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Report of Preliminary Investigation of the Occurrence of Ground Water in the Trinity Group Near Gainesville, Cooke County, Texas

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October 1960

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INTRODUCTION

Purpose and Scope

This report summarizes the more important general information regarding the occurrence and development of ground water in the Trinity group near Gainesville, Cooke County, Texas. It contains data on the major wells in the area, brief geologic and hydrologic explanations, and projections of the future needs of the area. The report was prepared in response to a local request for ground water information on the area.

Primarily, the basic data in this report was collected for inclusion in a statewide reconnaissance study which is being conducted jointly by the Texas Board of Water Engineers and the U. S. Geological Survey. The reconnaissance study will determine the order of magnitude of the ground water supplies potentially available from the principal water-bearing formations in Texas. These determinations will be suitable for generalized evaluations of ground water conditions over large areas, but will not be adequate for detailed water planning or for the planning of individual water supplies. Hence it should be understood that the data in this report was collected for a regional analysis of ground water conditions and not for the purpose of a detailed quantitative evaluation of the ground water supplies in the Gainesville area.

Acknowledgments

Appreciation is expressed to the city officials of Gainesville, Layne Texas Company, and individual well owners who contributed information for this report. The assistance of the staff of the City of Gainesville water department is especially appreciated.

Location of Area

The Gainesville area, as defined for this report, includes the north-central part of Cooke County. (See Figure 1). Cooke County, in extreme north-central Texas, is one of the northern border counties of Texas. It is bounded on the north by the Red River, on the west by Montague County, on the south by Wise and Denton Counties, and on the east by Grayson County.

Well Information

Information on wells in the area is given in Table 2. The numbers in the first column of the table correspond to well numbers used on the well location map (Plate 1), in the table of chemical analyses (Table 4), and in the list of drillers' logs (Table 3).

The well location map utilizes the statewide well numbering system adopted by the Texas Board of Water Engineers. This system is based on the repeated division and numbering of specific quadrangles, defined by longitude and latitude. The Gainesville area includes all or part of four $7\frac{1}{2}$ minute quadrangles. These are numbered 23, 24, 31, and 32 on the well location map. The $7\frac{1}{2}$ minute quadrangles are subdivided into $2\frac{1}{2}$ minute quadrangles which are numbered left to

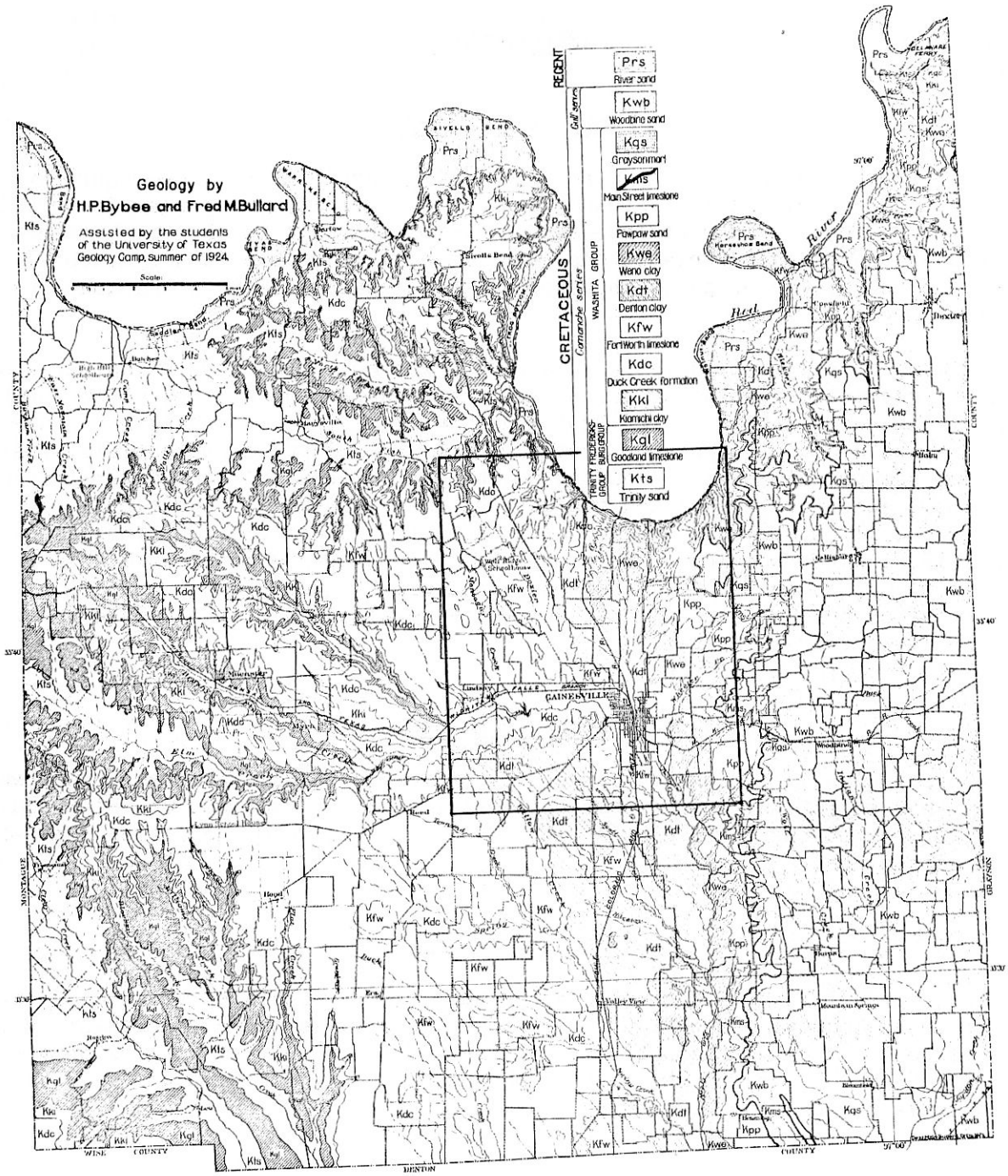

FIGURE I.- Geologic Map of Cooke County, showing the location of the Gainesville area

right, from one through nine. (It will be noted that the $2\frac{1}{2}$ minute grid lines have been omitted on the well location map). The wells in each $2\frac{1}{2}$ minute quadrangle are numbered consecutively, beginning with the number 01. Hence, the designation for the City of Gainesville water well #6 is 23901. This indicates that it is well 01 in $2\frac{1}{2}$ minute quadrangle 9 of $7\frac{1}{2}$ minute quadrangle 23.

GENERAL GEOLOGY

The rocks exposed in the Gainesville area are Cretaceous marine sediments and Recent alluvial deposits. The Cretaceous sediments are underlain by Pennsylvanian strata. The Cretaceous beds strike just east of north and dip east at a rate of 40 to 50 feet per mile. (See Plate 2).

