horizontal line representing the water-level stage when pumping was stopped, these figures should be considered only as indicating the order of magnitude of the coefficient of storage in some of the water-bearing beds penetrated by the wells. The magnitude of the coefficient of storage indicates that the water in at least part of the water-bearing beds is confined.

A very rough determination of the coefficients of storage at wells 43/37-34C3 and 43/37-34C1, obtained by extrapolating the data shown in figures 2 and 5, and assuming that the effective radius of the wells was 0.5 foot, indicated a coefficient of storage of about 0.13 at well 43/37-34C3 and 0.017 at well 43/37-34C1. Although the values differ considerably from each other and may be quite different from the true values, these coefficients indicate that at least part of the water that was pumped from these wells was unconfined. The fact that the coefficient of storage at well 43/37-34C1 was computed as 0.00044 when well 43/37-34C3 was pumped and as about 0.017 when the well itself was pumped suggests that pumping the well itself lowered the piezometric surface enough to partly dewater one or more water-bearing beds in the immediate vicinity of the well, but that pumping well 43/37-34C3, 1,200 feet distant, for as much as 5 days did not eliminate artesian conditions in all the beds common to both wells. These data suggest that, in the vicinity of the pumping-test site, geologic conditions are too complex for the hydraulic coefficients to be determined within close limits by simple pumping tests.

Figure 6 shows the theoretical relationship between the decline of water levels, time after pumping begins, and distance from a well pumping 1,000 gallons per minute from an areally extensive, homogeneous, and isotropic aquifer having a transmissibility of 20,000 gallons per day per foot and a coefficient of storage of 0.0005. The coefficients of transmissibility and storage are comparable to some of the coefficients obtained during the test. Other rates of pumping would cause a proportional drawdown -- that is, pumping at the rate of 2,000 gallons per minute would double the drawdown and pumping at 500 gallons per minute would halve the drawdown shown in figure 6. Other values of the coefficient of transmissibility would cause a drawdown having roughly the same ratio to the drawdown indicated in figure 6 as the ratio of 20,000 to the other coefficient.

Figure 6 shows that under ideal conditions the decline of the water level in well 42/37-3B1 as a result of pumping well 43/37-34C3, which is 735 feet away,

