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Effect of development of ground-water west of Red Mountain, NM

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EFFECT OF DEVELOPMENT
OF
GROUND WATER WEST OF RED MOUNTAIN, NEW MEXICO

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U. S. DEPARTMENT OF INTERIOR
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CONTENTS

ILLUSTRATIONS

Manuscript page

TABLES

Manuscript page

EFFECT OF DEVELOPMENT OF GROUND WATER WEST OF RED MOUNTAIN, LUNA COUNTY, NEW MEXICO

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INTRODUCTION

The Mimbres ground-water basin, as declared by the New Mexico State Engineer, was closed to the filing of applications for the appropriation of ground water by order of the State Engineer dated April 20, 1945. Subsequent studies of the ground-water conditions led to the conclusion that additional limited development of the ground water in outlying areas of the basin would cause only minor effects upon prior appropriators. Accordingly, on April 26, 1950, the State Engineer reopened parts of the basin to further appropriation. Included in this opening order was the portion of the basin, west of Red Mountain, in T. 23 S., R. 12 W., T. 24 S., R. 11 W., and most of T. 23 S., R. 11 W. This area, which is about 10 miles west of Deming, N. Mex. is referred to as the area west of Red Mountain and is the area discussed herein. (See fig. 1.)

Following the opening order a large number of applications to appropriate ground water in the area west of Red Mountain were received by the State Engineer and a number of permits were granted. Also, as about 20 percent of the area is in the public domain, the Bureau of Land Management received a large number of requests for reclassification of land to irrigation homesteads. Because of the large number of applications received by the State Engineer and because farmers in the remainder of the basin protested that the granting of additional permits would be detrimental to their existing rights, the State Engineer withheld action upon the remaining applications until a better detemination could be made of the effect the new permitted development would have upon prior existing rights in the main part of the basin.

As a part of the investigations of the ground-water conditions in New Mexico being made by the U. S. Geological Survey in cooperation with the State Engineer of New Mexico, a continuing investigation of the area was begun by members of the Geological Survey in March 1951.

Published reports on the geology and ground-water conditions in the Mimbres Valley contain little detailed information on the area in question. Darton (1916 and 1917) described the geology and ground-water conditions in Luna County. These reports include maps showing the general depth to water in the area west of Red Mountain, approximate contours on the water table, and geology. These and other reports are given in the list of references (p. 41).

GENERAL DISCUSSION

The area west of Red Mountain is in the Basin and Range province and is characterized by bolson (valley-fill) deposits of small relief between mountains.

Red Mountain, which lies between the area under consideration and the main area of ground-water development, is a fairly symmetrical conical hill of rhyolite which projects several hundred feet above the surrounding sediments. Surface indications of the underground lateral extent of the rhyolite of Red Mountain are lacking. The composition of Red Mountain is dissimilar to that of Black Mountain, which is about 7 miles to the north and composed of basalt capping volcanic ash and sand. Red Mountain is also dissimilar to the Snake Hills, which are about 3 miles to the south and composed of limestone. Because of the difference in composition of these mountains, it appears that Red Mountain may not extend an appreciable distance laterally underground at a shallow depth.

The bolson deposits which underlie the area west of Red Mountain, as well as the other parts of the basin between the mountains, are a thick heterogeneous mixture of clay, sand, and gravel derived from the hills and mountains. Environment changed greatly during the deposition of these sediments and resulted in large areal and vertical changes in their character. In general, the bolson deposits consist of lenses or stringers of sand and gravel of varying lateral extent that thicken and thin within short distances. Separating these lenses are layers or lenses of clay which also are variable in thickness and lateral extent. The boundaries between these various lenses and layers are often not sharp but of a gradational nature. Because of this condition individual beds or layers in one well can rarely, if ever, be positively identified in another well unless the distance between the wells is very small. The variability of the conditions is illustrated somewhat by the attached logs of irrigation wells drilled west of Red Mountain. (See table 1.)

The thickness of the bolson deposits west of Red Mountain is not known, as the present wells, which are from 200 to 300 feet in depth, do not fully penetrate the deposits. However, on the basis of wells in other areas to the east, it appears likely that the deposits west of Red Mountain are considerably in excess of 200 feet thick except possibly near the flanks of Red Mountain.

GROUND-WATER CONDITIONS

The important basic facts about the occurrence of ground water in the Mimbres Valley area have been summarized in previous reports on the area as listed in the references. The conclusions reached are that the greater part of the ground water in the bolson deposits in the Mimbres River basin comes from the Mimbres River and from San Vicente Arroyo and their tributaries. These streams sink into the ground after leaving the mountains and only in times of flood persist for an appreciable distance beyond the bedrock of their mountain courses. Minor amounts are contributed by runoff from the mountains immediately adjacent to the basin, such as the Floridas, and by rainfall upon the floor of the valley northward from Spalding, but practically none is contributed by rainfall on the valley floor south of Spalding.

The general direction of movement of the ground water in the basin is given on maps by Darton (1916, pl. 8; 1917, map - underground water) and by White (1932, p. 184). These maps show that the ground water under the main part of the basin east of Red Mountain moves southeastward. The maps by Darton show that the ground water west of Red Mountain moves generally southward from the Mimbres River to Palomas Arroyo, about 8 miles south of Red Mountain, whence it is diverted southeastward by the Burdick Hills which lie south of Palomas Arroyo. It would thus appear that there is a slight ground-water divide northward from Red Mountain coincident with a slight topographic ridge projecting in that direction from Red Mountain.

Contours on the water table in the immediate vicinity of the new development for irrigation in the northeast part of T. 24 S., R. 11 W., west of Red Mountain, are given on figure 2. The contours are based upon altitudes of the water levels in the wells as determined by measurements of the depth to water made in January 1952 and altitudes of the land surface obtained by aneroid. These contours indicate that the general direction of movement of the ground water in the immediate area of new development was in January 1952 generally southwestward. The northeastward deflection in the contours in figure 2 is caused by the lowering of water level resulting from the pumping in the area in 1951.

The depth to water in the area west of Red Mountain as shown by Darton (1916, pl. 1) increases from south to north and from east to west. In the immediate vicinity of the present development, the nonpumping level ranges from nearly 120 feet below land surface in the western part of sec. 2, T. 24 S., R. 11 W., to about 85 feet in the southern part of sec. 24, T. 24 S., R. 11 W. (See fig. 2.) In the older developed irrigated area, from about 3 to 7 miles east of Red Mountain, the nonpumping depths to water range from about 70 to 90 feet below land surface. The depth to water in the remainder of the declared ground-water basin west of Red Mountain is not definitely known because of the scarcity of wells. However, the depth to water in October 1939 was 146 feet in a well in NE¼ sec. 6, T. 24 S., R. 11 W.; and about 270 feet in a well in sec. 32, T. 23 S., R. 12 W.

The trend of the water levels in the area west of Red Mountain is shown by the records of water level in well 24.11.1.333. (See fig. 3.) (For description of well-numbering system see p. 38.) This well was equipped with a turbine pump but very little irrigation was done during the period of record of water levels. On the basis of measurements of water levels in this well each January since 1944, the water levels have shown a rather consistent lowering of a few tenths of a foot a year prior to 1951. From 1951 to 1952 the water level in this well declined 3 feet as a result of the development for irrigation in the immediate vicinity in 1951.

In 1913 (Darton, 1916, pl. 1), the water level in the area west of Red Mountain was reportedly 90 to 94 feet below the land surface in secs. 2, 11, and 12, T. 24 S., R. 11 W. As the depth to water in January 1952, figure 2, in this area was 102 to 117 feet, a lowering of water level of 12 to 23 feet seemingly has taken place in 39 years. Making allowance for the large lowering in this area in 1951 of some 3 feet, it appears that the water levels prior to pumping in the area declined on the average a few tenths of a foot a year, essentially the same as observed from 1944 to 1951 (fig. 3). The gradual lowering prior to 1951 was probably the result mainly of pumping from the area of older development to the east. (See fig. 4.)

The trend of the water levels in unused well 24.10.29.222, 1 mile south of Red Mountain, is also shown in figure 3. This well is also distant from pumped wells east of Red Mountain but closer than well 24.11.1.333. This graph shows the gradual decline of water levels as exhibited in well 24.11.1.333; however, the decline is somewhat greater because well 24.10.29.222 is closer to pumped wells than well 24.11.1.333. (See fig. 4.)

The areal change in water levels during the first year of pumping, 1951, in the area west of Red Mountain is given in figure 2. The changes are based upon tape measurements of water level made in the wells, generally in March or May 1951, and January 1952. (See table 2.) As shown, the water levels declined throughout the area with a maximum decline of more than 4 feet under sec. 12, coincident with the approximate center of pumpage. As the water levels in 1951 and 1952 were measured when pumping was practically at a minimum, the changes in water level represent the net change in ground-water storage in that period.

Changes in water level west of Red Mountain and in the older irrigated areas to the east in 1951 are shown by the map, figure 5. It is noted that the maximum decline observed throughout the area during the period from January 1951 to January 1952 was slightly greater than 4 feet and occurred in the newly developed area west of Red Mountain. This is to be expected, as water levels decline at a greater rate in the early periods of pumping than in the latter periods as discussed in a succeeding part of this report. The map shows several centers of lowering which coincide in general with the areas of greatest concentration of pumpage, including the newly developed area west of Red Mountain.

The long-term lowering of water levels that has occurred in the older developed areas in the period from January 1940 to January 1950 is shown in figure 6. The maximum observed lowering was slightly in excess of 18 feet and occurred about 8 miles south of Deming. This is the area where much of the additional development of ground-water irrigation has taken place since about 1947. By extropolating the contours of lowering on figure 6 to include the newly developed area west of Red Mountain and projecting to 1940 the water-level graph given for well 24.11.1.333 on figure 3, it appears that the water level in the area west of Red Mountain must have declined approximately 2 to 3 feet in the period from 1940 to 1950, prior to irrigation in that area. Much of this apparent lowering, west of Red Mountain, was probably the result of pumping in the older irrigated areas east of Red Mountain.

GROUND-WATER DEVELOPMENT AND WELL CHARACTERISTICS

Prior to 1951, only two irrigation wells were in existence in the part of the declared basin west of Red Mountain and very little irrigation was practiced. In 1951, fourteen wells were used to irrigate approximately 1,100 acres. By January 1952 there were 17 irrigation wells, of which 16 were equipped with pumps. (See table 2 and fig. 2.) Data obtained from the State Engineer's office show that 19 permits have been granted as of September 1952, covering 2,593 acres. On the basis of electric-power records and measured rates of discharge and power consumption for most of the pumps, and reported and estimated related information, it appears that about 1,900 acre-feet of water was pumped for irrigation in 1951, less than 2 acre-feet per acre irrigated.

In general, the present irrigation wells are 16 inches in diameter and drilled to a depth of about 200 feet. The casing is usually perforated from the water level to the bottom of the well unless the well penetrates clay for a distance at the bottom in which case the perforations may end at the top of the clay.

The pumping rate for 15 wells, for which information was obtained, ranged from about 75 to 485 gallons a minute and the specific capacity of 7 of the wells ranged from less than 6 to about 45 gallons a minute per foot of drawdown. The performance of these wells is comparable to that of wells in the older developed areas. The pumping rate of 18 wells given by Conover and Akin (1942, pp. 26, 27) in the older developed areas to the east ranged from 145 to 575 g.p.m. while the specific capacities of 21 wells ranged from 5 to 44 gallons a minute per foot of drawdown. As the pumping rate from a well depends as much upon the size of the pump and power unit as upon the characteristics of the well, the discharge per unit of lowering--that is, the specific capacity of the well--is a more conservative and representative element for comparing performances of wells. However, as the water level in a well progressively lowers the longer it is pumped, the specific capacity is not constant but also progressively diminishes with time. Thus, for proper comparison of the performance of wells the length of pumping time should be equal. The values of specific capacity given above were determined for various times of pumping and are not strictly comparable, but as the greater part of the lowering of water level in a well occurs within a relatively short time, these values indicate that on the whole the characteristics of the wells in the new area west of Red Mountain are about the same as for the irrigation wells in the older developed areas.

Because of the variable nature of the bolson deposits it is expected that there will be considerable variation in the performance of individual wells. One well failed to obtain an adequate quantity of water for irrigation within a depth of 277 feet. As deep drilling of wells in the older developed area to the east has generally resulted in increasing the yield of wells, it appears that such may be the case also in the deposits west of Red Mountain.

