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RESULTS OF PUMPING TESTS ON THE CITY WELLS AT WAXAHACHIE, TEXAS

Prepared in cooperation between the Geological Survey, U. S. Department of the Interior, and the Texas State Board of Water Engineers

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By

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(Prepared from data collected and computed by B. A. Barnes and D. B. Knowles)

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INTRODUCTION

Owing to the large decline in artesian pressure in the basal Cretaceous sands in northern Texas, many towns, cities, and industrial plants are seeking information concerning the water-bearing properties of those sands. Among those concerned are the cities of Dallas, Denison, Waxahachie, and Hillsboro, and the industries of Fort Worth and Dallas. In order that more might be known about the water-bearing properties of the Cretaceous sands in the region as a whole, pumping tests are being made in different parts of the region whenever facilities become available. The pumping tests discussed in this report were made in cooperation with the City of Waxahachie.

The investigation was conducted at Waxahachie in March 1948 to obtain information concerning the possibility of developing additional water from wells in the basal sands of Cretaceous age. These sands were formerly known as the Trinity sand but now, together with interbedded shales, they are usually designated the Pearsall formation. In this report the name "Trinity sands" will be used. The investigation consisted of a series of pumping tests on the existing municipal wells, all of which draw from the "Trinity sands". From these tests, the coefficients of transmissibility and storage of the sands in the well field were determined by the Theis non-equilibrium method [a]. In turn, the coefficients as determined from the tests have been used to compute the decline in pumping levels that may be expected from increases in pumpage from the existing wells and the decline to be expected in existing wells from adding a new well of 500 gallon a minute capacity at distances ranging from 1,000 to 5,000 feet north of well 2 (the northernmost existing well). The pumping tests were made by B. A. Barnes, D. B. Knowles, and D. W. Finlayson, engineers of the Board of Water Engineers and the U. S. Geological Survey. The computations of the coefficient of transmissibility, the coefficients of storage, the specific capacity of well 1, and the future declines in water levels were made by B. A. Barnes, and constitute the basis for this report.

a Theis, C. V., The relation between the lowering of the piezometric surface and the rate and duration of discharge of a well using ground-water storage: Am. Geophys. Union Trans., 1935, pp. 519-524.

History of city water supply

The first deep water well in Waxahachie was probably the one described by Hill *b* in his report written in 1899. The well was completed at a depth of 1,521 feet, drew from sands in the Woodbine formation at 772 and 962 feet, and presumably was used for public supply. It is thought to be the well just east of the concrete storage reservoir and is now known as the 'mineral' well. The next development of a public water supply took place prior to 1913, when three wells were drilled to the sand in the Woodbine formation at depths of about 950 feet. Owing to the small yield of these wells (60 to 72 gallons a minute each), deeper wells were drilled to the 'Trinity sands' and the wells in the sand of the Woodbine formation were abandoned The first well to the 'Trinity sands' was drilled in 1913, the second in 1919, and the third in 1931. The third well was drilled to a depth of 2,950 feet. No records of the first two wells are available.

Use of water

Records of the amount of water sold by the City of Waxahachie, in millions of gallons a month, and the average daily sales in gallons throughout the year from 1940 through 1947 are given below. This table reveals that, during the 8-year period, the average sales amounted to about 585,000 gallons a day and the rate of use has nearly doubled in the 8-year period.

Total amount of water, in millions of gallons a month, sold in Waxahachie from 1940 through 1947, and average amount of water sold each year, in gallons a day

	1940	1941	1942	1943	1944	1945	1946	1947
Jan.	12.6	12.5	12.3	13.9	14.3	15.8	18.2	21.4
Feb.	13.8	14.1	12.9	14.9	14.3	16.5	20.7	22.8
Mar.	12.7	12.8	13.3	15.9	15.6	17.7	23.7	25.0
Apr.	14.6	15.0	15.5	17.5	19.5	17.9	27.1	29.4
May	17.1	15.6	16.2	21.2	21.6	18.2	31.0	30.9
June	16.4	14.9	12.9	17.6	17.4	17.2	25.1	24.0
July	15.8	13.7	13.2	19.1	16.8	17.1	24.9	24.2
Aug.	15.0	12.5	11.9	16.5	16.0	16.9	23.8	24.3
Sept.	13.0	12.3	12.6	16.6	16.3	18.1	23.0	24.1
Oct.	12.6	14.1	13.5	14.9	16.4	18.4	22.9	25.8
Nov.	12.0	11.1	12.7	13.7	13.3	16.7	20.2	26.5
Dec.	12.3	13.3	14.1	14.6	16.5	18.0	21.0	25.8
Average in gallons a day for the year	461,000	440,000	442,000	533,000	542,000	571,000	773,000	833,000

b Hill, R. T., The Black and Grand Prairie region of Texas: U. S. Geol. Survey 21st Ann. Rept., 1900.