Recent alluvial and terrace deposits occur in and near the major drainages of the area. The feather edge of the Woodbine group crops out in the extreme eastern edge of the Gainesville area. The Washita and Fredericksburg groups underlie the Woodbine group, and crop out over a major part of the area. (See Figure 1). Rocks of the Washita and Fredericksburg groups have a total thickness of 450 feet in the area, and consist chiefly of alternating limestones and shales. The most easily recognized beds in the sequence are the Kiamichi and Goodland formations. (See Figure 2).

The Trinity group, underlying the Fredericksburg group, is the nearshore or beach deposit laid down by the Comanchean sea as it encroached upon the land from the southeast. It consists chiefly of a white to buff fine-grained quartz sand, occurring in massive beds 40 to 50 feet in thickness. Lenses of clay are found throughout the group, ranging in thickness from a few inches to 30 feet. Individual clay layers cannot be traced throughout the area. Interpretation of electric log data indicates that the Trinity group consists of about 60 percent sand throughout the area.

The Trinity group crops out in the northwest corner of the Gainesville area and underlies the entire area. (See Figure 3). The group is about 620 feet thick in the northwest corner of the area and attains a thickness of 850 feet in the southeast corner. (See Plate 4). The depth to the top of the Trinity group increases toward the east and southeast, ranging from zero in the outcrop area to 460 feet in the eastern part of the area.

OCCURRENCE OF GROUND WATER

The Trinity group is the chief water-bearing unit in the area; it supplies all the ground water used for municipal and industrial purposes. The rocks overlying the Trinity group yield only small quantities of good quality water. Water-bearing strata older than the Trinity group generally contain highly mineralized water and are not presently considered practical water sources in the area.

GROUND WATER IN THE TRINITY GROUP

Occurrence and Movement of Ground Water

Ground water occurs under water table and artesian conditions. Under water table conditions the water is unconfined and does not rise in wells above the level at which it is first encountered. Under artesian conditions the water is confined in permeable beds between relatively impermeable beds, and is under

Table 1.--Stratigraphic column of rocks exposed in the Gainesville area

Quaternary System	Recent alluvium and terrace deposits		
Cretaceous System	Gulf Series	Woodbine Group	"Woodbine sand"
	Comanche Series	Washita Group	Grayson fm.
			Mainstreet fm.
			Pawpaw fm.
			Weno fm.
			Denton fm.
			Fort Worth fm.
			Duck Creek fm.
			Kiamichi fm.
		Fredericksburg Group	Goodland fm.
		Trinity Group	"Trinity sand"