THEORY OF PUMPING EFFECTS

Prior to development of ground water for irrigation in the Mimbres basin, the discharge from the ground-water body during a climatic cycle was equal to the recharge, that is, no more ground water left the basin than entered. Thus, over a long period of time equal to a climatic cycle, the average water levels in the formation remained constant. Discharge by wells in the Mimbres basin is a new discharge imposed upon the essentially stable ground-water system. This new discharge, if water levels are not to decline, must be balanced by an increase in recharge to the formation or decrease in discharge from the formation or a combination of the two. As the water levels in the areas of recharge are some distance below ground level, lowering of the water levels as a result of pumping in the area west of Red Mountain cannot induce additional recharge to the formation. Also, as the natural discharge from the formation is many miles to the southeast, the pumping will not cause a significant, if any, decrease in natural discharge for years to come. It is thus evident that the pumpage must be from ground-water storage with a consequent long-term lowering of water levels.

The lowering of water levels in the area will depend upon the rate at which water is pumped, the length of time pumping is practiced, the areal extent of the aquifer, and the hydraulic characteristics of the aquifer--that is, the coefficient of transmissibility which denotes the ease with which water moves through the formation, and the coefficient of storage which denotes the amount of water represented by a change in water level in the formation.

A formula relating the drawdown to the discharge from a well in an ideal aquifer of large areal extent was developed by Theis (1935, pp. 519-524). The formula, which is an integral equation, is evaluated by an infinite series which, however, reduces essentially to the following when the ratio of r^2S/tT is small:

$$s = \frac{264\ Q}{T} \left(\log t + \log \frac{T}{r^2S} - 0.522\right)$$

where s = drawdown, in feet

Q = rate of discharge of the well, in gallons a minute

t = time the well has been discharging, in days

r = distance from the discharging well to the point where drawdown is to be determined, in feet

T = coefficient of transmissibility, in gallons a day per foot

S = coefficient of storage, ratio of water released from storage to the lowering of water level.

This equation shows that ideally the water level in the vicinity of a well pumping at a constant rate lowers as the logarithm of the time since pumping began--that is, the lowering in 10 years will be one-half that which will occur in 100 years. Also, the lowering is directly proportional to the rate of pumping--that is, doubling the pumping rate results in doubling the lowering at a particular time and distance.

Evaluation of the future effects of pumping requires determination of the values of the coefficients of transmissibility and storage. These can usually be determined from properly interpreted results of pumping tests.

DETERMINATION OF AQUIFER CHARACTERISTICS

In an effort to determine the hydraulic characteristics of the aquifer west of Red Mountain, pumping tests were made on two wells in November and December 1951. Well 24.11.11.211 was pumped for 48 hours and water levels were measured in the pumped well and in well 24.11.2.344, which is 724 feet north, and in well 24.11.12.111, which is one-half mile east. Measurements in well 24.11.2.344 were discontinued before the end of the test, as the windmill began pumping. Discharge from well 24.11.11.211 was essentially constant as determined by measurements made with a pygmy current meter. Well 24.11.12.324 was pumped for 48 hours and water levels were measured in the pumped well and well 24.11.12.412, which is 1,453 feet northeast, and in well 24.11.13.311, which is nearly a mile southwest. Discharge from well 24.11.12.324 was essentially constant as determined by means of an orifice gage. Water-level measurements made during these tests are given in table 3.

As shown by the equation on page 18, the coefficient of transmissibility can be determined by plotting the values of drawdown in a well versus the logarithm of time. The points should fall on a straight line and the coefficient of transmissibility may be determined from its slope. If s_2 and s_1 are values of the drawdown separated by one log cycle on the time axis:

$$T = \frac{264\ Q}{s_2 - s_1}$$

The recovery of water level in a well following termination of pumping can be thought of as being the result of a continuation of pumping plus the introduction of an equal rate of recharge into the well--that is, a zero discharge from the well. Thus the curve of recovery of water levels is the same as the drawdown if the recovery is taken as the difference between the water level and that which would have occurred had the well continued to be pumped. Therefore the coefficient of transmissibility can be determined from the recovery of water level in a well by means of the same formula. However, as this formula is an approximation, a somewhat more reliable determination is made by plotting the residual drawdown versus the ratio of the logarithm of the time since pumping started to the time since pumping stopped (Theis, 1935, pp. 519-524). The coefficient of transmissibility is determined from the slope of the line by the same formula as given above.

Semilogarithmic graphs of the recovery of water level in the pumped well 24.11.11.211 and the lowering and recovery of water levels in the pumped well 24.11.12.324 are given in figures 7, 8, and 9. The graph of recovery of water level in well 24.11.11.211 follows a fairly straight line for the first part of the recovery but departs markedly from a straight line in the final stages. The coefficient of transmissibility therefore is not definitely determinable. However, the value obtained from the straight-line portion of the curve is 5,000 gallons per day per foot. Measurements of the lowering of water level in well 24.11.11.211 were erratic, because of water clinging to the casing and leaking into the well at high levels, which obviated a good determination of the coefficient of transmissibility. However, measurements of the lowering of water level during the first 5 minutes of pumping were consistent in that on a semilogarithmic plot they formed a straight line. The coefficient of transmissibility for this short period was 3,800 gallons per day per foot. On the basis of these values and the fact that the 48-hour specific capacity of this well was 5.6 gallons per minute per foot (table 2), it appears that the coefficient of transmissibility of the formation penetrated by well 24.11.11.211 is low and on the order of 5,000 gallons per day per foot.

The curves of lowering and recovery of water levels in well 24.11.12.324 are fairly consistent and give values of 32,900 gallons per day per foot for the lowering and 31,800 gallons per day per foot for the recovery. This well had a 48-hour specific capacity of 17.5 gallons per minute per foot.

The 48-hour period of pumping during each of these two tests was too short to utilize the measurements of water levels in the nearby observation wells to determine true values of the coefficient of transmissibility. In such a case, as the full effect of pumping did not reach the observation wells, the values determined were fictitiously high.

As the specific capacity of well 24.11.11.211 is the poorest of 7 wells for which information is available, while that for well 24.11.12.324 is about average, it is concluded that, on the basis of presently available information, the most probable over-all value of the coefficient of transmissibility for the area west of Red Mountain is on the order of 30,000 gallons per day per foot.

The value of the coefficient of transmissibility for the area west of Red Mountain appears to be somewhat lower than that in the older developed area, primarily south of Deming, where values from 14 wells ranged from 17,000 gallons per day per foot to 152,000 gallons per day per foot with a probable average of about 55,000. However, the values compare favorably with those determined from four wells in the Miesse area east of Little Florida Mountain, where they ranged from 16,000 gallons per day per foot to 36,000 gallons per day per foot with a probable average of less than 25,000 (Conover and Akin, 1942, p. 26).

Determination of the value of the coefficient of storage is normally determined from the rate of lowering of water levels in observation wells nearby a pumped well after the full effects of pumping have reached the observation wells. Because of the distance of the observation wells from the pumped wells in the above tests the times of pumping were too short to allow the full effects of pumping to occur in the observation wells. Also, because of the nature of the bolson deposits, drainage occurs at a slow rate from the fine material and not instantaneously as assumed by the formula. In addition, the lenses of relatively permeable deposits act as conduits for short periods of pumping and thus exhibit some artesian effects. The semiconfined characteristics of the aquifer and the existance of shoestring-type lenses of gravel in the deposits which give preferential direction to short-term pumping effects are illustrated by Conover and Akin (1942, p. 28, fig. 3), who show that pumping from one well in sec. 12, T. 24 S., R. 10 W., caused a marked lowering of water level in an unused well equipped with a recording gage about a quarter of a mile distant, while pumping from two other wells in the same section at about the same distance from the unused well, but in different directions, did not noticeably affect the water level in the unused well.

Because of these semiconfined conditions, the coefficient of storage determined from the lowering of water levels in the observation wells during the pumping tests was fictitiously low and on the order of magnitude of 10^{-4}, which is generally considered indicative of artesian conditions. Long-term drainage of the sediments results in releasing greater quantities of water than indicated by short-term pumping tests.

In order to determine the coefficient of storage on a comparatively long-term basis, the volume of sediments dewatered by pumping in 1951 in the area west of Red Mountain was computed from the contours of lowering of water level shown on figure 2. Parts of the contours, particularly those of zero and minus 1 and 2 feet, were not definitely determined from the available data but were projected symmetrically to the more closely defined contours of minus 3 and 4 feet. The projected contours are shown in small scale on figure 5. The computed volume of sediments in which the water levels lowered in 1951 west of Red Mountain was about 21,000 acre-feet. This is based on the assumption that a line of zero lowering exists.

The assumption that a line of zero lowering exists is probably not justified, as part of the lowering of water level in 1951 in the area west of Red Mountain was the result of a probable natural lowering due to the drought of recent years and a lowering from the effects of pumping in the area to the east. The trend of the water levels in the area west of Red Mountain prior to most of the development in 1951 is shown by the water level in well 24.11.1.333, figure 3. Prior to 1951 this well, though equipped with a small turbine pump, was used only a minor amount and the trend of the water level is believed to be primarily a reflection of that in the area as a whole. From 1945 through 1950 the water level declined an average of about 0.4 foot a year. Under these conditions the line of zero lowering either did not exist or, if so, it was at a distance, probably to the west.

If it is assumed that the line of zero lowering, as projected in figure 2, is the limit of the lowering of water level caused by pumping in the area west of Red Mountain in 1951, then the coefficient of storage based on a pumpage of 1,900 acre-feet in 1951 is about 0.09. As it is believed the zero line was projected generously, this value of coefficient of storage is on the low side. A more conservative projection of the zero line, one which would include a smaller area, would result in an appreciable increase in the derived value of the coefficient of storage, as the volume enclosed between the contours of zero and 1 foot of lowering is more than 50 percent of the total volume dewatered. Also, if allowance is made for the normal lowering of water level of about 0.4 foot a year, the volume of sediments dewatered in 1951 as a result of pumpage in the immediate area would be smaller than the 21,000 acre-feet. It thus appears that the actual value of the coefficient of storage, as determined from the data for 1951, is greater than 0.09.

As the pattern of lowering of water level in an aquifer is the reflection of the location of the wells, the pumpage from each, the areal extent of the aquifer, and the hydraulic constants of the aquifer, these hydraulic constants can be determined if the other factors are known. As the locations of the wells in the area west of Red Mountain were known and the pumpage from each well known approximately, various combinations of the coefficients of transmissibility and storage were used in the formula, p. 18 , and the expected lowerings computed for three spots in the area on the basis that the aquifer has a large areal extent. In using this formula, it was assumed that the wells were pumped at a constant rate for a year to equal the pumpage given in table 2. Theoretically, with a given set of conditions of water-level lowering, pumpage, and well locations, only one combination of values of the coefficient of transmissibility and storage will satisfy the decline of water levels at two or more points. A few combinations were tried and two were found that gave values of lowering nearly equivalent to the actual lowering that occurred. The following table gives these coefficients of transmissibility (T, g.p.d. per foot) and storage (S). Also given are the actual lowerings, as taken from figure 2, and the computed lowerings at three locations.

Location (section corner)	Actual lowering (ft.)	Computed lowering (ft.) T=30,000	
		S = 0.10	S = 0.11
T. 24 S., R. 11 W., secs. 11, 12, 13, 14	3.5	3.6	3.3
T. 24 S., R. 11 W., Secs. 2, 3, 10, 11	2.3	2.5	2.3
T. 24 S., Rg's 10 & 11 W., sec's. 7, 18, 12. 13	3.0	3.2	3.0

Because of the assumptions involved, particularly that of a constant pumping rate, the close agreement between computed and actual lowering may be in part a coincidence. However, it is believed that the values of the coefficients obtained by this method are of the proper order of magnitude and confirm the values given previously.

As noted in the table, a small change in the value of the coefficient of storage makes an appreciable change in the computed lowering, with the result that, for the conditions assumed, the coefficient is fairly well determined and equal to about 0.10. As complete drainage of the sediments probably does not occur in one year, the true coefficient of storage would necessarily be determined from data for longer periods of record then presently available.

As a further check on the order of magnitude of the coefficient of storage in the bolson deposits of the Mimbres basin, the volume of sediments dewatered in the period from 1940 to 1950 was computed from the map of lowering of water level in that period, figure 6, by sketching in the contours from zero to minus 6 feet by inspection. The determined volume of dewatered sediments was approximately 1,500,000 acre-feet. As the pumpage for this period was on the order of 360,000 acre-feet (Water levels and artesian pressures in observation wells, 1939-50) the indicated coefficient of storage is 0.24.

Because of the limitations of the data, it is not expected that these values of the coefficient of storage are correct, but they do show that long-term drainage of the sediments yields appreciable water and that the coefficient of storage is probably at least 0.10 and may be 0.20 or more--definitely not on the order of 10^{-4} as determined in the short-term pumping tests. For the purposes of computing long-term future effects of pumping, it appears that 0.15 may be a representative average value of the coefficient of storage.