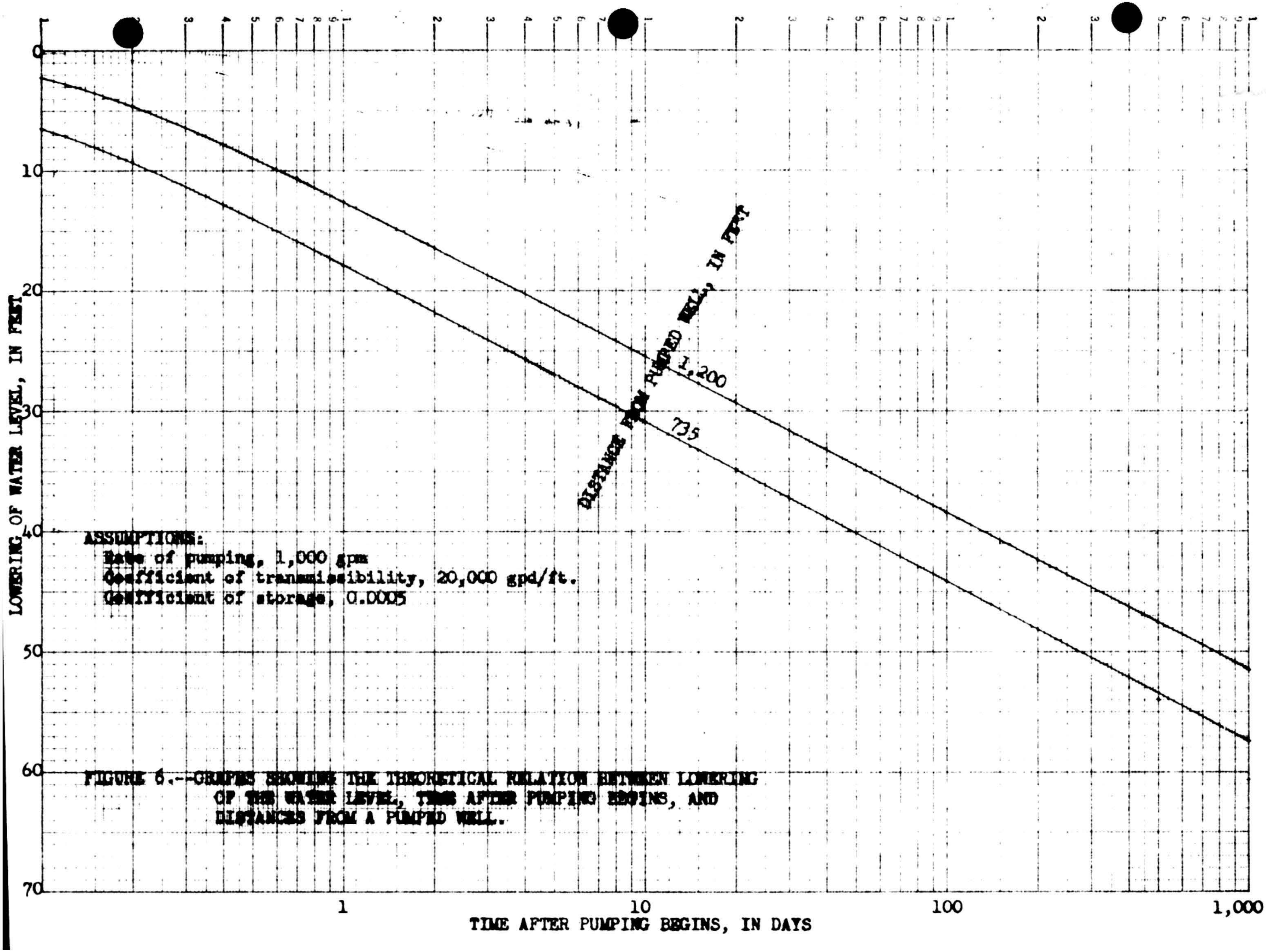

FIGURE 6.--GRAPHS SHOWING THE THEORETICAL RELATION BETWEEN LOWERING OF THE WATER LEVEL, TIME AFTER PUMPING BEGINS, AND DISTANCES FROM A PUMPED WELL.

at a rate of 885 gallons per minute for 6 days should have been about 25 feet. Actually it was only somewhat more than 3 feet, all of which occurred at least prior to the 6th day of pumping. Obviously the coefficients used in figure 6 do not apply for pumping periods as long as 6 days. Further, they probably do not apply even for short periods of pumping or recovery, because according to the chart the recovery of water level in well 42/37-3B1 after well 43/37-34C3 stopped pumping should have been in the neighborhood of 15 feet after 24 hours. Actually it was about 3 feet.

The agreement between the theoretical drawdown indicated in figure 6 and the drawdown observed in well 43/37-34C1 likewise is very poor.

Therefore, it appears that the actual changes in water level in the aquifer differ significantly from changes that theoretically would occur under ideal artesian conditions.

Figure 7 shows the theoretical decline of water level to be expected for the same conditions as shown in figure 6 except that the coefficient of storage has been changed from 0.0005, a common value for artesian conditions, to 0.20, which is believed to be somewhere near the maximum value for the aquifer in the area of the pumping test when the water occurs under water-table conditions.

According to figure 7, if all the discharge of the pumped well had occurred under water-table conditions, the decline of water level in well 42/37-3B1 at the end of the 6-day pumping period should have been 0.88 times 0.4 foot or about 0.35 foot. The actual drawdown, however, was somewhat more than 3 feet. Similarly, the decline of water level in well 43/37-34C1 should have been a few hundredths of a foot, whereas the observed drawdown was about 2.5 feet. It thus appears that the theoretical drawdowns shown in figure 7 also depart significantly from the drawdowns that were observed during the period of the pumping test.