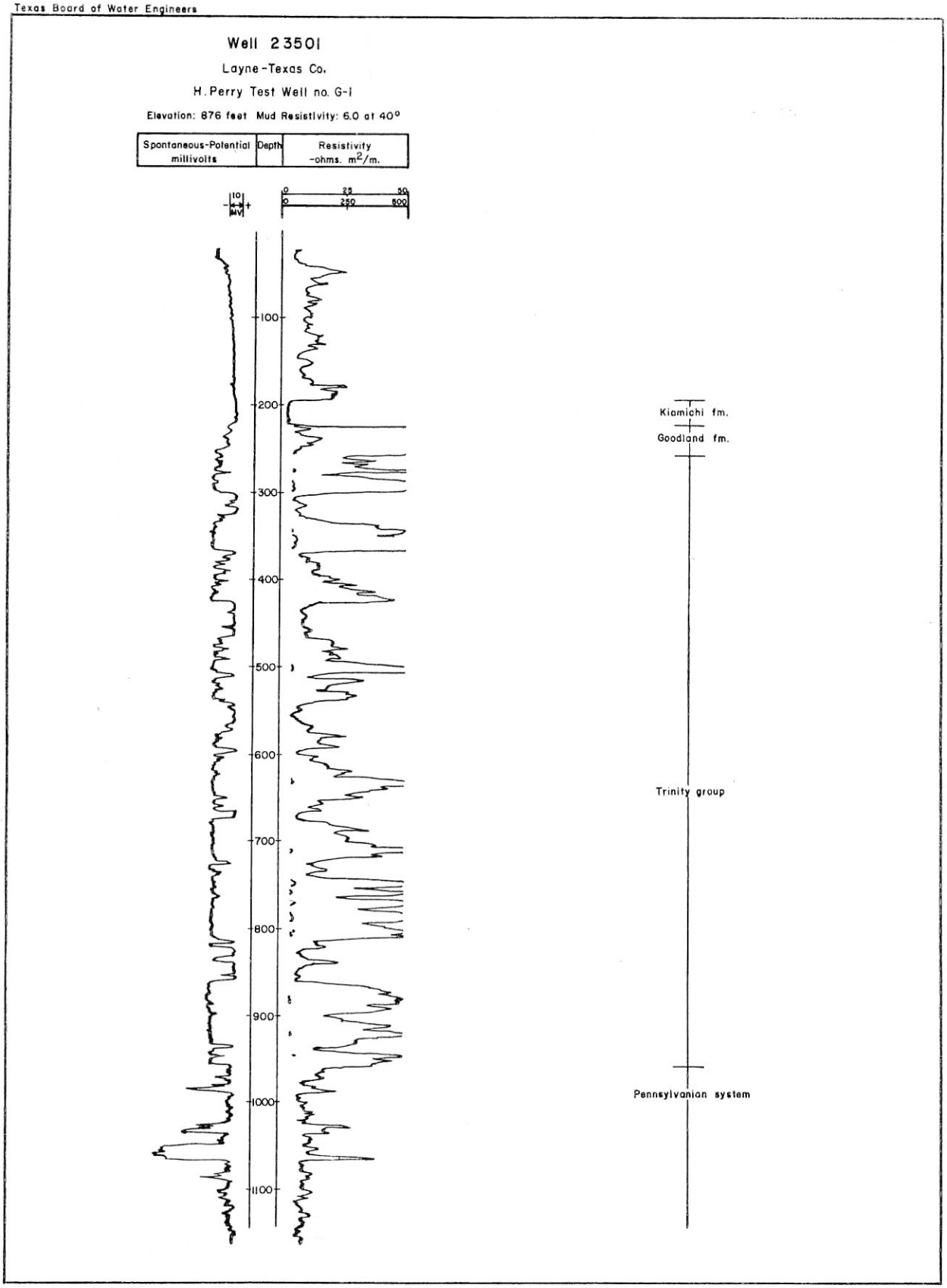

FIGURE 2.- Typical electric log in the Gainesville area

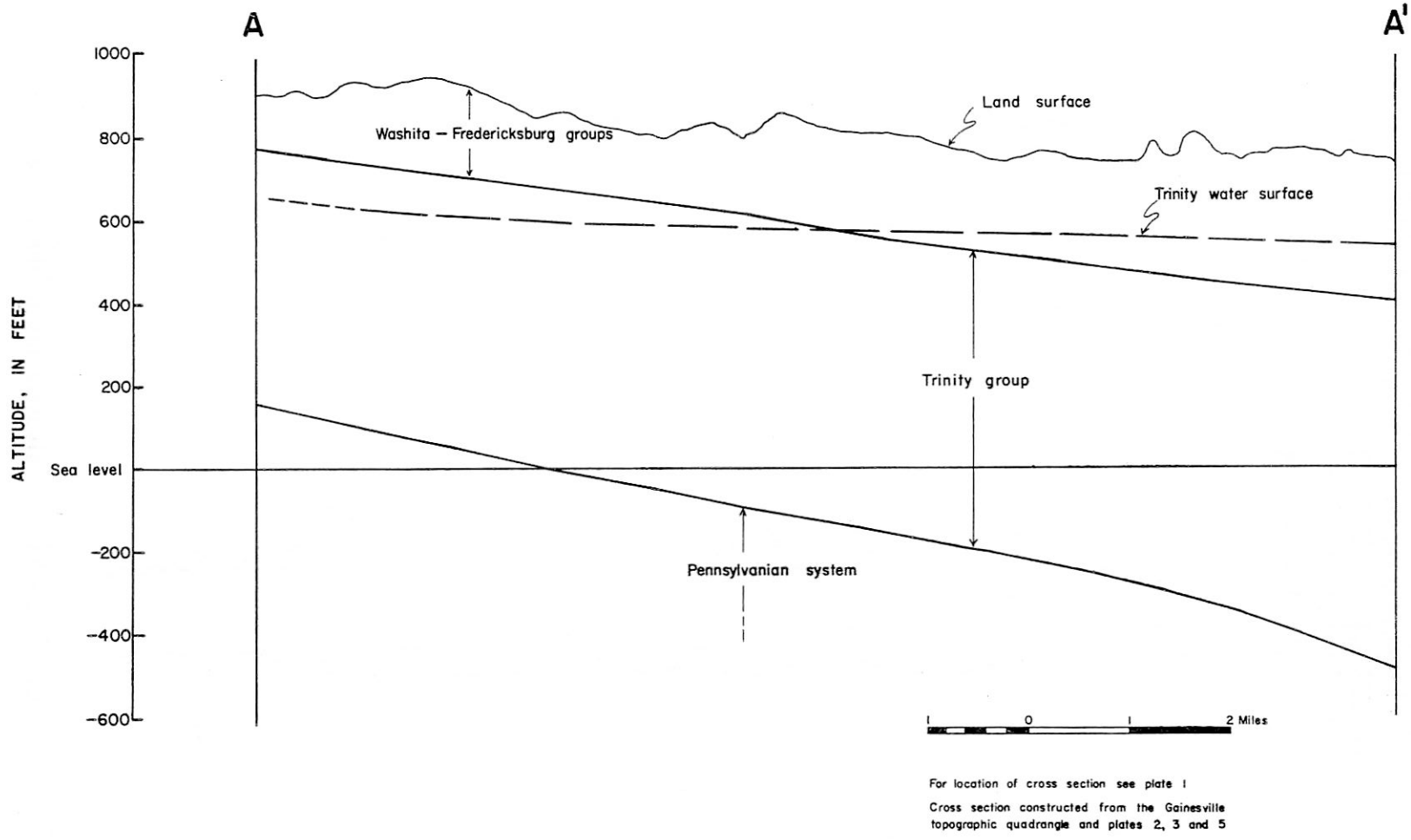

FIGURE 3.—Geologic section along line A—A' of the Gainesville area

hydrostatic pressure. Hence, the water will rise in wells above the level at which it is first encountered. The eastward dipping structure of the Cretaceous rocks in Cooke County and the interbedding of sand, shale, and limestone favor the occurrence of artesian conditions. In the Gainesville area, water table conditions exist in and adjacent to the outcrop area of the Trinity group; artesian conditions occur downdip from the outcrop where the Trinity group is saturated with water and overlain by relatively impervious material.

Ground water moves steadily from areas of intake to areas of discharge under the influence of gravity. The rate of movement is slow due to friction, and where the transmissibility and hydraulic gradient are low the time required for water to move, for example, from the outcrop of the Trinity group to the City of Gainesville, would be measured in centuries rather than years.

The general direction of movement and the hydraulic gradient of water in the Trinity group are shown by a contour map (Plate 5). Water movement is at right angles to the contours toward the lower elevation.

Recharge and Discharge of Ground Water

Ground water in the Trinity group is derived chiefly from precipitation that falls on the outcrop area. A portion of this precipitation percolates to the water table, then moves down the hydraulic gradient into the artesian portions of the aquifer. The remainder of the precipitation runs off directly into streams, evaporates, or is transpired by plants. Ground water is discharged naturally from the Trinity group chiefly through evapotranspiration and springs. It is discharged artificially from the Trinity group through wells.

The amount of water withdrawn annually from the Trinity group in the Gainesville area has increased from about 427 million gallons in 1950 to about 617 million gallons in 1958. The City of Gainesville withdraws the largest quantities of water; the Lone Star Gas Company and the State School for Girls pump only minor amounts. The City of Gainesville has eight wells in operation while the Lone Star Gas Company and the State School for Girls each have one well in operation.

Fluctuations of Water Levels

The water level in a well tapping an artesian aquifer fluctuates almost continuously. These fluctuations, resulting from natural and artificial processes, vary considerably in magnitude and pattern. Generally, small fluctuations of the water level are due to changes of atmospheric pressure, loading and unloading of the aquifer, earthquakes, or changes in rates of recharge and discharge. Large fluctuations of water levels usually are the result of ground water withdrawals.

The earliest report of a water level in a well tapping the Trinity group was on the City of Gainesville well #3 (23903). In 1931 the reported static water level in this well was 74 feet below the land surface. In 1960 the static water level was 173 feet below the land surface. This is an average decline of 3.4 feet per year. Water levels in several wells in the area are available for 1942 and 1944 and again for 1960. Over-all declines in this 16-18 year period range from about 55 feet to about 80 feet and average approximately four feet per year.

A major part of the decline in water levels has been caused by an increase in pumpage. A smaller part of the decline in water levels has resulted from

depletion of storage in the recharge area. The pumpage increase has caused more water to flow from the recharge or inflow area to the wells. Hence, a steeper hydraulic gradient has developed from the recharge area to the wells. The amount of decline, resulting from the development of the steeper hydraulic gradient, varies directly with the pumping rate and depends on the transmissibility of the sands.1/ These declines generally occur within several years after the increase in pumpage takes place. After sufficient time elapses for the total development of the steeper hydraulic gradient, the decline of water levels ceases. At this time, the amount of water flowing toward the wells is equal to the amount being pumped. This equilibrium is upset if a change in the pumping rate occurs or if insufficient recharge occurs to maintain the water level in the inflow area. Should there be insufficient recharge, a continued decline of water levels occurs, resulting from the slow dewatering of the inflow area. This decline will continue until the necessary amount of water is supplied to the wells. At this time, equilibrium will again be reached; and the decline of the water levels will cease.

The pumping level of most of the wells in the area is below the top of the Trinity group. At Gainesville pumping levels are a few feet below the top of the Trinity group. Pumping levels in the old "Camp Howze" area, about six miles northwest of Gainesville, are about 160 feet below the top of the Trinity group. In the "Camp Howze" area, pumping levels have always been below the top of the Trinity group, and pumping levels in Gainesville were never far above the top of the Trinity Group.