FUTURE EFFECTS OF PUMPING

Determination of the amount of development allowable in the area west of Red Mountain depends in part upon the rate at which water levels will lower in the future. In turn, the rate and magnitude of the lowering of water levels resulting from pumping depends upon the transmissive character of the aquifer, the volume of water contained in the aquifer, other characteristics of the aquifer such as impermeable boundaries, and the rate of pumping. These factors are all known to one degree or another and have been discussed previously.

In determining the future lowering of water levels at a distance from the immediate area of new development, the more probable range in values of the coefficient of transmissibility, 15,000 to 30,000 g.p.d. per foot and the coefficient of storage of 0.10 to 0.20 were used.

Other factors being equal, the shape of the cone of depression--that is, whether narrow and deep or wide and shallow--depends upon what combinations of the coefficients of transmissibility and storage are used. As an example, the high value of the coefficient of transmissibility when used in combination with the low value of the coefficient of storage results in the greatest spread of the effects of lowering at a particular time, that is, the lowering at a distance is comparatively large. Using the low value of the coefficient of transmissibility in combination with the low value of storage results in the greatest lowering in the immediate area of the pumping.

In computing the future lowering of water levels, a pumpage rate of 5,200 acre-feet a year was used, because that is the probable order of pumpage in the future provided that there is full development of the 2,600 acres having water permits. The pumpage rate of 5,200 acre-feet is a little more than twice the pumpage in 1951. The resultant graphs are shown in figure 10. For the purpose of determining the future lowering at a distance, it was assumed that the pumpage of 5,200 acre-feet a year was from a single source. This assumption introduces no significant errors in the computed lowering at appreciable distances from the center of pumping; however, for short distances, possibly a mile or so, the graphs in figure 10 indicate a greater lowering that would occur had actual well spacings and pumpage been used.

The graphs in figure 10 were constructed also with the assumption that the aquifer was areally extensive--that is, that boundaries do not exist within the limits of the effects of pumping. This is essentially true except, in small part, for the existence of Red Mountain, which will limit to some extent the eastward spread of the effects of pumping from the area west of Red Mountain. This means that the lowering of water levels beyond about 3 miles to the east of the new development will be somewhat less than given by the graphs. Also, as Red Mountain is a partial boundary to the aquifer, the lowering of water levels in the part of the new area of development immediately west of Red Mountain will be somewhat greater than given by the graph.

Under the assumptions given, pumpage of 5,200 acre-feet a year in the new area of permitted development west of Red Mountain will in 10 years result in lowering the water levels in the nearest older area of concentrated irrigation development, about 6 miles to the east, on the order of 1 foot. (See fig. 10.) This is small when compared with the 10-year lowering from 1940 to 1950 of 8 to 10 feet (fig. 6) that occurred in this older developed area as a result of local pumping.

If pumping in the area west of Red Mountain will effect the water levels in the older irrigated areas to the east, then it must be assumed that pumping in the older areas has by now lowered water levels in the area west of Red Mountain, as pumping has been practiced in the older areas for many years. Thus, the amount of lowering that has occurred in the newly developed area as a result of pumping in the older areas should give an inidcation of the amount of lowering that pumping in the new area will have upon the older area. As given on page , it appears that the 13
water levels west of Red Mountain lowered approximately 2 to 3 feet in the period from 1940 to 1950, probably mainly as the result of pumping in the older irrigated areas to the east. The amount of pumping in the older irrigated areas during this period is not known by individual areas. However, the pumpage within about 8 miles of the area west of Red Mountain has undoubtedly exceeded the assumed pumpage of 5,200 acre-feet a year in the newly developed area. On this basis, it thus appears safe to conclude that pumpage in the new area west of Red Mountain will not effect the older areas to the east any more than pumpage from the older areas has affected the new area in past years--that is, apparently on the order of 2 to 3 feet in 10 years.

In order to determine the amount of lowering to be expected in 10 years in the immediate area of new development west of Red Mountain, the locations of irrigation wells under permit and the amount of land with permits issued as of September 1952 were compiled. Figure 11 shows these permitted wells and acreages and the permit number assigned by the State Engineer. The expected lowering of water levels that would result from pumping the permitted wells at constant rates equal to 2 feet of water per year upon the respective permitted acreage has been computed for three points and shown on figure 11. The total acreage under permit, as given in figure 11, is 2,593 acres and at an average pumpage of 2 acre-feet per acre per year, represents a pumpage of about 5,200 acre-feet per year.

The expected lowerings given on figure 11 are those that would occur provided the irrigated acreage is equal to that under permit. However, as the policy of the State Engineer is to limit the acreage to that which can be served by the pertinent wells under permit, the actual acreage when development is completed under the present permits will doubtless be less than 2,593 acres. Assuming that the average acreage per well under full development will be equal to the average of the wells used in 1951, that is, 1,100 acres for 14 wells, the acreage at full development with 20 wells will be approximately 1,600 acres. If the distribution of the 1,600 acres is the same as the permitted 2,593 acres, then the water levels will lower only 0.6 of the amounts shown in figure 11. On the whole, this distribution will be true, as some 70 percent of the expected development has already occurred.

As noted (fig. 11) the lowering expected in 10 years at the northwest corner of sec. 13, T. 24 S., R. 11 W. is 30 feet, assuming a pumpage of 5,200 acre-feet per year. This is to be compared with a lowering of about 3.5 feet at this spot, as given in figure 2, after approximately 1 year's pumping (1951) of about 1,900 acre-feet. Had the pumpage in 1951 been 5,200 acre-feet, the lowering presumably would have been more than double that observed, or about 9.5 feet at the northwest corner of sec. 13. As the effects of pumping result in diverting water from greater and greater areas, as time goes on, the rate of lowering progressively diminishes so that the lowering in succeeding years will normally be less than experienced the first year. Also, however, as the pumpage is from a number of wells spaced over an area rather than from one well, the rate of lowering near the center of pumpage will not proceed at a logarithmic rate but at a slightly greater rate. It is thus seen that the expected lowering of water levels of 30 feet in 10 years at the northwest corner of sec. 13 is greater than about 19 feet, which would occur if the lowering proceeded at a logarithmic rate, based upon the first year's lowering, and less than the approximately 95 feet that would occur if the lowering proceded at a linear rate, based upon the first year's lowering. It should be pointed out also that, as the distribution of pumpage in 1951 was somewhat different than would have occurred had all permitted wells and acreage been developed, exact comparison between the observed 1-year lowering and expected 10-year lowering should not be made.

In computing the expected lowering of water levels, it was assumed that pumpage from each well was continuous and at a constant rate, whereas in reality pumpage is at varying rates and is greatest during the irrigation season and least during the winter. Thus, the pumpage is cyclic in nature and not steady as assumed. However, on a long-term basis, the differences in effect between steady and cyclic pumping disappear, provided that the pumping effects are computed for full cycles--that is, from time of minimum pumping one year to minimum the next. Thus, the computed lowering is basically correct for a full 10-year cycle.

Also, in computing the future lowering of water levels in the immediate area of development, the values of the coefficients of storage and transmissibility were assumed as 0.15 and 30,000 g.p.d. per foot, respectively. These are believed to be approximately the most likely average values based upon present information, as previously discussed, and present well depths. If deeper wells are drilled it is probable that artesian pressures will be exhibited because of penetration of partial confining clay layers and the over-all coefficient of transmissibility probably will be slightly greater because of the greater thickness of water-producing formation that would be tapped. The net effect of deeper wells upon the expected future lowering of water levels, will probably be small and may result in somewhat less lowering in the immediate area of pumping and somewhat greater lowering at distances from the pumping.

The lowering of water level expected in 10 years was computed on the basis of an areally extensive aquifer. This is not the case exactly, as Red Mountain is about 2 miles east of the center of development and the Snake Hills are about 5 miles southeast. There is, therefore, a partial boundary nearby to the east. This partial boundary will result in water levels lowering in the new area of development at a rate somewhat greater than would otherwise occur. The effect of this partial boundary cannot be evaluated. However, in 10 years it is expected to be small and, on the basis of the sector intercepted by Red Mountain, the maximum additional lowering caused by the position of Red Mountain probably would not exceed 10 percent of the theoretical lowering.

If additional development is allowed, water levels will lower at greater rates than with the development that will result from present permits. The exact amount of increased lowering at a particular spot will, of course, depend upon the location of additional wells and the pumpage from them. Development of new wells at adequate distances from existing wells will result in affecting the water levels in existing wells by only small amounts, as compared with locating new wells at small distances from existing wells. On a long-term basis, if wells are spaced and pumped fairly uniformly throughout the new area and undeveloped areas to the north, west, and south, the water levels will decline at nearly a linear rate. Assuming a coefficient of storage of 0.15, pumpage at a rate of 320 acre-feet a year in each and every section of land, sufficient for irrigating about 160 acres per section, the long-term average lowering would be 3.3 feet per year. Correspondingly, greater or less development would result in correspondingly greater or less lowering of water levels.

SUMMARY

Since opening of a part of the Mimbres ground-water basin in the area west of Red Mountain by the New Mexico State Engineer on April 17, 1950, development resulted in 14 wells being used to irrigate approximately 1,100 acres in 1951. By January 1952 there were 17 irrigation wells, of which 16 were equipped with pumps. Permits for appropriation of ground water issued by the New Mexico State Engineer as of September 1952 total about 2,600 acres.

On the average, wells west of Red Mountain produce sufficient water for irrigation and are comparable to irrigation wells in the older irrigated areas to the east. The nonpumping depth to water in January 1952 was approximately 100 feet below the land surface, which in general was slightly greater than in the older irrigated areas.

Ground water pumped in the areas west of Red Mountain is from ground-water storage and long-term net lowerings of water level will occur. Pumpage of approximately 1,900 acre-feet in 1951 resulted in net lowerings of water level by January 1952 of 2 to 4 feet under most of the irrigated area. Pumpage of 5,200 acre-feet a year on the permitted acreage is expected to result in a maximum lowering in the area in 10 years of approximately 30 feet. As actual development of land under present permits is expected to be less than the maximum applied for, the actual lowering of water level in 10 years is expected to be somewhat less than the computed maximum of 30 feet.

Present indications are that pumping of 5,200 acre-feet a year in the area west of Red Mountain will in 10 years lower water levels in the older irrigated area, about 6 miles to the east, on the order of 1 to a maximum of 3 feet. This compares with an actual lowering of 8 to 10 feet in the older area from 1940 to 1950 that resulted from pumping in the older area itself.

WELL-NUMBERING SYSTEM

The system of numbering wells is based on the common subdivisions in sectionized land. By means of it the well number, in addition to designating the well, locates its position to the nearest 10-acre tract in the land net. The number is divided by periods into four segments. The first segment denotes the township north or south of the New Mexico base line; the second denotes the range east or west of the New Mexico principal meridian; and the third denotes the section. In a county such as Roosevelt County, where wells are situated both north and south of the base line, an N is added to the first segment of the well number if the well is north of the base line, but no letter is added if the well is south of the base line. Similarly, in a county where wells are located both east and west of the meridian, an E is added to the second segment of the well number of those wells east of the meridian. In counties lying entirely within one quadrant of the principal meridian and base line, the direction north or south of the base line or east or west of the meridian is not given.

The fourth segment of the number, which consists of three digits, denotes the particular 10-acre tract in which the well is situated. 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 quarter section is divided into four 40-acre tracts numbered in the same manner, and the second digit denotes the 40-acre tract. Finally, the 40-acre tract is divided into four 10-acre tracts, and the third digit denotes the 10-acre tract.

Thus, well 12.36.24.123 in Lea County is located in the SW¼NE¼NW¼ sec. 24, T. 12 S., R. 36 E. If a well cannot be located accurately within a 10-acre tract, a zero is used as the third digit, and if it cannot be located accurately within a 40-acre tract, zeros are used for both the second and third digits. If the well cannot be located more closely than the section, the fourth segment of the well number is omitted. When it becomes possible to locate more accurately a well in whose number zeros have been used, the proper digit or digits are substituted for the zeros. In Water-Supply Paper 911 and earlier reports the digits corresponding to unknown 10-acre and 40-acre tracts were simply omitted, but this practice caused some confusion in cataloging the wells. In Water-Supply Paper 941 and subsequent reports, wells the last segment of whose numbers end in one or two zeros correspond to wells whose numbers in earlier reports are the same except for the omission of the last one or two zeros. Letters a, b, c, ... are added to the last segment to designate the second, third, fourth, and succeeding wells in the same 10-acre tract.

The following diagram shows the method of numbering the tracts within a section.