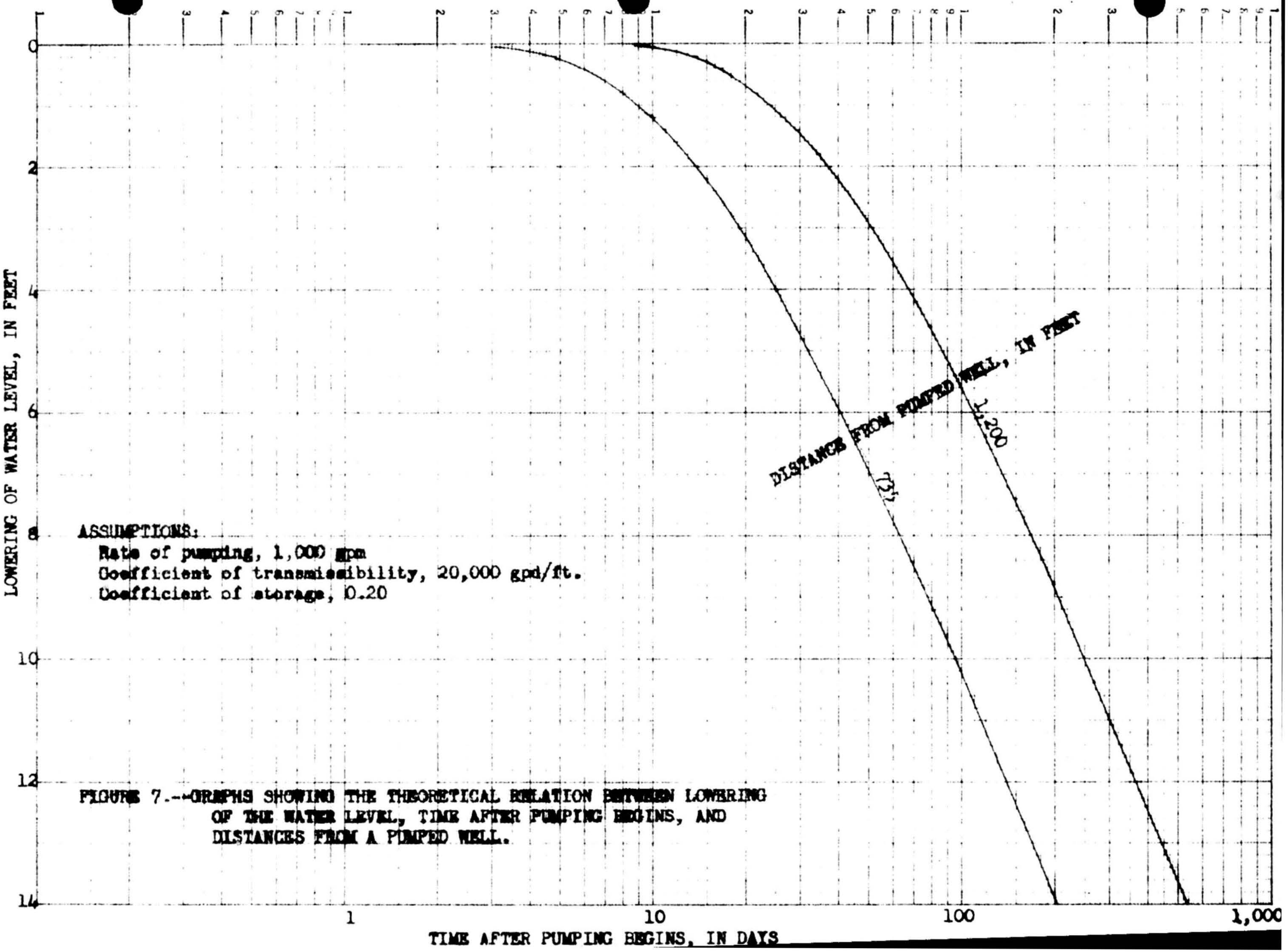

FIGURE 7.--GRAPHS SHOWING THE THEORETICAL RELATION BETWEEN LOWERING OF THE WATER LEVEL, TIME AFTER PUMPING BEGINS, AND DISTANCES FROM A PUMPED WELL.