As long as the pumping level remains above the top of the aquifer from which the well draws water, the aquifer is full of water; and a decline in water level represents a decline in pressure. When the pumping level is lowered below the top of the aquifer, the aquifer is partly dewatered. Dewatering of the aquifer indicates that more water is being pumped than is moving toward the areas of heavy pumping. However, under these conditions, the growth of the cone of depression at a given rate of pumping becomes much slower.

Yields of Wells

The yield of a well depends on the ability of the aquifer to transmit water, the thickness of the material screened, the efficiency of the well, and the allowable drawdown. As none of the wells in the area are screened in all the water-bearing material penetrated and a few wells fail to penetrate all the water-bearing material, the yields of most wells are somewhat less than the maximum obtainable yield. The yields of nine wells tapping the Trinity group range from 200 to 750 gpm (gallons per minute). The largest yields are obtained from wells that are underreamed, gravel packed, and screened.

Specific Capacity of Wells

Another useful index to well performance is the specific capacity of a well which is generally expressed as the ratio of yield in gallons per minute to the drawdown in feet. The term tends to imply that the ratio of yield to drawdown is constant and may be extrapolated over any period of time. Because this is not the

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1/ The coefficient of transmissibility computed from a test of well 23503 was about 10,000 gallons per day per foot. The coefficient of transmissibility computed for a test of well 23903 was about 20,000 gallons per day per foot. Well 23903 is located in the artesian portion of the area, while well 23503 is not.

case, due to the effects of rate of withdrawal and the element of time, the specific capacity should be regarded only as an approximation. Also a comparison of specific capacities, as an indication of aquifer productivity, can be seriously in error unless methods of well construction and degree of development are considered. Within the area, the specific capacities of four wells tapping the Trinity group range from 5 to 13.9 gpm/ft. (gallons per minute per foot). The average specific capacity of the wells in the area is probably nearer the lower value.

Quality of Water

Chemical analyses of water from nine wells tapping the Trinity group are given in Table 4. The water is of a sodium bicarbonate type and soft. In the 16 samples analyzed, the hardness ranged from 4 to 14 ppm (parts per million); the total dissolved solids ranged from 437 to 711 ppm; and the fluoride content ranged from 0.1 to 0.6 ppm. The percent sodium averaged 98, making the water unsuitable for continued irrigation of crops.

FUTURE NEEDS

In 1959 the Bureau of Business Research of the University of Texas prepared a projection of water requirements and population for areas and cities of Texas. As the City of Gainesville uses about 95 percent of the water requirement of the area, the projections for the City of Gainesville are most useful for estimating future needs of the area.

The projection for the City of Gainesville is as follows:

Year	Population	Water Requirements (In millions of gallons per year)
1950 (base year)	11,246	422 (mg/yr)
1965	19,497	1,011
1975	22,347	1,280
2000	28,849	1,859

With existing well facilities, the City of Gainesville can presently produce 1,829 mg/yr. However, in comparing amounts in "millions of gallons per year", consideration must be given to the large seasonal variation of municipal water requirements. It is generally imperative that municipalities have the capacity to pump relatively large amounts of water during the summer months. For this reason, perhaps a more meaningful comparative figure is the maximum amount of water used in one day. With existing well facilities, the City of Gainesville can presently produce 5 mg/d (million gallons per day). During the summer of 1960, the maximum use was about 3.3 mg/d. Projecting this amount, the maximum use is estimated at 5.4 mg/d in 1965, 6.8 mg/d in 1975, and 9.9 mg/d in 2000. As the 1960 population of Gainesville was determined by the Federal Census to be 12,606 the projections of population and water requirements made by the Bureau of Business Research may be optimistic. In any event, a careful continuing review of population and water requirement changes should be maintained for municipal planning of water supplies.

Based on the present producing capacity of the area and barring any large unforeseen development, it seems the Trinity group can support the needs of the area in the foreseeable future. However, in increasing the total withdrawal of ground water from the Trinity group, great care should be taken in selection of

well sites to avoid concentration of large scale pumping. A detailed analysis of the Trinity group's hydraulic character in the Gainesville area will be required to define conclusively the ability of the ground water supplies to meet the potential needs of the area.

Table 2.--Records of wells in the Gainesville Area

Method of lift (includes type of power): T, turbine; C, cylinder; E, electric; W, windmill
Use of water: D, domestic; Ind, industrial; N, not used; P, public supply; S, stock.
Electric log: An asterisk (*) indicates the log is in the files of the Texas Board of Water Engineers.
Chemical analysis: An asterisk (*) indicates the analysis is in table 3.
(See table 2 for drillers' logs of wells in the Gainesville area.)

Well	Owner	Driller	Date completed	Depth of well (ft.)	Water-bearing unit	Altitude of land surface (ft.)	Water Level		Method of lift	Use of water	Yield in GPM 1960	Electric Log	Chemical Analysis	Remarks
							Below land surface datum (ft.)	Date of measurement						
23101	Hubert Felderhoff	Layne Texas Co.	1942	920	Trinity group	891±	228 299.1	Sept. 7, 1942 June 29, 1960	C,W	S	--	*	--	Howze well 5.
23401	do	do	1942	891	do	929.7	249 318.7	Aug. 29, 1942 June 29, 1960	C,W	S	--	*	--	Howze well 6.
23501	City of Gainesville Howze well 1	do	1942	1,158	do	876	214 305.8	Feb. 20, 1942 June 30, 1960	--	N	--	*	--	H. Perry test well G-1. Abandoned.
23502	City of Gainesville Howze well 2	do	1942	943	do	871±	220 303 rept.	Sept.12, 1942 Aug. 8, 1960	T,E	P	650	*	*	Pump setting: 440 feet. Specific capacity: 6.5 gal./ft. Pumping level: 402 feet after 80 hours at 650 gpm.
23503	City of Gainesville Howze well 3	do	1942	915	do	891.5	219 317.2	Aug. 23, 1942 Aug. 16, 1960	T,E	P	580	*	*	Pump setting: 458 feet. Specific capacity: 5 gal./ft. Well pump tested on Aug. 19, 1960. Pumping level: 434 feet after 5 days at 580 gpm.
23504	C. A. Beck	do	1942	890	do	891±	222 302.0	Sept. 2, 1942 June 29, 1960	C,E	S,D	--	*	--	Howze well 4.
23601	--	Daube's Oil Dept.	1959	4,330	--	797.5	--	--	--	--	--	*	--	Oil test. Dovie Burch #1.
23801	G. L. Campbell	do	1958	3,835	--	813	--	--	--	--	--	*	--	Oil test. Campbell #1.
23802	City of Gainesville Airport well	Layne Texas Co.	1942	840	Trinity group	833±	--	--	T,E	P	Rept. 200	--	*	
23803	Lone Star Gas Co. Well 1	--	--	890	do	--	--	--	T,E	N	--	--	--	Leaky casing.