DIAGRAM SHOWING METHOD
OF NUMBERING TRACTS WITHIN A SECTION

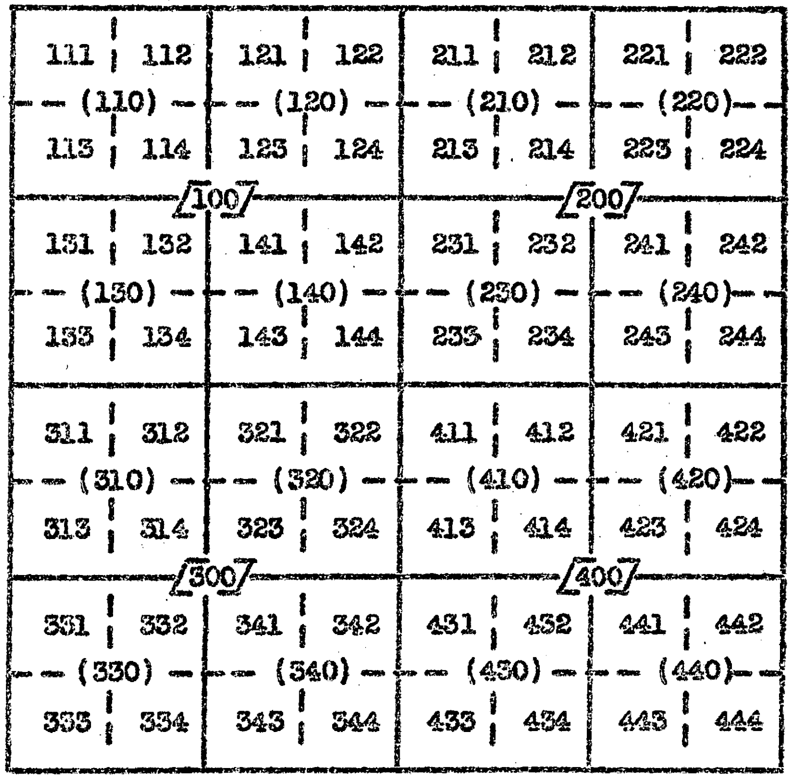

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TABLE 1:--DRILLERS' LOGS OF WELLS WEST OF RED MOUNTAIN, LUNA CO., N. MEX.

24.11.11.211 Permit: M-462
Owner: Ramon S. Dominguez
Driller: S. E. McConnaughey
Casing perforated: From 104 to 202 feet

Material	Thickness (ft.)	Depth (ft.)	Material	Thickness (ft.)	Depth (ft.)
Silt	2	2	Clay and gravel	50	170
Soil	4	6	Sand and gravel	20	190
Clay and gravel	84	90	Clay and gravel	12	202
Sand	30	120			

24.11.12.111 Permit: M-463
Owner: George S. Dominguez
Driller: S. E. McConnaughey
Casing perforated: 102 to 200 feet

Material	Thickness (ft.)	Depth (ft.)	Material	Thickness (ft.)	Depth (ft.)
Silt	2	2	Coarse gravel	5	100
Soil	6	8	Sand and gravel	30	130
Clay and gravel	47	55	Fine sand	8	138
Gravel	13	68	Clay, sand, and gravel	62	200
Clay and gravel	27	95			

24.11.12.211 Permit: M-469
Owner: James W. Hurt
Driller: Mimbres Valley Drilling Co.
Casing perforated: From 100 to 178 feet

Material	Thickness (ft.)	Depth (ft.)	Material	Thickness (ft.)	Depth (ft.)
Dug	107	107	Sand, pea gravel, & clay balls	25	158
Caliche and sand	16	123	Sand	9	167
Sand	10	133	Heavy clay, sand, and gravel	40	207

24.11.12.324 Permit: M-442
Owner: Minnie and W. G. Post
Driller: McBee Drilling Co.
Casing perforated:

Material	Thickness (ft.)	Depth (ft.)	Material	Thickness (ft.)	Depth (ft.)
Soil	5	5	Sandy clay	57	102
Gravel	75	80	Sand and gravel	12	194
Sandy clay	30	110	Clay	6	200
Sand and gravel	15	125			

TABLE 1:--DRILLERS' LOGS OF WELLS WEST OF RED MOUNTAIN, LUNA CO., N. MEX. Cont'd.

24.11.12.412 Permit: M-448
Owner: James W. Hurt
Driller: James W. Hurt
Casing perforated: from 97 to 166 feet

Material	Thickness (ft.)	Depth (ft.)	Material	Thickness (ft.)	Depth (ft.)
Clay and caliche.....	45	45	Soft clay.........................	11	143
Coarse sand and gravel	10	55	Gravel, water......................	8	151
Clay.................	42	97	Clay and caliche..................	8	159
Fine sand, water.....	7	104	Sand and gravel, water............	5	164
Red clay.............	17	121	Clay..............................	4	168
Sand and gravel, water	5	126	Gravel, water.....................	1	169
Clay.................	3	129	Clay..............................	54	223
Gravel, water...	3	132			

24.11.13.111 Permit: M-474
Owner: James W. Hurt
Driller: James W. Hurt
Casing perforated: from 95 to 181 feet

Material	Thickness (ft.)	Depth (ft.)	Material	Thickness (ft.)	Depth (ft.)
Clay..................	4	4	Gravel and clay balls............	2	210
Coarse sand, gravel, and boulders.........	72	76	Clay.............................	49	259
Clay..................	54	130	Gravel and clay..................	6	265
Clay and gravel......	3	133	Heavy clay.......................	12	277
Red clay.............	75	208			

24.11.14.122 Permit: M-526
Owner: Charles Waldrop
Driller: McBee Drilling Co.
Casing perforated: from 85 to 210 feet

Material	Thickness (ft.)	Depth (ft.)	Material	Thickness (ft.)	Depth (ft.)
Soil..................	3	3	Clay and gravel..................	41	160
Caliche..............	14	17	Clay, some sand and gravel.......	32	192
Clay.................	68	85	Sand and gravel..................	3	195
Clay and sand........	25	110	Clay.............................	5	200
Sand and gravel	9	119	Gravel and sand..................	10	210

TABLE 1:--DRILLERS' LOGS OF WELLS WEST OF RED MOUNTAIN, LUNA CO., N. MEX., Cont'd.

24.11.24.311 Permit: M-531
Owner: Ernest and Max Madrid
Driller: McBee Drilling Co.
Casing perforated: from 100 to 198 feet

Material	Thick-ness (ft.)	Depth (ft.)	Material	Thick-ness (ft.)	Depth (ft.)
Soil	4	4	Sandy clay	16	164
Clay	46	50	Gravel	23	187
Gravel	20	70	Clay	4	191
Sandy clay	70	140	Gravel	5	196
Clay	8	148	Sandy clay with gravel streaks	4	200

24.11.24.411 Permit: M-533
Owner: Ernest and Max Madrid
Driller: McBee Drilling Co.
Perforated: from 100 to 197 feet

Material	Thick-ness (ft.)	Depth (ft.)	Material	Thick-ness (ft.)	Depth (ft.)
Soil	5	5	Clay	7	152
Clay	43	48	Sandy clay	12	164
Gravel	18	66	Gravel	19	183
Sand clay	54	120	Clay	4	187
Clay	20	140	Gravel with clay streaks	13	200
Sandy clay	5	145			

TABLE 2.--WELLS DRILLED FOR IRRIGATION WEST OF RED MOUNTAIN
LUNA COUNTY, N. MEX.
August 1952

Well location number	Diameter (in.)	Reported depth (ft.)	Date drilled	Water level below land surface datum (ft.) Mar. or May 1951	Water level below land surface datum (ft.) Jan. 1952	Change in water level 1951-1952 (ft.)	Approximate yield (gpm)	Approximate yield (date)	Approximate specific capacity (gpm per ft. drawdown)	Altitude (ft. above msl) land surface datum a/	Altitude (ft. above msl) water table Jan. 23 1952	Approximate pumpage 1951 (A-ft.)
24.11.1.311	16	-	Apr. 1951	101.42	102.98	-1.56	-	-	-	-	-	195
1.333	12	175	before1944	b102.18	105.26	-3.08	-	-	-	4,425	4,320	40
2.313	16	300	Mar. 1951	-	117.18	-	210	Aug.1952	-	-	-	25
2.322	16	191	Mar. 1951	109.66	112.18	-2.52	200	Aug.1952	-	4,433	4,321	110
11.211	16	202	Oct. 1950	105.48	108.41	-2.93	300	Nov.1951	5.6	4,426	4,318	180
11.411	16	200	Feb. 1952	-	-	-	485	Aug.1952	-	-	-	0
12.111	16	200	Sept. 1950	101.57	104.49	-2.92	400	June1951	20	4,418	4,314	360
12.211c/	36	207	May 1951	107.92	-	-	-	-	-	-	-	0
12.324	16	200	Sept. 1950	98.53	102.73	-4.20	420	July1951	17.5	4,408	4,305	230
12.412	36	200	Apr. 1951	97.71	-	-	-	-	-	4,409	d4,306	40
13.111	12	277	May 1952	-	-	-	e75	-	-	-	-	-
13.241	12	200	May 1951	-	-	-	210	Aug.1952	-	-	-	115
13.311	16	250	Oct. 1951	-	95.48	-	455	Aug.1952	-	4,388	4,293	0
13.411	12	-	1951	86.77	88.22	-1.45	450	Jan.1952	45	4,393	4,305	235
13.421	10	-	(f)	g96.20	-	-	d300	May 1951	-	4,393	-	120
14.111	12	212	Apr. 1951	g114	108.06	-	380	May 1951	20	d4,405	-	125
14.122	12	210	Apr. 1951	g120	107.66	-	180	May 1951	10	d4,405	-	100
24.311	16	200	Apr. 1951	g100.05	87.71	-	360	May 1951	25	-	-	55
24.411	16	200	Dec. 1951	-	88.22	-	310	Aug.1952	-	-	-	0

a. By aneroid.
b. Jan. 1951 measurement.
c. Not equipped.
d. Estimated.
e. Reported.
f. Dug well - reported to be "very old".
g. Pumping level.

24.11.11.211. Raymond Dominguez. Irrigation well, depth 200 feet. Pumped at 280 gallons a minute from 1350 November 29 to 1350 December 1, 1951. Measuring point top of hole in base of pump, 1.70 feet above land-surface datum at chisel mark, west side of pump.

Date and time	Water level below m.p. (feet)	Date and time	Water level below m.p. (feet)	Date and time	Water level below m.p. (feet)
Nov. 29		1352:55	c142.03	1402	c157.61
1148	ab111.00	1353:20	c143.03	1550	c157.63
1150	a111.00	1353:30	c143.50	2145	c156.94
1205	c110.94	1353:40	c143.78	Dec. 1	
1210	c110.93	1353:45	c144.03	0217	c156.92
1215	a110.91	1353:50	c144.28	0645	c156.96
1220	c110.90	1354	c144.53	0830	c156.94
1240	a110.85	1351:10	c144.78	1101	c156.92
1259	c110.83	1354:15	c145.03	1350	c156.87
1310	c110.82	1354:25	c145.23	1351:08	c150.03
1334	c110.79	1354:30	c145.43	1352:10	c141.13
1341	c110.78	1354:40	c145.63	1353:12	c137.83
1347	c110.78	1410	a150.40	1354:02	c136.11
1350	110.78	1413	a149.92	1354:50	c134.83
1350:15	c118.53	1419	a150.95	1355:59	c133.28
1350:30	c127.03	1438	c155.68	1357:09	c132.03
1350:35	c129.03	1439:15	c155.53	1358	c131.28
1350:50	c131.03	1441	c155.63	1359:16	c130.28
1351:10	c134.03	1457	c158.63	1400:25	c129.53
1351:15	c135.03	1514	c160.93	1401:12	c129.03
1351:25	c136.03	1653	c160.70	1403:01	c128.03
1351:30	c136:53	1806	c155.60	1405:05	c127.03
1351:40	c137.53	2004	c156.69	1407:34	c126.03
1351:45	c138.03	2203	c156.81	1409:13	c125.43
1351:55	c138.53	Nov. 30		1411:06	c124.83
1352	c139.03	0015	c156.86	1413:09	c124.23
1352:10	c139.53	0213	c156.88	1415:05	c123.73
1352:15	c140.03	0343	c156.86	1417.09	c123.23
1352:25	c140.53	0640	c156.89	1420:26	c122.53
1352:35	c141.03	0840	c156.94	1423	c122.03
1352:45	c141.53	1120	c156.94	1426:35	c121.43

See footnotes at end of table.