Although the value for the coefficient of storage was more or less arbitrarily selected for figure 7, it appears that the curves shown in figure 7 indicate much more closely than do the curves in figure 6 the pumping effects that probably can be expected after long periods of pumping. Evidence for this statement is afforded by the periodic measurements of water level made in well 42/37-3B1. On March 29, 1951, the water level in this well was 17.84 feet below land-surface datum. On July 26, 1951, the depth to water was 23.6 feet. Well 43/37-34C3 was pumping at the time. On September 17, 1951, the depth to water was 20.35 feet, and on March 27, 1952, the depth to water was 18.2 feet. Taking into account the probable seasonal change which would have occurred had well 43/37-34C3 not been pumped, a decline in the neighborhood of 6 feet is indicated as being caused by pumping. Pumpage data for well 43/37-34C3 shows that the well was pumped for 1,668 hours at an estimated rate of 800 gallons per minute. According to figure 7, pumping 800 gallons per minute continuously for about 70 days from well 43/37-34C3 should have caused a lowering of water level in well 42/37-3B1 of about 6.8 feet. Thus, the theoretical lowerings indicated by figure 7 are in much closer agreement with the actual lowerings than are the theoretical lowerings in excess of 30 feet shown in figure 6. The fact that Mr. Hosack was not aware of any significant continued lowering of water level in his wells during previous pumping seasons lends further support to the belief that the lowerings in the nonpumped wells probably are considerably less than 30 feet.

CONCLUSIONS

The following conclusions were reached as a result of the pumping test:

1. Because the geologic conditions in the vicinity of the pumping tests are complex, a reliable determination of the hydraulic characteristics of the aquifer penetrated by the wells, by means of the pumping tests described, was not possible.

2. The coefficient of transmissibility of the water-bearing beds tapped by the wells probably is 20,000 gallons per day per foot, or more.

3. The coefficient of storage may range from a few ten-thousandths to a tenth or two, depending to a large degree on whether the water being pumped results in a decrease in storage in water-bearing beds in a region where the water is confined or in a region where the water in unconfined.

4. Pumping a well even for a few hours at a rate of about 1,000 gallons per minute results in at least a partial dewatering of some but not all of the water-bearing beds in the vicinity of the well.

5. Because of the conditions outlined in the preceding paragraphs it is impractical to construct a series of graphs based on data obtained during a simple pumping test that can be used to predict pumping effects within close limits. Figure 6 shows in a generalized way the nature of pumping effects under artesian conditions and figure 7, the nature of pumping effects under water-table conditions.

6. Pumping tests should be made in other parts of the valley wherever it is practical to do so in order to determine more closely the hydraulic characteristics of the aquifers of the valley.

Table 1.--Well and pumping-test data

Well data

42/37-3B1. George Reed. NW¼NW¼ sec. 3, T. 42 N., R. 37 E., 735 feet due south of well 43/37-34C3. Drilled irrigation well, diameter 12 inches, depth 160 feet. No equipment.

Driller's log

Drilled July 1949 by A. E. Hosack and Son, Nampa, Idaho.

Material	Thickness (feet)	Depth (feet)
Soil	4	4
Sand, gravel, and silt	14	18
Clay, gray	5	23
Sand and gravel, brown, muddy	11	34
Sandy clay, brown	22	56
Sandy clay, gray	14	70
Gravel and sand	1	71
Sandy clay, gray	3	74
Sandstone, hard	2	76
Clay and stringer of gravel	14	90
Clay, brown	17	107
Sand and gravel	5	112
Clay, brown	27	139
Clay, gray	13	152
Clay, brown	8	160

Cased to 160 feet; perforated from 10 to 150 feet below land surface with ¼- by 3-in. slots on 6-in. centers, 18 slots per round. First water at 23 feet; static level at 16 feet.