Table 2.--Records of well in the Gainesville Area--Continued

Well	Owner	Driller	Date completed	Depth of well (ft.)	Water-bearing unit	Altitude of land surface (ft.)	Water Level		Method of lift	Use of water	Yield in GPM 1960	Electric Log	Chemical Analysis	Remarks
							Below land surface datum (ft.)	Date of measurement						
23804	Lone Star Gas Co. Well 2	Layne Texas Co.	--	985	Trinity group.	--	175 rept.	Oct. 1959	T,E	Ind.	--	--	--	
23901	City of Gainesville Well 6	do	1952	906	do	784	180 rept.	July 1952	T,E	P	Rept. 380	*	*	Pump setting: 430 feet.
23902	City of Gainesville Well 5	Wham Drlg. Co.	1943	953	do	756±	133.3 187.7	Feb. 25, 1944 May 25, 1960	--	N	--	--	*	Abandoned. See drillers' log.
23903	City of Gainesville Well 3	--	1941	931	do	740±	74 rept. 138 rept. 172.1	1931 1944 May 30, 1960	T,E	P	320	--	*	Pump setting: 250 feet. Specific capacity: 13.9 gal./ft. Well pump tested on May 30, 1960. Pumping level: 186 feet in 1944 at 400 gpm. See drillers' log.
23904	City of Gainesville Well 2	--	1912	864	do	740±	110.6 130	Feb. 25, 1944 1952	T,E	P	Rept. 200	--	*	Pump setting: 220 feet in 1944. Yield: 400 gpm in 1944. See drillers' log.
23905	City of Gainesville Well 4	--	1937	1,025	do	740±	110 rept. 180.4	Sept.10, 1937 May 13, 1960	T,E	P	Rept. 400	--	*	Pump setting: 270 feet. See drillers' log. Pumping level: 331 feet in 1943 after 100 hours at 720 gpm.
24401	--	Harper & Harris	1958	2,746	--	839	--	--	--	--	--	*	--	Oil test. Hinton #1.
24701	C. F. Sullivant	Seitz & Harper	1959	3,176	--	753	--	--	--	--	--	*	--	Oil test. C. F. Sullivant #1.
24702	Gainesville State School for Girls	Layne Texas Co.	1948	950	Trinity group.	880	321.1	June 29, 1960	T,E	P	--	*	--	Pump setting: 400 feet.
24703	do	Star Oil Co.	1959	4,040	--	878	--	--	--	--	--	*	--	
31301	Ralph Breeding	Sohio Petr. Co.	1946	3,092	--	746	--	--	--	--	--	*	--	Oil test. Ralph Breeding #1.
31302	City of Gainesville Well 7	Layne Texas Co.	1957	997	Trinity group	726	175.4	July 1, 1960	T,E	P	Rept. 750	*	*	Pump setting: 380 feet. Specific capacity: 6.8 gal./ft. Pumping level: 289 feet after 4 hours at 750 gpm.
32101	--	T & O Drlg. Co.	1956	2,098	--	760	--	--	--	--	--	*	--	Oil test. William Turner #1.

Table 3.- Drillers' logs of wells in the Gainesville area

Well 23902

Owner: City of Gainesville well 5

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Soil	8	8	Sand, shale, shells	15	650
Clay	16	24	Lime, shells	15	665
Shale and clay, brown	3	27	Shale	10	675
Shale, shells	29	56	Shale, sandy	9	684
Sand, shells	22	78	Lime, shale	6	690
Shale	39	117	Shale, hard sand	17	707
Shale, shells	35	152	Shale	10	717
Shale, sandy	22	174	Sand	33	750
Lime	28	202	Shale, sandy	58	808
Sand, lime, shale	18	220	Shale	13	821
Lime, shale	23	243	Shale, sandy	46	867
Sand	39	282	Sand	17	884
Sand and shale	18	300	Sand and shells	3	887
Sand, shale, clay	74	374	Sand, hard shells	36	923
Sand, shale, shells	55	429	Sand, coarse-grained	6	929
Sand	23	452	Sand, coarse-grained, shells	16	945
Shale, shells	22	474	Shale, sandy	2	947
Sand, shale, shells	90	564	Shale	6	953
Shale, sandy	71	635			

Table 3.- Drillers' logs of wells in the Gainesville area--Continued

Thickness (feet)	Depth (feet)	Thickness (feet)	Depth (feet)

Well 23903

Owner: City of Gainesville well 3

Soil	15	15	Sand	10	570
Gravel	10	25	Lime and shale	65	635
Clay, blue	5	30	Sand	11	646
Shale and shell	87	117	Shale	4	650
Sand	3	120	Sand	28	678
Slate, blue	34	154	Shale, sandy	35	713
Lime	28	182	Lime	5	718
Sand	13	195	Sand	14	732
Shale	40	235	Lime, hard	2	734
Sand	25	260	Red beds	5	739
Gumbo, layers sandstone	68	328	Shale	25	764
Sand, hard	22	350	Sand and gravel, coarse-grained	26	790
Shale and lime	10	360	Shale	30	820
Soapstone	12	372	Sand, fine-grained	19	839
Shale and lime	31	403	Shale	19	858
Soapstone	4	407	Sand	18	877
Gumbo	43	450	Lime, white	8	885
Sand, hard	15	465	Sand	28	913
Soapstone	20	485	Lime	2	915
Sand	15	500	Gravel, sandy	15	930
Lime and shale	27	527	Clay, yellow	1	931
Red beds	9	536			
Shale, sandy	24	560			

Table 3.- Drillers' logs of wells in the Gainesville area--Continued

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Well 23904					
Owner: City of Gainesville well 2					
Soil	16	16	Sand	18	493
Gravel	7	23	Shale, hard	7	500
Rock, lime	78	101	Sand	9	509
Shale and boulders	41	142	Shale and sand	3	512
Rock	29	171	Sand	6	518
Shale	22	193	Shale	8	526
Rock	3	196	Sand	7	533
Shale and sand	116	312	Shale and sand	5	538
Sand rock	2	314	Sand	12	550
Sand rock and shale	20	334	Shale, red	26	576
Sand	8	342	Sand	9	585
Shale	7	349	Shale and rock, hard	9	594
Sand rock	7	356	Shale	21	615
Shale	6	362	Shale and sand	6	621
Sand, hard shale	9	371	Sand	7	628
Shale, blue	19	390	Shale	12	640
Shale and sand	41	431	Sand	10	650
Shale	12	443	Rock	4	654
Rock	2	445	Shale	10	664
Shale and boulders	7	452	Sand	15	679
Shale and sand rock	8	460	Shale	4	683
Rock	10	470	Rock	5	688
Shale	5	475	Shale	26	714

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Table 3.- Drillers' logs of wells in the Gainesville area--Continued

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Well 23904--Continued					
Shale and boulders	23	737	Sand	7	800
Shale	20	757	Sand and shale	16	816
Rock	16	773	Rock	4	820
Shale	20	793	Sand	30	850