Decline of artesian pressure

The original artesian water level in well 1 is reported to have been about 90 feet above the land surface. The well ceased flowing in 1932 and in January 1943 the water level was about 40 feet below the surface. On January 16, 1948, the Layne-Texas Company reported that the static water level was 135 feet below the land surface. On March 16, 1948, the water level was 112.60 feet below the land surface after wells 1, 2, and 3 had been idle 32 hours 24 minutes, 16 hours 30 minutes, and 8 hours, respectively.

No records are available of the water levels in well 2, but the well is known to have stopped flowing in 1932. The water level could not be measured during the tests in March 1948.

It is reported that well 3 flowed slightly when it was drilled in 1931 but ceased flowing in 1932. Early in the summer of 1945 the water level is reported to have been 98 feet below the land surface. On September 19, 1947, the Layne-Texas Company reported the static water level as 125 feet below the land surface. On March 16, 1948, the level was 120.31 feet below the land surface after wells 1, 2, and 3 had been idle for 32 hours 24 minutes, 16 hours 30 minutes, and 8 hours, respectively.

These fragmentary records indicate that the artesian head in the 'Trinity sands' declined about 200 feet between 1913 and March 1948. Most of the decline was undoubtedly the result of the Waxahachie pumping, but some was probably caused by other pumping from the 'Trinity sands' throughout the general region, including that at Dallas and Fort Worth.

Theis nonequilibrium method

For the purpose of this report, only a brief discussion is given of the Theis method of determining the coefficients of transmissibility and storage, and the amount of drawdown caused by pumping. For a detailed description of the Theis method, the reader is referred to U. S. Geological Survey Water-Supply Paper 887, 'Methods for determining permeability of water-bearing materials.' The formula developed by Theis can be used in two ways. If the coefficients of transmissibility and storage are known, the drawdown can be computed for any time at any point on the cone of depression. If the drawdowns are known, the coefficients of transmissibility and storage can be computed.

It should be borne in mind, however, that the Theis formula is developed on the theory that the aquifer is homogeneous, isotropic, infinite in areal extent, and uniform in transmissibility at all places, that the pumped well penetrates its full thickness, and that water is released from storage instantaneously when the well is pumped. The accuracy of predicted future drawdowns depend on the extent to which these conditions are fulfilled.

Pumping tests

During the pumping tests, measurements were made of the drawdown in well 3 while well 1 was pumped and in well 1 while well 3 was pumped. Recovery of the water levels in the pumped wells themselves was observed after the pumps were stopped. From these observations the coefficients of transmissibility and storage were computed and these figures, in turn, were used in the Theis formula for computing future drawdowns to be expected as a result of increasing the withdrawals from the existing wells and from a proposed new well. The following table gives the time at which the pumps were turned on or off, the rate of pumping, the total number of minutes the pumps were operated, the well observed, and the computed coefficients of transmissibility and storage.

Table 1

Results of pumping test on city wells, Waxahachie, Texas

		PUMPING SCHEDULE				COEFFICIENTS		
Date	Hour	Well	Yield (gpm)	Period (minutes)	Well observed	Transmissibility (gpd/ft.)	Storage	Remarks
3/14/48	9:15 a.m.	1 on	504	470	3	8,800	0.0000954	Interference method.
					3	8,500	.0000834	Do.
3/14/48	5:05 p.m.	1 off	504	477	1	11,280		Recovery method.
3/15/48	1:02 a.m.	3 on	617	478	1	8,460	.0000906	Interference method.
3/15/48	9:00 a.m.	2 off	460	451	1	8,200	.0000682	Do.
3/15/48	5:31 p.m.	3 off	606	480	1	8,960	.0000854	Do.
		3 off	611	480	3	7,300		Recovery method.
				Average		8,500	.0000846	

Computed lowering of pumping levels by increasing the pumpage from the city wells now in service