Pumping-test data

Date	Time	Depth to water below land-surface datum (feet)	Remarks
April 21, 1953	4:25 p.m.	20.17	
	5:55	20.16	
	9:46	20.14	
	11:40	20.15	
April 22	5:15 a.m.	20.15	
	1:00 p.m.	20.14	

42/37-3B1--Continued

Date	Time	Depth to water below land-surface datum (feet)	Remarks
	1:05		Stopped pumping well 43/37-34C3.
	2:25	19.85	
	3:00	19.66	
	3:32	19.47	
	4:07	19.28	
	4:50	19.05	
	5:38	18.86	
	6:46	18.62	
	8:39	18.34	
	11:40	18.05	
April 23	2:43 a.m.	17.87	
	5:35	17.78	
	8:55	17.69	
	12:45 p.m.	17.62	

Well data

43/37-34C1. Vera Reed. NW¼SW¼ sec. 34, T. 43 N., R. 37 E., 1,200 feet N. 2° E. of well 43/37-34C3. Drilled irrigation well; diameter 12 inches 0 to 205 feet, 8 inches 180 to 515 feet; depth 515 feet. Equipped with turbine pump and diesel engine. Temperature, 56°F.

Driller's log

Drilled August 1952 by A. E. Hosack and Son, Nampa, Idaho.

Materail	Thickness (feet)	Depth (feet)
Soil	7	7
Sand and silt	21	28
Sand, muddy, and pea gravel	45	73
Clay, brown	21	94
Clay, sandy	6	100
Sand, muddy, and gravel	18	118
Gravel, cemented	8	126
Gravel, muddy	8	134
Clay, gray, hard	18	152
Clay, brown	25	177
Gravel, cemented	7	184
Clay, brown, and gravel	69	253
Gravel, cemented	5	258
Sand and gravel	2	260

43/37-34C1--Continued

Material	Thickness (feet)	Depth (feet)
Gravel, cemented	2	262
Clay, brown	39	301
Gravel, cemented	3	304
Clay, brown	30	334
Gravel	14	348
Clay, brown	47	395
Gravel, cemented	10	405
Gravel and sand	3	408
Clay	17	425
Sand and gravel	1	426
Clay, gray	20	446
Gravel, cemented	2	448
Clay, gray, with gravel	17	465
Clay, gray-blue, with gravel	10	475
Gravel, cemented	5	480
Clay, brown	35	515

Cased to 515 feet; perforated from land surface to 205 feet with $\frac{1}{4}$- by 3- in. slots on 6-in. centers, 13 slots per round, and from 180 to 515 feet with 3/16- by 3-in. slots on 5-in. centers, 7 slots per round. First water at 21 feet; static level at 21 feet.

Pumping-test data

Stanley universal orifice with 6-inch diameter orifice plate at end of 8-inch-diameter discharge pipe used to measure discharge.

Date	Time	Depth to water below land-surface datum (feet)	Yield (gpm)	Remarks
April 21, 1953	4:10 p.m.	21.19		Well 43/37-34C3 pumping.
	5:50	21.19		
	9:13	21.19		
	9:38	21.19		
	11:35	21.19		
April 22	5:05 a.m.	21.20		
	8:45	21.19		
	10:15	21.19		
	12:53 p.m.	21.18		
	1:05			Stopped pumping well 43/37-34C3
	2:21	21.08		

43/37-34C1--Continued

Date	Time	Depth to water below land-surface datum (feet)	Yield (gpm)	Remarks
	2:53	21.01		
	3:26	20.94		
	4:01	20.84		
	4:45	20.72		
	5:32	20.59		
	6:50	20.40		
	8:31	20.21		
	11:30	19.92		
April 23	2:40 a.m.	19.71		
	5:28	19.60		
	9:10	19.48		
	1:26 p.m.			Began pumping about 600 gpm.
	1:40	48.9	720	
	1:44	51.0		
	1:45	50.9		
	1:46	50.9		
	1:48	51.5		
	1:53	51.0		
	1:54	51.27		
	1:56	51.50	710	
	1:58	51.65		
	2:00	52.02		
	2:04	52.55		
	2:10	52.66		
	2:12	52.89		
	2:20	53.18	700	
	2:21		720	Increased pump speed.
	2:23	53.85		
	2:28	54.34	720	
	2:30	54.57	720	
	2:36	54.84		
	2:40	55.13		
	2:43	55.39		
	2:45	55.51		
	2:50	55.59	720	
	2:52	55.81		
	2:54	56.04		
	3:00	56.15	720	
	3:01			do

Well data

43/37-34C2. A. E. Hosack. SW$\frac{1}{4}$SW$\frac{1}{4}$ sec. 34, T. 43 N., R. 37 E., 20 feet south of well 43/37-34C3. Drilled well, diameter 12 inches, depth 80 feet. No equipment.