Well 23905

Owner: City of Gainesville well 4

Soil	5	5	Lime, hard	3	220
Clay	15	20	Lime, white	25	245
Gravel	10	30	Sand, water	5	250
Shale and shell	30	60	Sand rock, hard	3	253
Lime, gray	22	82	Sand	24	277
Shale, blue	6	88	Shale	49	326
Lime, gray	2	90	Sand	6	332
Shale, blue	10	100	Lime	4	336
Lime, sandy	20	120	Sand, good	20	356
Shale, blue	6	126	Sand, fine-grained	16	372
Lime, hard, sandy	19	145	Shale, sandy	24	396
Shale, gray	14	159	Shale, hard	28	424
Lime	1	160	Sand	11	435
Shale, gray	8	168	Shale, hard	25	460
Lime, white	9	177	Lime, sandy	10	470
Lime, hard, sandy	11	188	Sand, hard, fine-grained	32	502
Lime, gray	4	192	Shale, hard	18	520
Shale, black	25	217	Sand, hard, fine-grained	17	537

(Continued on next page)

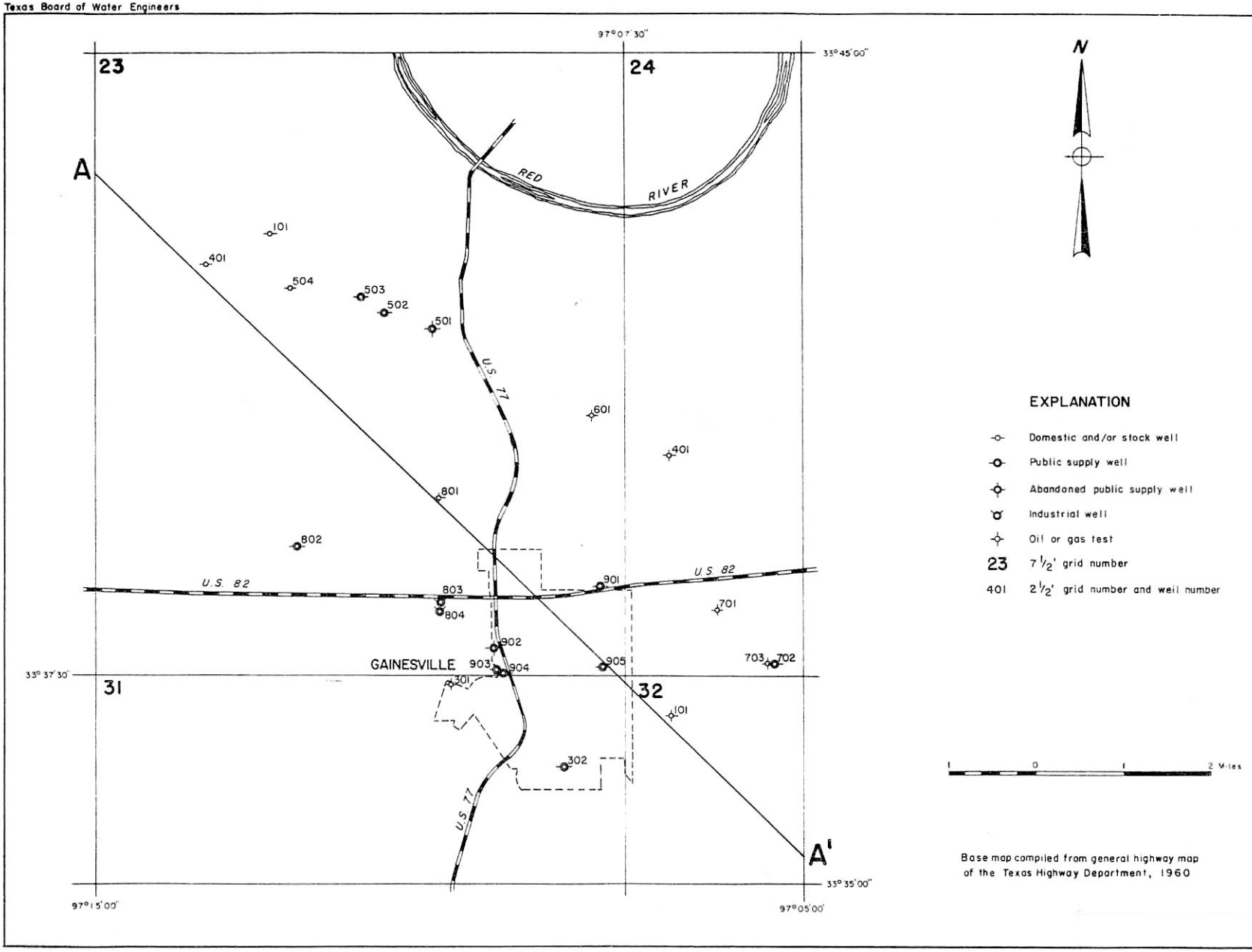
Table 3.- Drillers' logs of wells in the Gainesville area--Continued

Thickness (feet)	Depth (feet)	Thickness (feet)	Depth (feet)
Well 23905--Continued			
Shale, hard---------- 18	555	Shale, hard sandy------- 5	845
Lime and shell--------- 2	557	Shale------------------- 29	874
Shale, hard---------- 27	584	Sand, fine-grained------ 29	903
Sand, hard fine-grained 20	604	Lime-------------------- 4	907
Shale, sandy; layers of sand---------- 36	640	Sand, fine-grained------ 19	926
Shale, hard---------- 25	665	Shale------------------- 10	936
Shale, sandy; layers sandy---------- 33	698	Sand, fine-grained------ 22	958
Sand, hard, fine-grained 39	737	Lime-------------------- 3	961
Lime, sandy---------- 7	744	Sand-------------------- 8	969
Shale, red---------- 6	750	Lime, shell---------- 1	970
Lime---------- 2	752	Sand, coarse-grained, small gravel, layers of shale---------- 15	985
Shale, red and blue---- 22	774	Shale------------------- 3	988
Sand---------- 32	806	Sand, good---------- 15	1,003
Lime, sandy---------- 5	811	Lime-------------------- 5	1,008
Shale---------- 6	817	Shale and lime, hard---- 17	1,025
Sand---------- 23	840		