24.11.11.211. Raymond Dominguez--Continued.

Date and time	Water level below m.p. (feet)	Date and time	Water level below m.p. (feet)	Date and time	Water level below m.p. (time)
1429:08	c121.03	1514:56	c117.03	0654	a111.51
1432:41	c120.53	1520:18	c116.73	1201	a111.38
1435:06	c120.23	1525:27	c116.48	1445	a111.29
1438:23	c119.88	1531:01	c116.23	1804	a111.26
1440:56	c119.58	1533:26	c116.13	2200	a111.22
1444:15	c119.23	1545:19	c115.68	Dec. 3	
1447:20	c118.93	1618	a114.72	0215	a111.19
1450:02	c118.68	1917	a112.78	0350	a111.17
1455:03	c118.28	2206	a112.21	0715	a111.14
1459:58	c117.93	Dec. 2		1159	a111.10
1505:11	c117.63	0255	a111.80	1552	a111.04
1509:50	c117.33	0503	a111.60	2247	a110.98

a. Measured with steel tape.
b. Pumped sometime before measurement, apparently for a few minutes.
c. Measured with electric contact device.

24.11.12.111. Lee Palayo. Irrigation well, depth 200 feet approximate. Measuring point northeast half-inch hole in base of pump 0.85 foot above land-surface datum.

Measurements made with steel tape

Date and time	Water level below m.p. (feet)	Date and time	Water level below m.p. (feet)	Date and time	Water level below m.p. (feet
Nov. 29		1130	106.17	1625	106.14
1040	106.20	1351	106.12	2200	106.14
1800	106.16	1603	106.12	Dec. 2	
2023	106.18	1745	106.12	0110	106.14
2049	106.17	2130	a107.80	0320	106.14
2222	106.18	Dec. 1		0525	106.14
2357	106.17	0205	106.18	0706	106.15
Nov. 30		0403	a108.91	0920	106.16
0240	106.17	0635	a108.04	Dec. 3	
0410	106.16	0851	106.20	1145	106.14
0900	106.10	1434	106.12	Dec. 4	
				0710	106.07

a. Pumped recently.

TABLE 3.--Continued

24.11.12.324. Lee Palayo. Irrigation well, depth 200 feet. Pumped at 374 gallons a minute from 1003 December 2 to 1003 December 4, 1951. Measuring point}file mark X on lower edge of opening in base of pump case, 1.0 foot above land-surface datum.

Measurements, except ones noted, made with steel tape

Date and time	Water level below m.p. (feet)	Date and time	Water level below m.p. (feet)	Date and time	Water level below m.p. (feet)
Dec. 1		1102:30	a122.86	1011	112.01
1905	104.14	1114	a123.18	1014	111.49
Dec. 2		1128	a123.42	1016	111.23
0717	104.14	1143	a123.62	1018	110.99
0958	104.16	1153	a123.71	1020	110.80
1001	104.16	1208	a123.90	1024	110.43
1003:26	a111.72	1218	a124.02	1026	110.34
1004:13	a114.92	1240	a124.15	1030	110.11
1005:10	a116.42	1300	a124.33	1033	109.95
1006:11	a117.42	1432	a124.85	1037	109.76
1007:13	a118.07	1507	a125.00	1043	109.53
1008:05	a118.47	1530	a125.20	1045	109.48
1009	a118.82	1600	a125.04	1048	109.39
1010	a119.17	1752	a125.46	1050	109.33
1011	a119.32	2000	a125.87	1053	109.23
1012:08	a119.62	2217	a126.22	1055	109.20
1013:02	a119.82	2230	125.50	1057	109.15
1015	a120.22	Dec. 3		1059	109.05
1017:04	a120.52	0155	125.50	1101	109.05
1019:19	a120.80	0835	125.49	1103	109.00
1020:58	a120.96	1104	125.50	1106	108.91
1023:04	a121.16	1345	125.53	1110	108.85
1026	a121.36	1605	125.53	1113	108.79
1028:36	a121.56	1850	125.52	1118	108.70
1031.55	a121.76	2220	125.54	1123	108.62
1034:06	a121.90	Dec. 4		1128	108.55
1036:32	a122.02	0104	125.53	1133	108.47
1039:26	a122.14	0955	125.54	1138	108.41
1042:22	a122.22	1006	113.65	1143	108.34
1051	a122.57	1007:30	112.98	1148	108.28
1057	a122.74	1009:30	112.35	1153	108.23

See footnotes at end of table.

24.11.12.324. Lee Palayo--Continued

Measurements, except ones noted, made with steel tape

Date and time	Water level below m.p. (feet)	Date and time	Water level below m.p. (feet)	Date and time	Water level below m.p. (feet)
1200	108.13	1957	106.52	1024	105.42
1211	108.03	2215	106.28	1445	105.18
1220	107.96	Dec. 5		1805	105.13
1230	107.88	0001	106.09	2115	105.16
1324	107.56	0213	105.92	Dec. 6	
1354	107.41	0415	105.81	0028	105.18
1500	107.20	0600	105.70	0220	105.10
1600	107.01	0730	105.56	0555	105.04
1805	106.75	0845	105.52	0825	105.07

a. Electric contact device.

24.11.13.311. Phillips. Irrigation well, depth 200 feet approximate. Measuring point base of pump, 0.5 foot above land-surface datum.

Measurements made with steel tape

Date and time	Water level below m.p. (feet)	Date and time	Water level below m.p. (feet)	Date and time	Water level below m.p. (feet)
Dec. 2		0735	95.99	1053	96.00
1136	95.99	1133	95.98	1615	95.98
1456	95.98	1420	95.99	2205	96.00
1745	95.99	1635	95.99	Dec. 5	
1947	95.98	1915	95.99	1427	95.98
2210	95.99	2235	95.99	Dec. 6	
Dec. 3		Dec. 4		0005	95.99
0205	96.01	0055	95.99	Dec. 6	
0335	95.98	0655	95.99	0515	96.00

TABLE 3.--Continued

24.11.12.412. James W. Hurt. Irrigation well, depth 200 feet. Measuring point base of pump, 0.5 foot above concrete pump base and land-surface datum.

Measurements, except ones noted, taken from recorder chart.

Date and time	Water level below m.p. (feet)	Date and time	Water level below m.p. (feet)	Date and time	Water level below m.p. (feet)
Dec. 1		0600	102.40	1400	102.31
1843	a101.53	0755	a102.53	1500	102.29
Dec. 2		1200	102.53	1600	102.28
0001	101.57	1600	102.58	1800	102.20
1000	101.57	1800	102.58	2000	102.14
1200	101.80	2000	102.58	2200	102.10
1400	101.93	2200	102.58	Dec. 5	
1540	102.00	Dec. 4		0001	102.08
1800	102.10	0001	102.59	0300	101.96
2000	102.19	0500	102.66	0600	101.89
2200	102.24	1003	a102.73	0800	101.88
Dec. 3		1030	102.62	1000	101.82
0001	102.28	1115	a102.54	1300	101.75
0200	102.32	1200	102.43	1600	101.68
0400	102.37	1300	102.37	Dec. 6	
				1246	a101.84

a. Measured with steel tape.

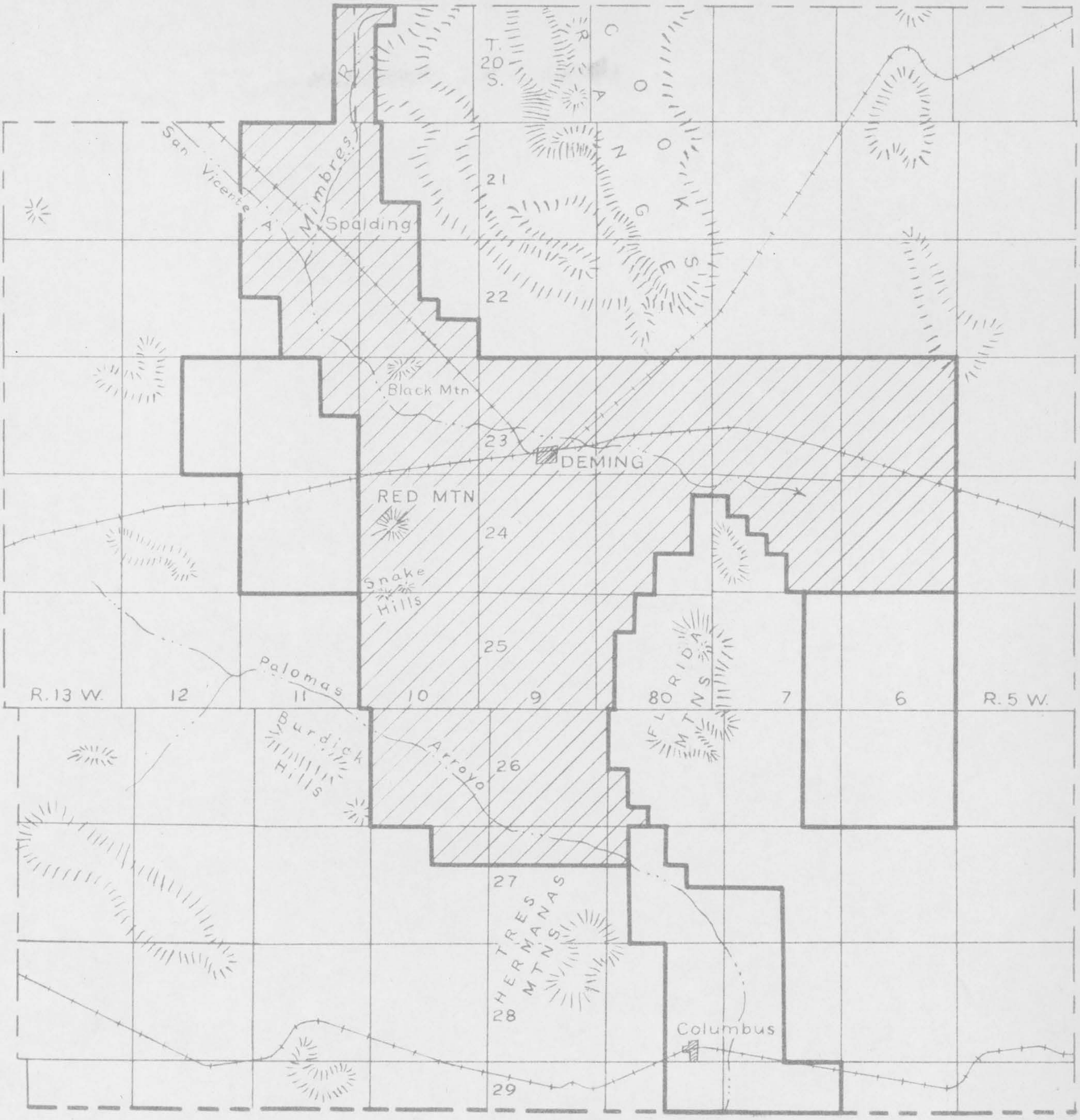
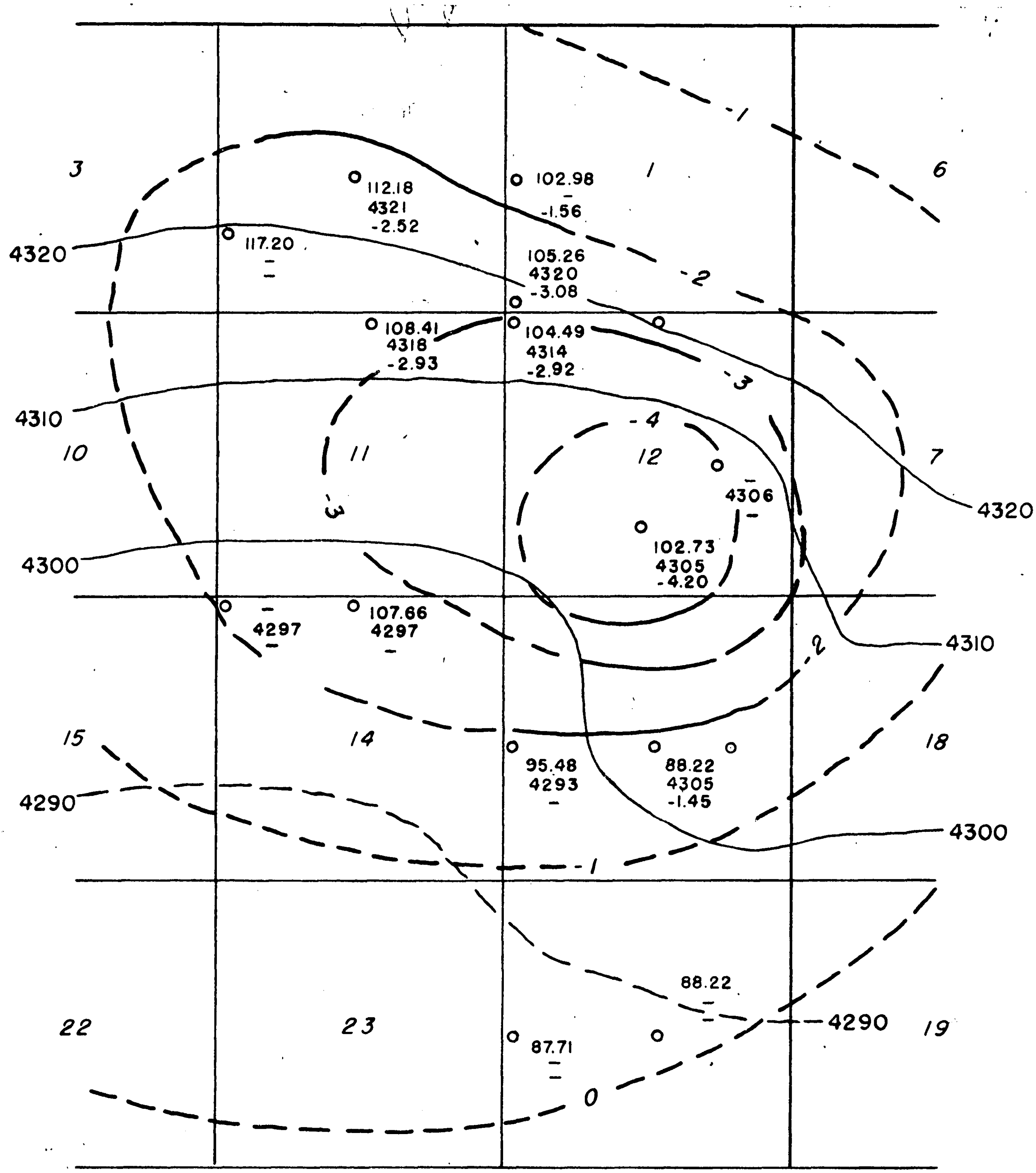