Pumping-test data

Date	Time	Depth to water below land-surface datum (feet)	Remarks
April 21, 1953	4:35 p.m.	19.94	
	5:20	19.93	
	6:05	19.93	
	9:00	19.95	
April 22	8:40 a.m.	19.98	
	12:45 p.m.	19.98	
	1:05		Stopped pumping well 43/37-34C3.
	1:49	20.04	
	1:59	20.03	
	2:33	20.01	
	3:10	19.97	
	3:37	19.95	
	4:12	19.91	
	4:55	19.88	
	5:42	19.86	
	7:00	19.83	
	8:45	19.81	
	11:27	19.73	
April 23	2:50 a.m.	19.68	
	5:20	19.67	
	8:49	19.63	
	12:58 p.m.	19.57	

Well data

43/37-34C3. A. E. Hosack. SW¼SW¼ sec. 34, T. 43 N., R. 37 E. Drilled irrigation well; diameter, 12 inches 0 to 179 feet, 8 inches 160 to 488 feet; depth 488 feet. Equipped with turbine pump and diesel engine. Temperature, 57°F.

Driller's log

Drilled March, 1950 by A. E. Hosack and Son, Nampa, Idaho.

Material	Thickness (feet)	Depth (feet)
Soil	16	16
Sand, muddy, and silt	52	68
Pea gravel, muddy	8	76
Clay, brown	14	90
Clay, brown, sticky	8	98
Sand, muddy	24	122
Sandstone, hard	6	128
Pea gravel, muddy	15	143
Gravel and clay	9	152
Sand, muddy	5	157
Sandstone	5	162
Clay, brown	8	170
Gravel, cemented	8	178
Clay, brown	6	184
Sand and gravel, cemented	10	194
Clay, blue, hard	10	204
Clay, blue, soft	19	223
Gravel, cemented	6	229
Clay, white, soft	2	231
Sandstone, hard	3	234
Clay, gray	9	243
Sandstone, hard	3	246
Clay, brown	39	285
Gravel, cemented	3	288
Clay, gray	4	292
Gravel, cemented	8	300
Clay, brown	14	314
Clay, gray	20	334
Gravel, cemented	36	370
Clay, brown	20	390
Gravel, cemented	5	395
Clay, brown	18	413
Sandstone	3	416
Clay, gray, sandy	4	420
Sand, coarse, firm	5	425
Clay, gray	15	440

43/37-34C3--Continued

Material	Thickness (feet)	Depth (feet)
Sand and pea gravel	4	444
Clay	2	446
Sand and gravel, firm	5	451
Sand and pea gravel	4	455
Sandstone	5	460
Sand and gravel	10	470
Gravel, cemented	3	473
Sand and pea gravel	6	479
Clay, gray	9	488

Casing perforated from land surface to 179 feet with 1/4- by 3-in. slots on 6-in. centers, 18 slots per round, and from 179 to 488 feet with 3/16- by 3-in. slots on 5-in. centers, 12 slots per round. First water at 20 feet; static level at 20 feet.

Pumping-test data

Date	Time	Depth to water below land-surface datum (feet)	Yield	Remarks
April 16, 1953	2:00 p.m.		800	Began pumping; yield estimated.
18	6:00 a.m.		885	Yield estimated.
21	5:27 p.m.	76.3		
	6:30		885	This and subsequent yields determined by means of orifice in end of discharge pipe.
	8:37		890	
	8:41	75.8		
	8:55	75.8		
	11:30	76.6	910	
	11:31			Decreased pump speed.
	11:35	75.8	885	
22	4:45 a.m.		883	
	4:47	75.3		
	8:20	74.0	860	
	8:25		885	Increased pump speed.
	8:35	75.0		
	9:28	75.3	885	
	10:38	75.1	883	
	11:10	75.2	885	
	12:43 p.m.	75.0	883	
	1:05			Stopped pumping.