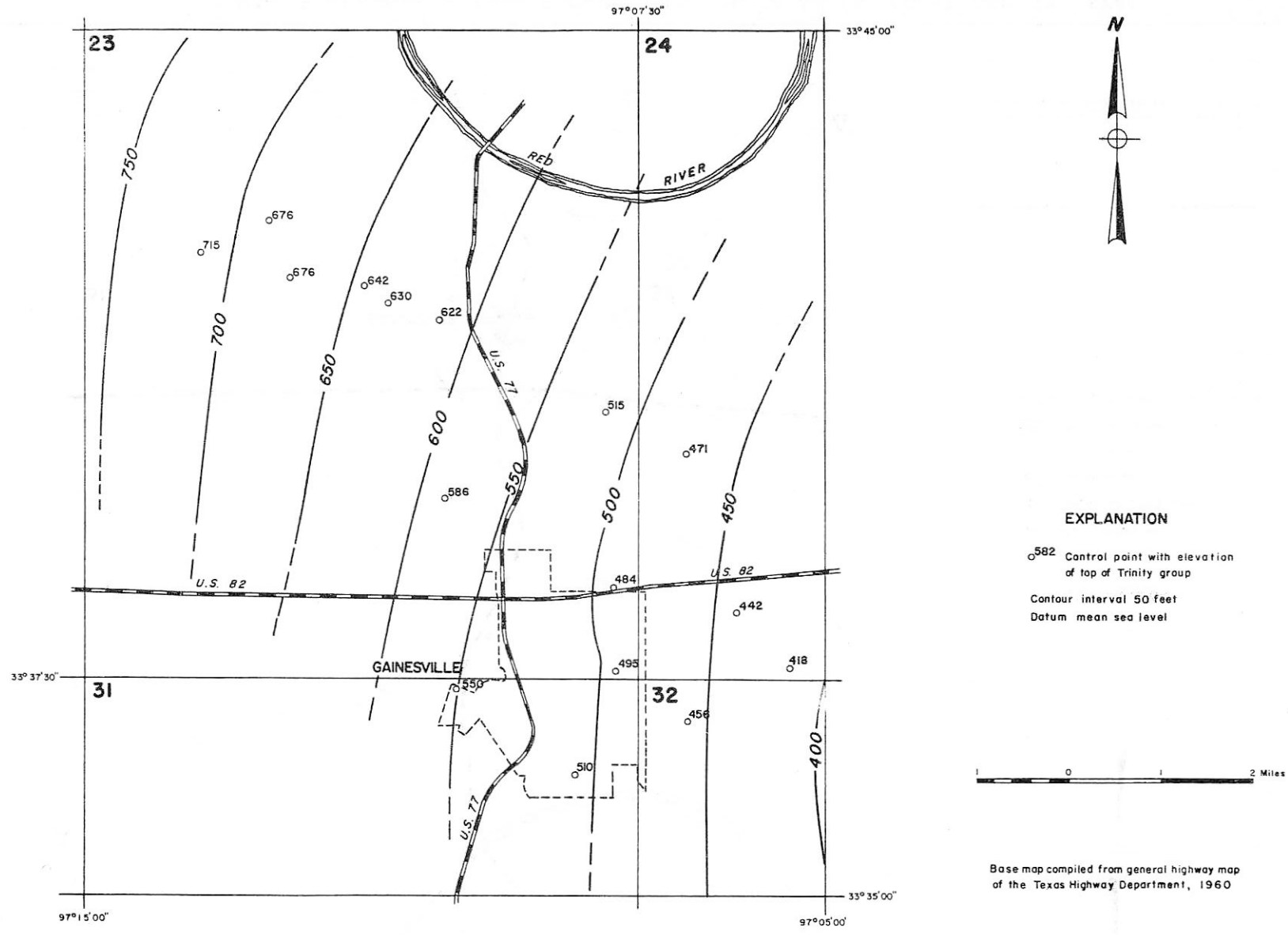
Table 4.--Chemical analyses of water from wells in the Trinity group in the Gainesville Area

(Analyses given are in parts per million except specific conductance, pH and percent sodium)

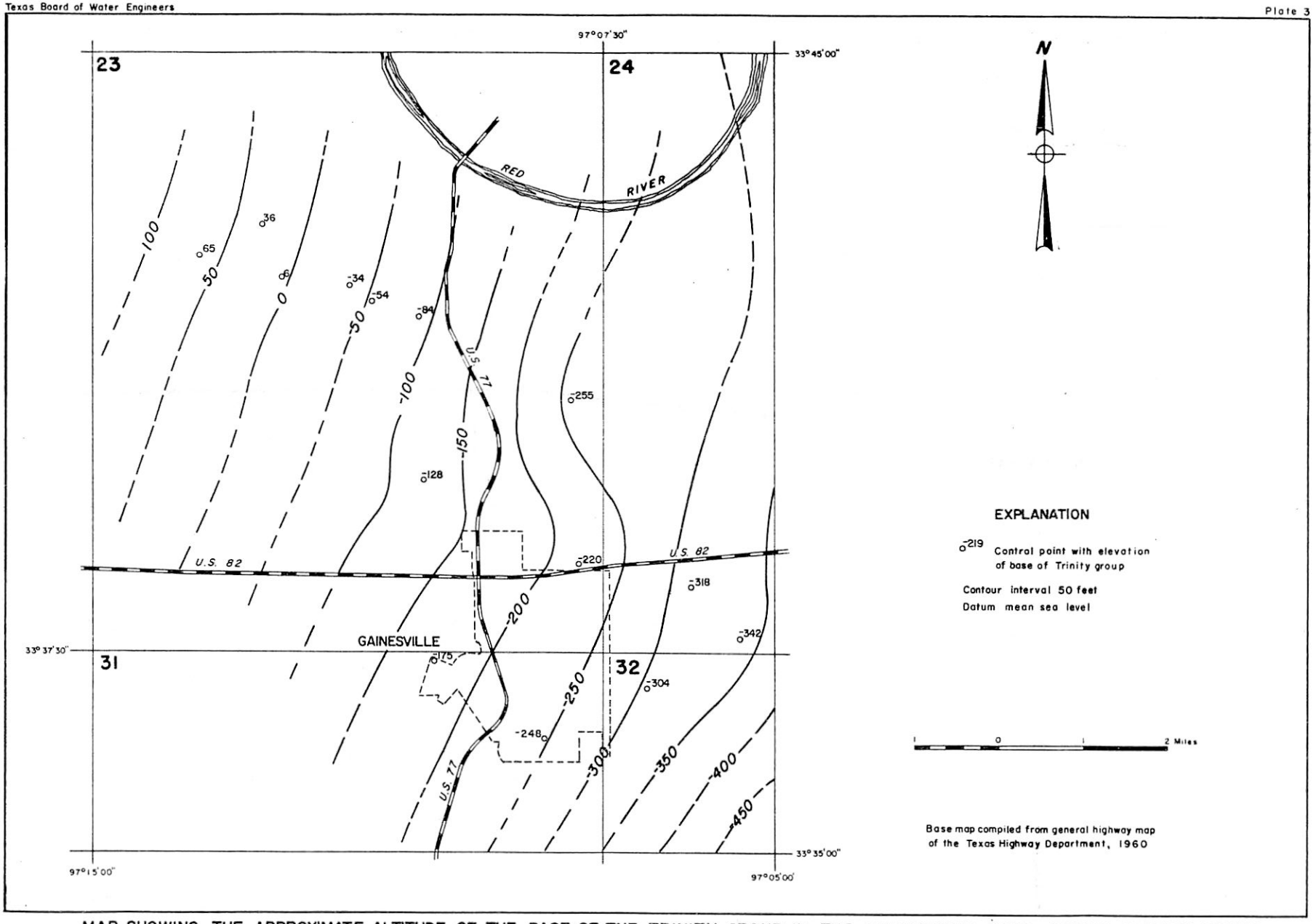
Well	Owner	Depth of well (ft.)	Date of collection	Silica (SiO_2)	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium and potassium (Na + K)	Bicarbonate (HCO_3)	Carbonate (CO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Dissolved solids	Hardness as ($CaCO_3$)	Percent sodium	Specific conductance	pH
23502	City of Gainesville Howze well 2	943	May 27, 1960	12	-	1.2	.2	219	421	19	43	34	.2	1.2	540	4	99	885	8.5
23503	City of Gainesville Howze well 3	915	Nov. 1955	18	.13	2.0	1.0	212	384	48	39	25	.2	.4	510	9	-	-	8.6
23802	City of Gainesville Airport well	840	Oct. 1942	-	.6	1.0	.3	190	378	33	30	13	-	-	711	5	-	-	8.8
23901	City of Gainesville Well 6	906	May 28, 1960	12	.01	1.8	.6	175	403	13	28	3.2	.2	.0	438	7	98	716	8.4
23901	do	906	Nov. 17, 1955	11	.03	2.0	1.0	181	384	24	27	14	.1	.4	437	9	-	-	8.7
23902	City of Gainesville Well 5	953	Nov. 1953	57	.07	2.0	10.0	191	-	-	32	32	.6	.7	597	-	-	-	8.8
23903	City of Gainesville Well 3	931	Nov. 17, 1955	11	.2	4.0	1.0	220	384	12	35	85	.2	.4	530	14	-	-	8.4
23903	do	931	Feb. 25, 1944	10	.02	3.6	1.0	197	340	26	31	58	.2	1.0	536	13	-	869	7.8
23904	City of Gainesville Well 2	864	Nov. 17, 1955	37	.5	2.0	1.0	201	421	30	31	14	.2	.4	508	9	-	-	8.8
23904	do	864	June 4, 1952	-	-	-	-	-	412	28	-	6	-	-	-	6	-	805	8.9
23904	do	864	Mar. 1944	13	.16	2.4	1.0	198	386	48	31	5	.2	1.2	490	8	-	804	8.6
23905	City of Gainesville Well 4	1,025	Nov. 17, 1955	8	.03	2.0	1.0	187	378	24	29	25	.2	.4	440	9	-	-	8.5
23905	do	1,025	Nov. 1953	14	.05	2.0	12.0	158	-	-	27	11	.2	-	455	-	-	-	8.7
23905	do	1,025	Feb. 25, 1944	9.2	.01	2.3	.6	173	348	32	26	10	.2	1.2	442	8	-	730	7.9
31302	City of Gainesville Well 7	997	May 27, 1960	12	.00	3.0	1.1	205	404	0	30	64	.2	.0	519	12	97	865	8.2
31302	do	997	Mar. 31, 1960	-	.07	3.0	-	200	389	18	34	45	.1	2.3	513	13	-	855	8.8