Figure 1.
Map of
Luna County, N. Mex.,
showing
boundary of Mimbres ground-water basin
as
declared by New Mexico State Engineer
and
areas of the basin, open and closed (hachured)
to further ground-water development,
October 1952.



o	Well
95.48	Depth to water January 23, 1952
4305	Altitude of the water table
-4.20	Change in water level 1951 - 52

Line of equal altitude of the water table

Line of equal change in water level 1951 - 52

FIGURE 2. GROUND-WATER CONDITIONS

West of Red Mountain

T.24S., R.11W., LUNA CO., N.MEX.

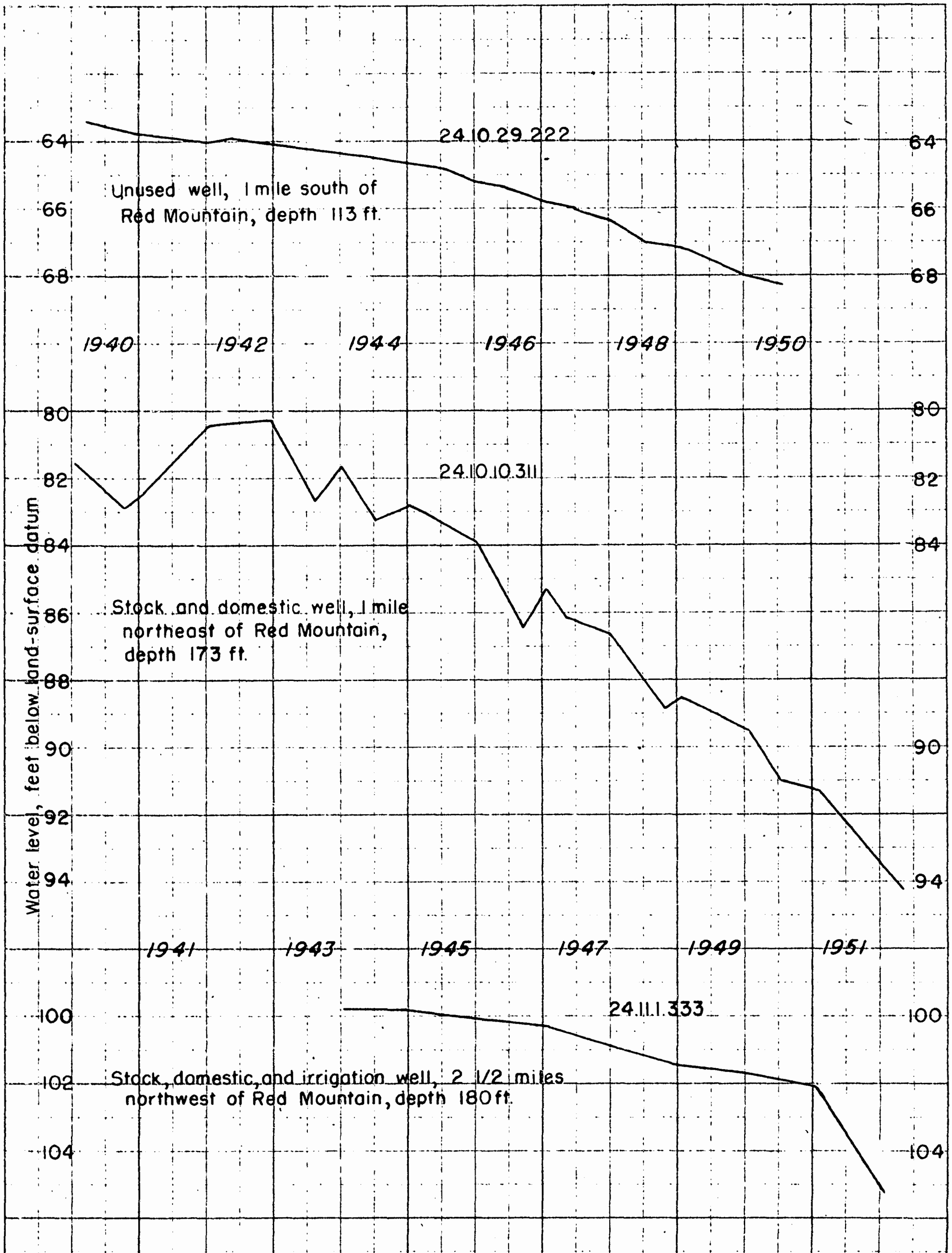
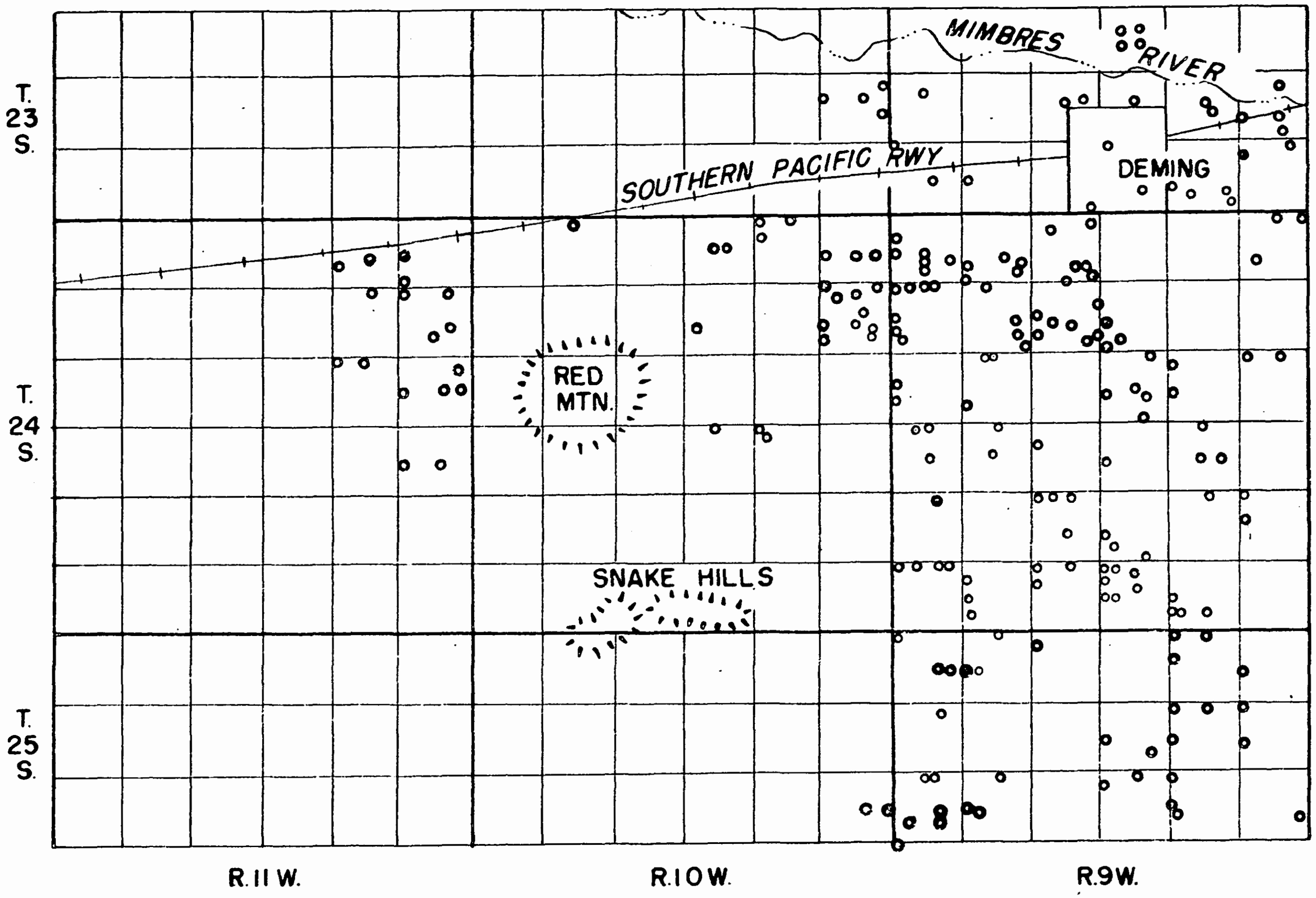


FIGURE 3. CHANGE OF WATER LEVEL IN THREE WELLS NEAR RED MOUNTAIN, LUNA COUNTY, N. MEX.



Note: All wells shown only in T.24S., R.11W.

FIGURE 4. IRRIGATION WELLS NEAR RED MOUNTAIN
LUNA CO., N.MEX., January 1952.

Prepared by U. S. Geological Survey in cooperation with New Mexico State Engineer

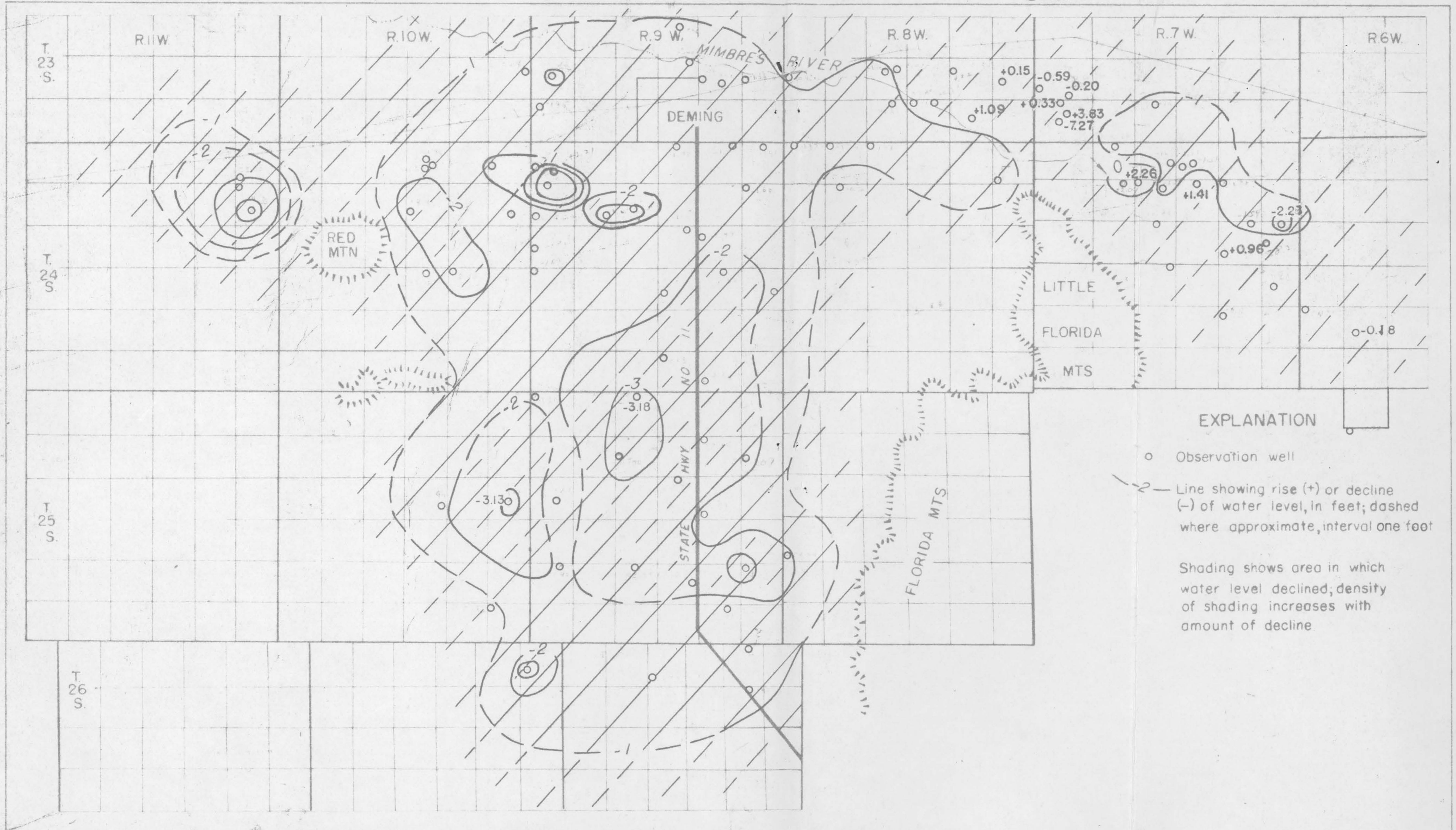


Figure 5. Change in ground-water level from January 1951 to January 1952 in Mimbres Valley, Luna County, New Mexico.