43/37-34C3--Continued

Date	Time	Depth to water below land-surface datum (feet)	Yield	Remarks
April 22	1:07	46.75		
	1:10	42.75		
	1:12	41.43		
	1:14	40.25		
	1:16	39.30		
	1:18	38.55		
	1:20	37.83		
	1:23	36.95		
	1:26	36.13		
	1:30	35.31		
	1:35	34.48		
	1:40	33.67		
	1:45	33.06		
	1:50	32.46		
	1:55	31.96		
	2:05	31.05		
	2:16	30.25		
	2:25	29.61		
	2:45	28.53		
	3:10	27.42		
	3:36	26.50		
	3:55	25.92		
	4:37	24.87		
	5:45	23.65		
	6:57	22.72		
	8:48	21.72		
	8:50	21.70		
	11:23	20.80		
April 23	2:55 a.m.	20.08		
	5:20	19.75		
	8:45	19.42		
	11:37	19.26		
	1:00 p.m.	19.18		

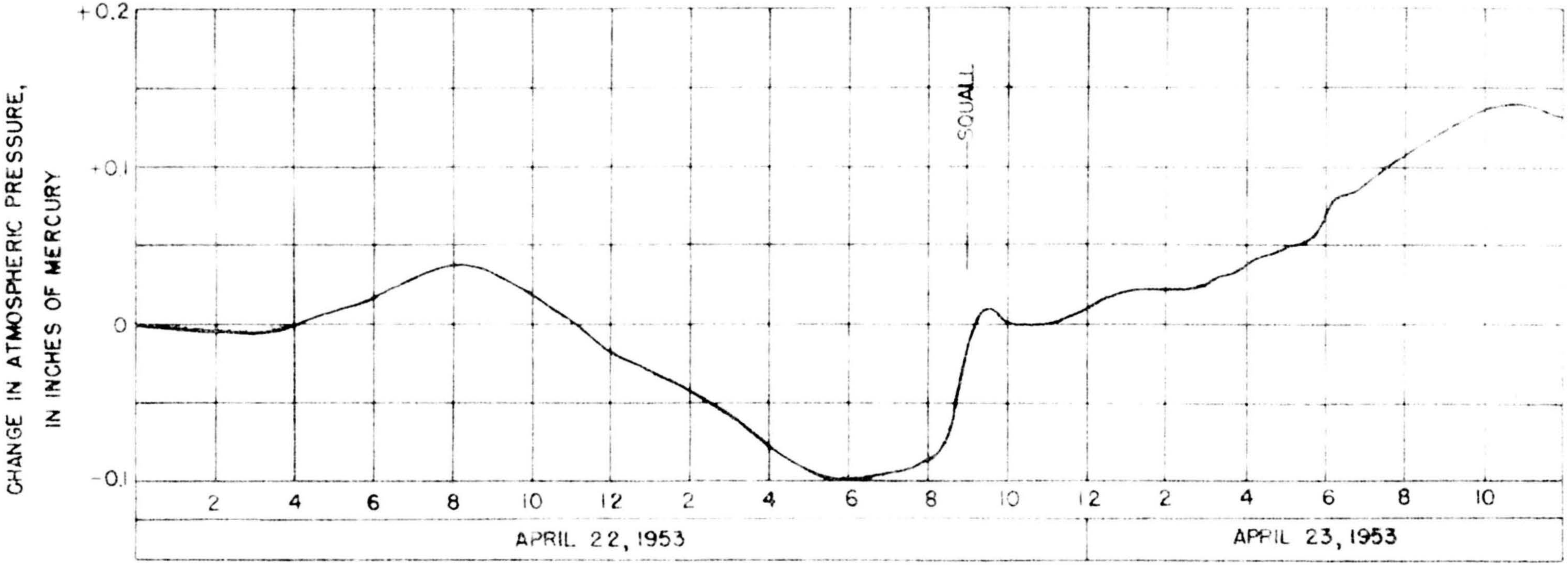

Figure 8 Chart showing changes in atmospheric pressure at pumping-test site, sec. 34, T. 43 N., R. 37 E., Humboldt County, Nevada, during the period April 22-23, 1953.