On the basis of measured yields of the wells and the present average consumption of about 833,000 gallons a day, it is estimated that the city pumps are operated about 36 percent of the time. It follows that, if all the pumps were operated continuously, the amount of water produced could be nearly tripled. However, the increase would be sure to be followed by a marked decline in the pumping levels. For the purpose of estimating the future declines, the following rates of continuous pumping have been assumed: 528 gallons a minute for well 1; 460 gallons a minute for well 2; and 611 gallons a minute for well 3. From these assumed figures on continuous pumping and the average coefficients of transmissibility and storage obtained by the interference methods and given in table 1, and assuming wells 2 and 3 to have the same specific capacity as well 1, computations have been made of the additional declines in pumping levels to be expected in the three city wells at the end of 3 months, 1 year, 5 years, 10 years, and 20 years. The pumping level in each well used as a starting point for the computations is the level after 1 day of continuous operation of the well in question, while the well field as a whole is still being operated on an intermittent basis. The results of the computations are given in the following table:

Table 2

Computed additional decline in pumping levels, in feet, that will occur in city wells if the three wells now in service are pumped continuously

Elapsed time after pumps start operating continuously	Additional decline in pumping level Well 1	Well 2	Well 3
3 months	88	85	79
1 year	109	107	100
5 years	134	131	125
10 years	148	144	138
20 years	160	156	150

Computed lowering of the artesian head by adding a new well north of well 2

For the purpose of estimating the decline in the city wells, in addition to the declines given in table 2, if another well is drilled and put into service, computations were made, based on a yield of 500 gallons a minute from a new well located at distances of 1,000, 2,000, 3,000, 4,000, and 5,000 feet north of well 2. The computed additional decline caused by pumping the new well continuously for periods of 3 months, 1 year, 5 years, 10 years, and 20 years is given in the following table:

Table 3

Computed additional decline in artesian head in the city wells now in service if a new well is pumped continuously at a rate of 500 gallons a minute

Time after pumping starts	Distance north of well 2 (feet)	Decline (feet) in present wells Well 1	Well 2	Well 3
3 months	1,000	43.6	52.9	36.3
	2,000	38.8	43.7	33.1
	3,000	34.9	38.2	30.5
	4,000	31.6	34.4	28.3
	5,000	29.2	31.4	26.4
1 year	1,000	52.9	62.2	45.7
	2,000	48.2	53.0	42.5
	3,000	44.3	47.6	39.8
	4,000	40.9	43.7	37.6
	5,000	38.5	40.7	35.7
5 years	1,000	63.7	73.0	56.4
	2,000	59.0	63.8	53.2
	3,000	55.0	58.3	50.6
	4,000	51.7	54.5	48.4
	5,000	49.2	51.5	46.5
10 years	1,000	68.3	77.6	61.0
	2,000	63.6	68.4	57.8
	3,000	59.6	63.0	55.2
	4,000	56.3	59.1	53.0
	5,000	53.8	56.1	51.1
20 years	1,000	72.9	82.2	65.7
	2,000	68.2	73.0	62.5
	3,000	64.3	67.6	59.9
	4,000	61.0	63.7	57.7
	5,000	58.5	60.8	55.7

Summary and conclusions

From 1913 to 1948 (a period of 35 years) the average rate of withdrawal by the city of Waxahachie appears to have been less than 500,000 gallons a day, and the artesian head in the city wells in the "Trinity sands" declined about 200 feet.

The computed specific capacity of well 1, after 24 hours of pumping, was 2.62 gallons a minute per foot of drawdown. Therefore, the pumping level in well 1 is computed to be about 306 feet below land surface while pumping at a rate of 528 gallons a minute. No reliable measurements are available from which the specific capacity or pumping levels of wells 2 and 3 can be computed.

If the three existing wells were pumped continuously at a rate of about 2,300,000 gallons a day, the results of the pumping test (table 2) indicates that the pumping levels in the three wells would be further lowered about 90 feet in 3 months, about 130 feet in 5 years, and about 160 feet in 20 years. If a new well were drilled 1,000 feet north of well 2 and pumped continuously, making the total pumpage about 3,000,000 gallons a day, a further lowering of the pumping level would take place in well 1 of about 55 feet in 1 year, about 65 feet in 5 years, and about 75 feet in 20 years. If the well is 5,000 feet from well 2, the pumping level in well 1 would be lowered 40, 50, and 60 feet for the same periods of time. Thus according to the results of the pumping tests, if all the existing wells and a new well, 5,000 feet from well 2, are pumped continuously for a period of 20 years at a combined rate of about 3,000,000 gallons a day, the pumping level in well 1 would be about 525 feet below land surface at the end of 20 years.