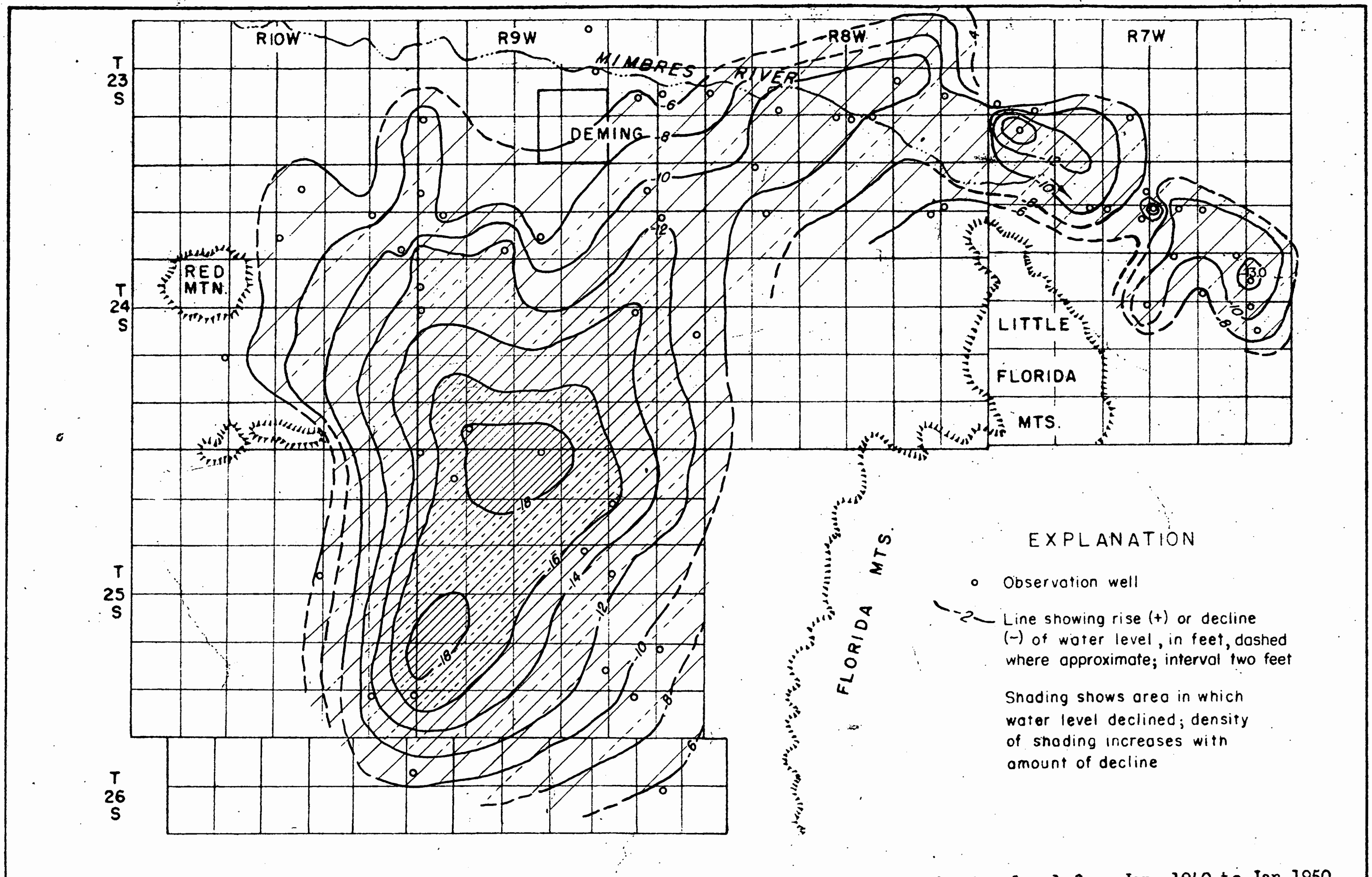


Figure 6 . Mimbres Valley, Luna County, New Mexico, showing decline of ground-water level from Jan. 1940 to Jan. 1950.

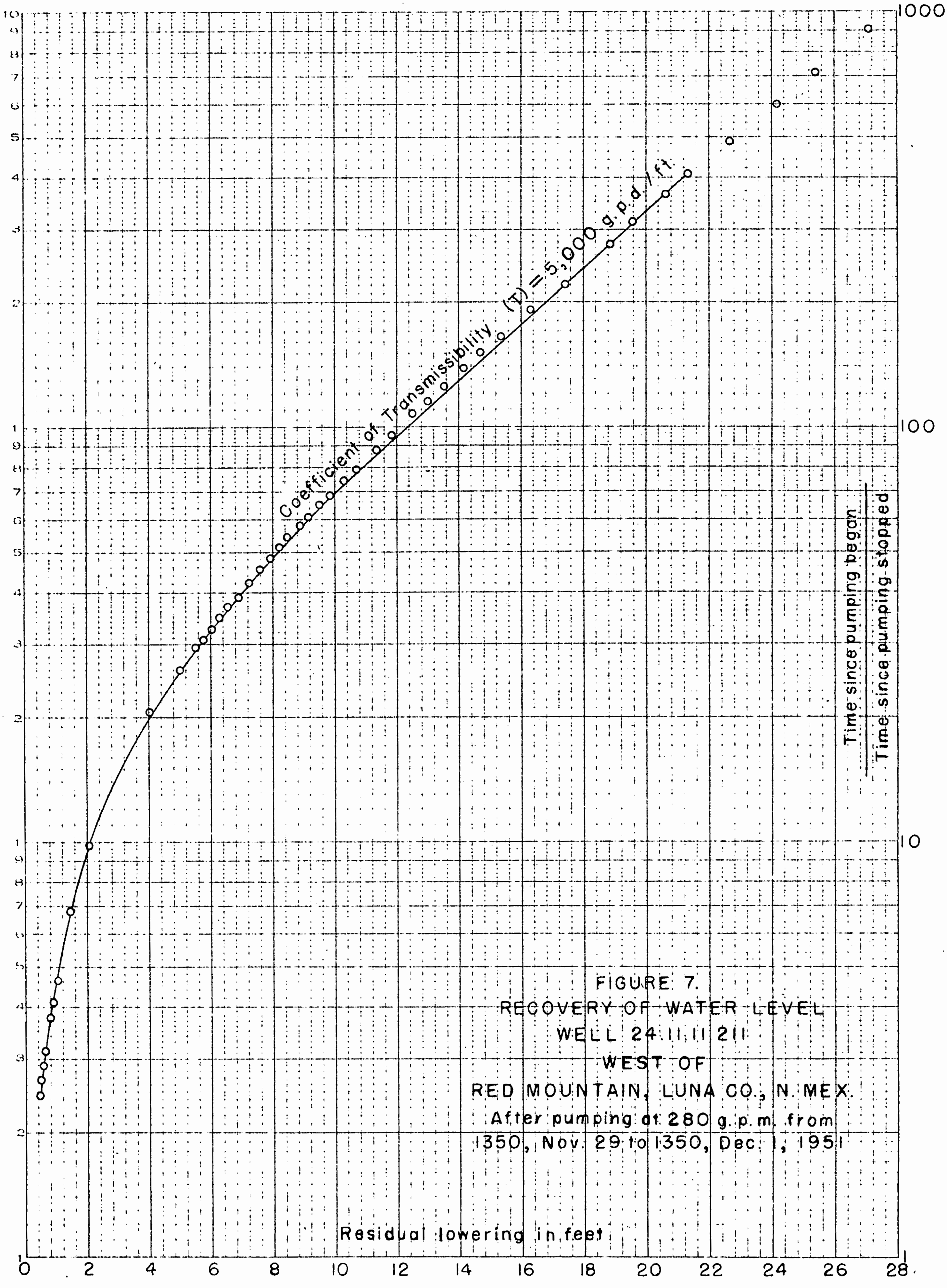
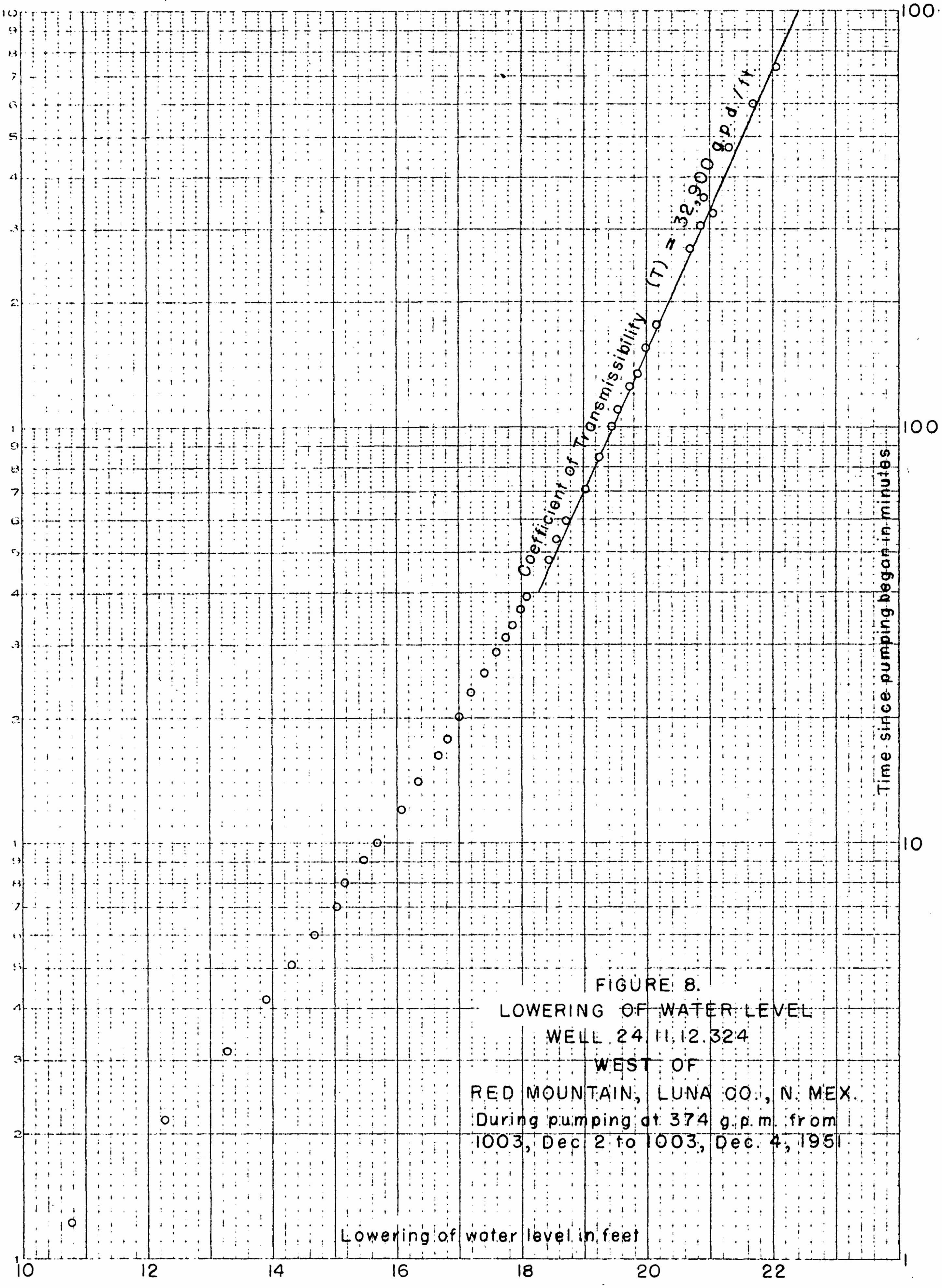
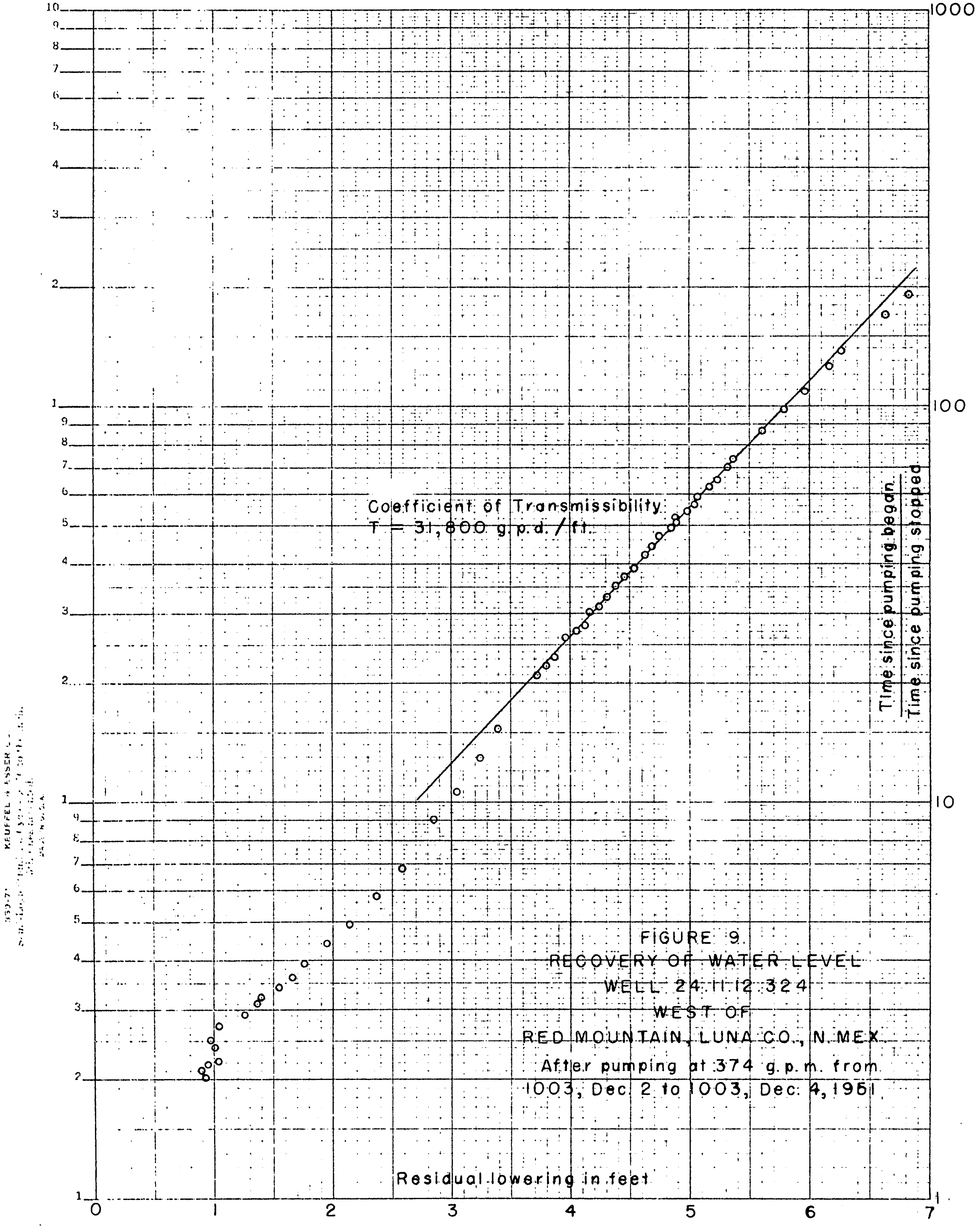