It should be remembered, however, that the actual pumping levels to be expected may vary considerably from those computed by the Theis formula, owing to the fact that conditions on which the formula is based may not be fulfilled. Any increase or decrease in withdrawal of ground water from wells in the "Trinity sands" near the city well field, or within a radius of several miles, will also influence the water levels in the city wells. The amount of influence will depend on the rate of increase or decrease in withdrawal from the sand, the distance from the city wells, and the time that has elapsed since the increase or decrease took place.

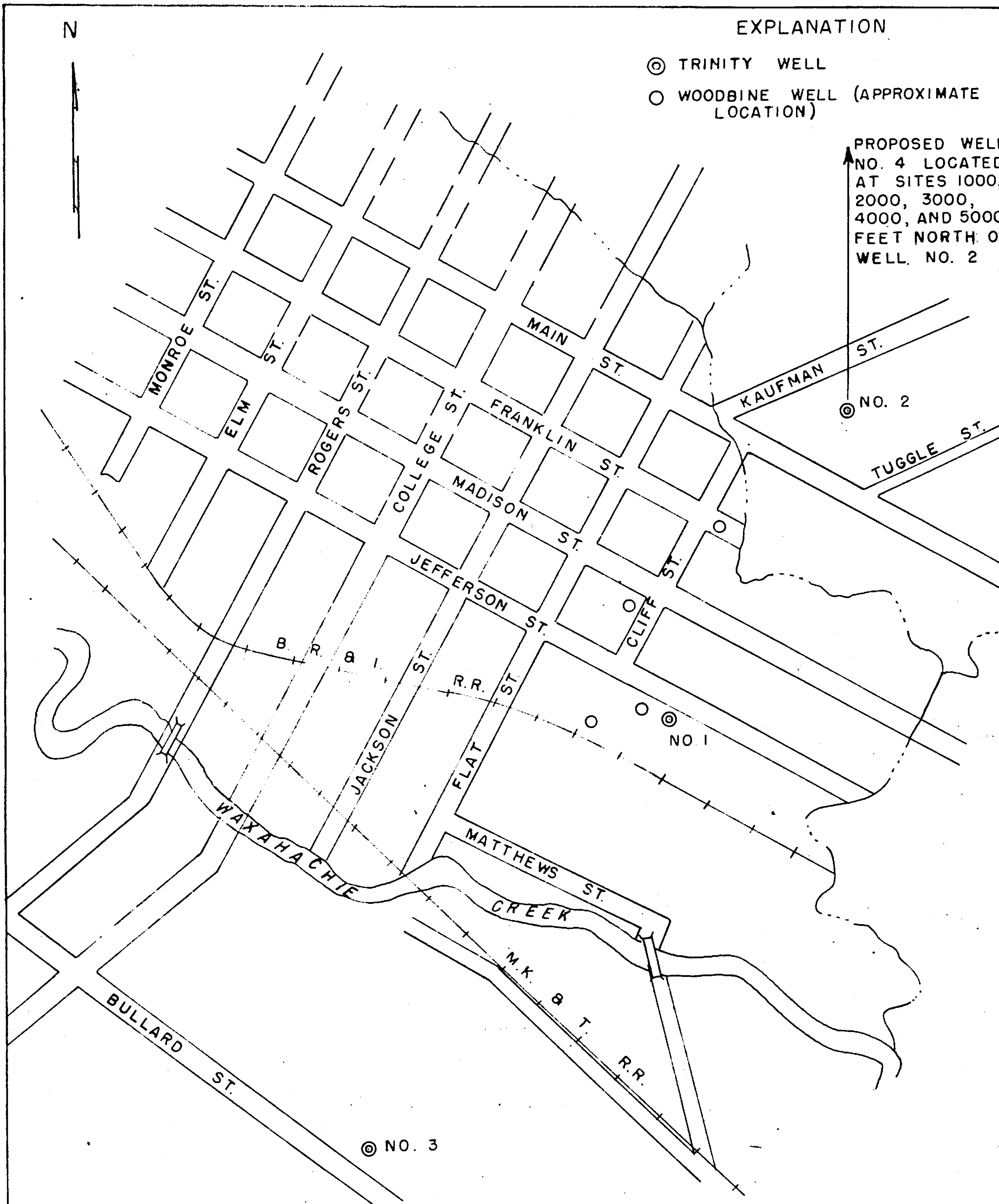

FIGURE I
SKETCH MAP OF PART OF WAXAHACHIE
ELLIS COUNTY, TEXAS