FIGURE 7.
RECOVERY OF WATER LEVEL
WELL 24.11.11.211
WEST OF
RED MOUNTAIN, LUNA CO., N. MEX.
After pumping at 280 g.p.m. from
1350, Nov. 29 to 1350, Dec. 1, 1951



Coefficient of Transmissibility (T) = 32,900 g.p.d./ft.
Time since pumping began in minutes
Lowering of water level in feet
FIGURE 8.
LOWERING OF WATER LEVEL
WELL 24.11.12.324
WEST OF
RED MOUNTAIN, LUNA CO., N. MEX.
During pumping at 374 g.p.m. from
1003, Dec 2 to 1003, Dec. 4, 1951
10
12
14
16
18
20
22
1
10
100



Coefficient of Transmissibility
T = 31,800 g.p.d./ft.
Time since pumping began
Time since pumping stopped
Residual lowering in feet
FIGURE 9
RECOVERY OF WATER LEVEL
WELL 24.11.12.324
WEST OF
RED MOUNTAIN, LUNA CO., N. MEX.
After pumping at 374 g.p.m. from
1003, Dec. 2 to 1003, Dec. 4, 1951

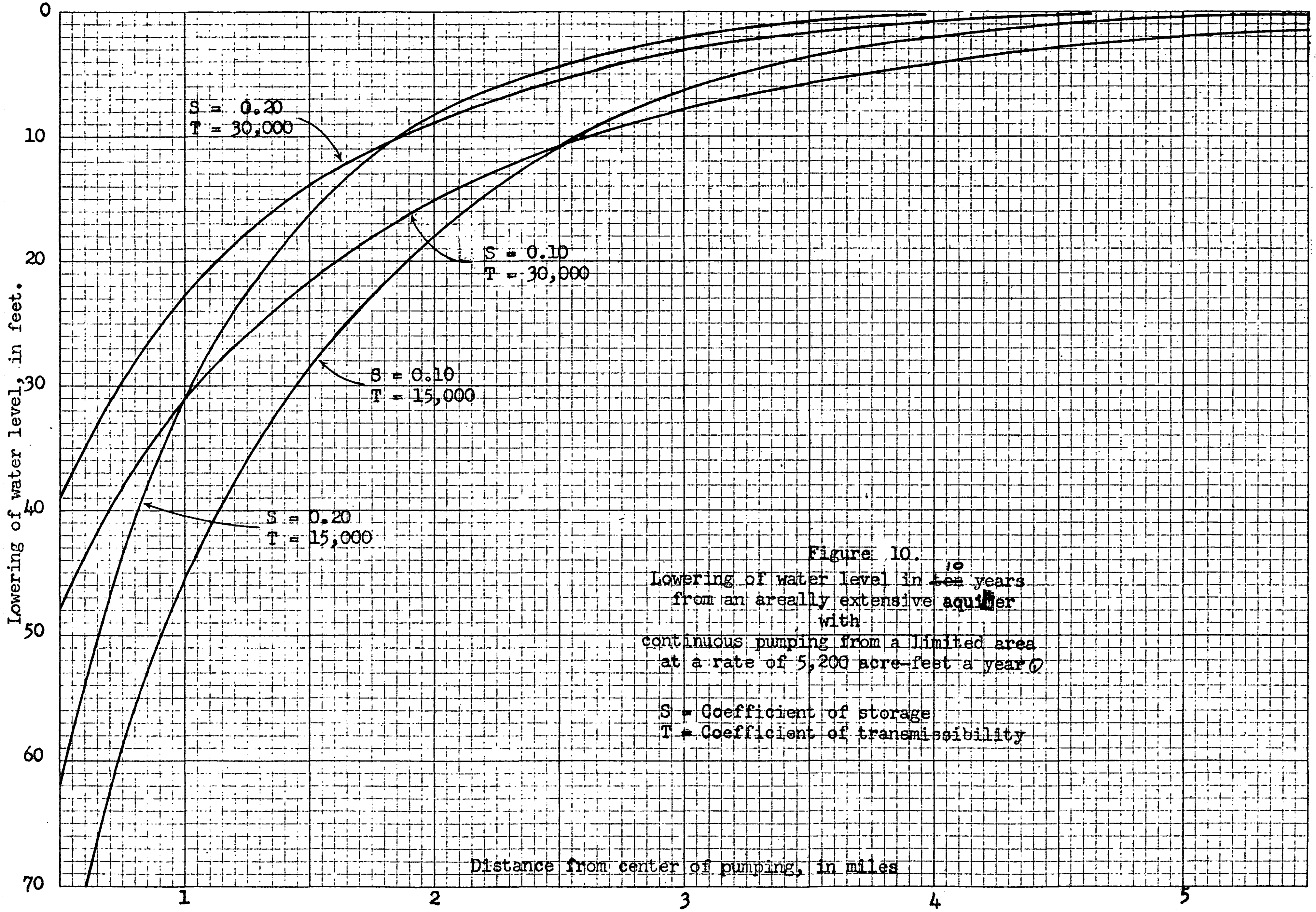


Figure 10.
Lowering of water level in ~~ten~~ 10 years
from an areally extensive aquifer
with
continuous pumping from a limited area
at a rate of 5,200 acre-feet a year.

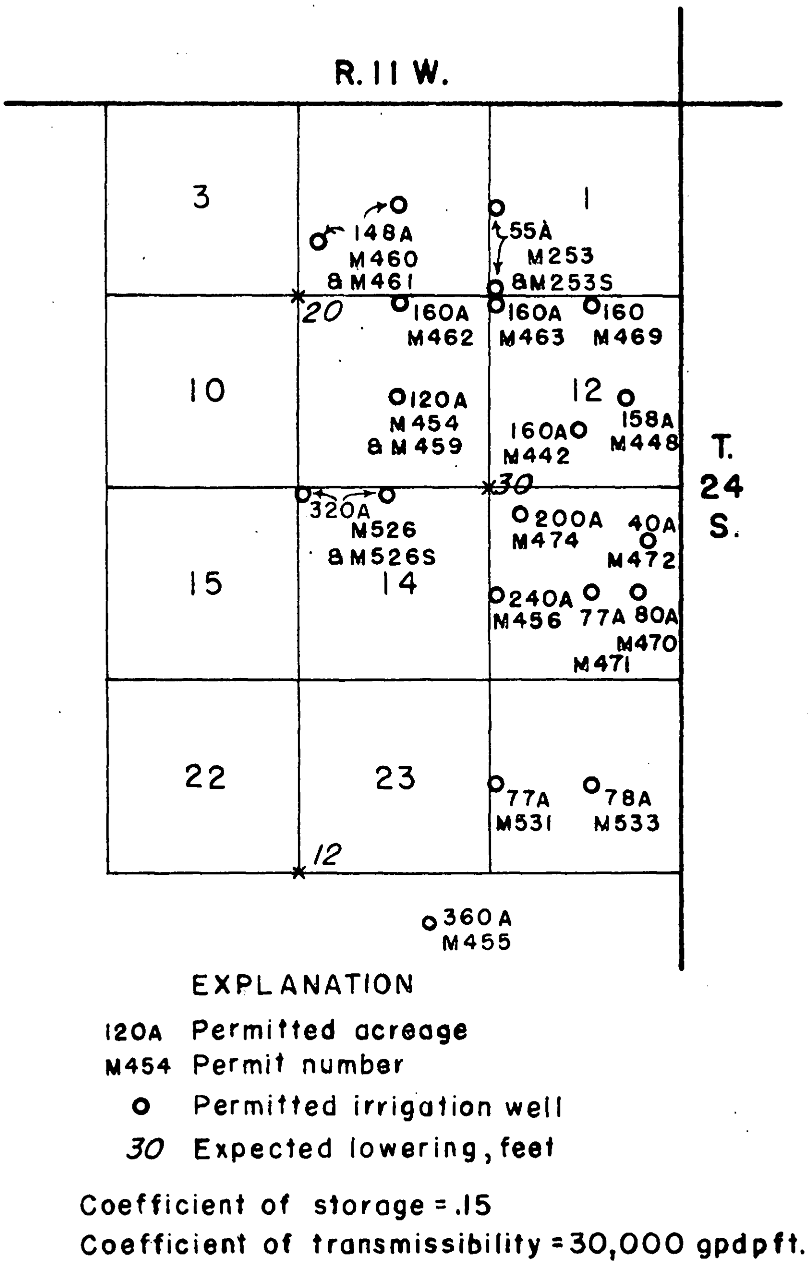


Figure 11.

Expected lowering of water level in first ~~ten~~ 10 years in area west of Red Mountain, Luna County, New Mexico, based on permits issued by New Mexico State Engineer as of Sept. 1952 and pumpage of two acre-feet per acre per year on permitted acreage.