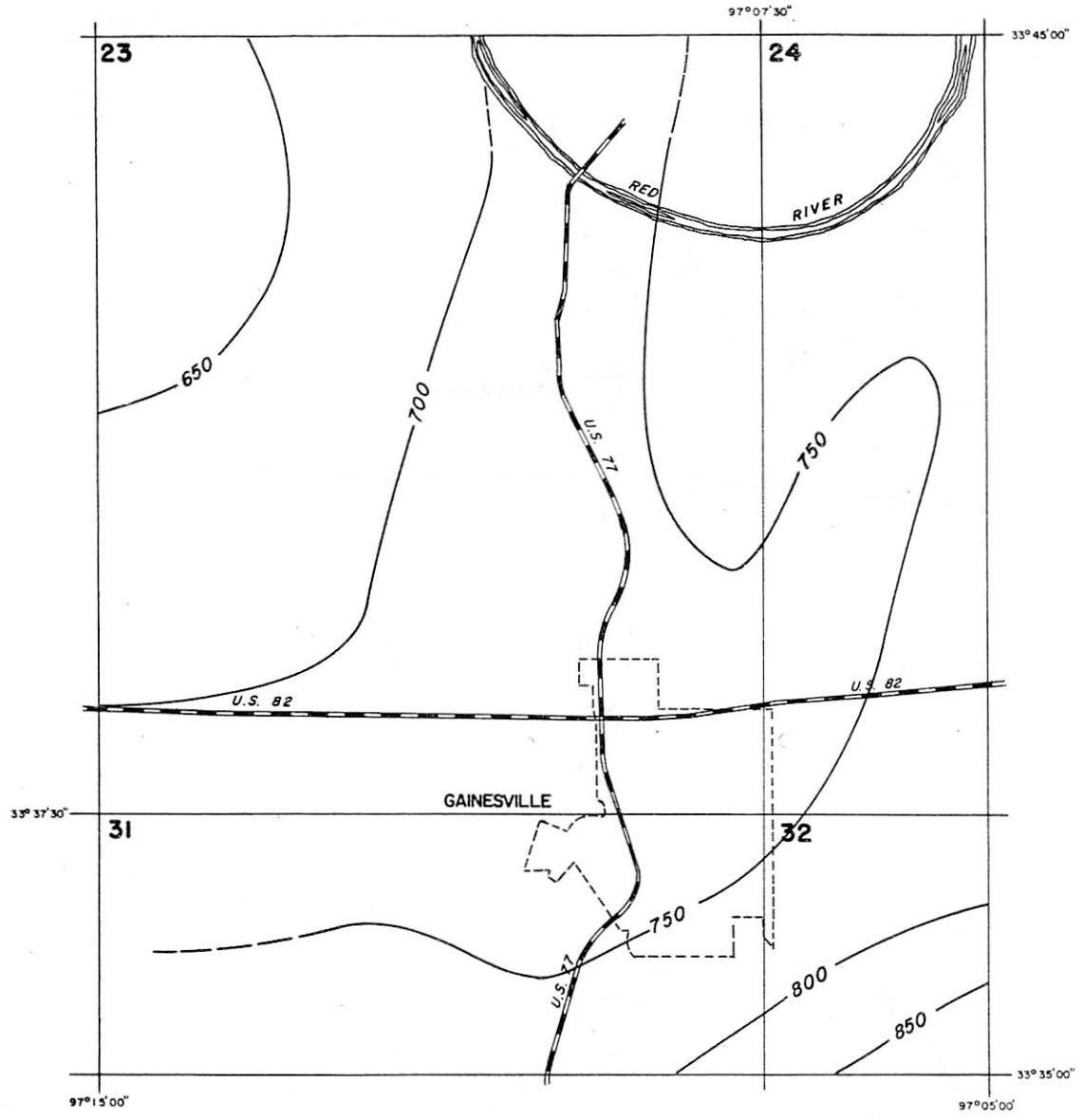
MAP OF GAINESVILLE AREA SHOWING LOCATION OF WELLS, COOKE COUNTY, TEXAS



MAP SHOWING THE APPROXIMATE ALTITUDE OF THE TOP OF THE TRINITY GROUP IN THE GAINESVILLE AREA, COOKE COUNTY, TEXAS



MAP SHOWING THE APPROXIMATE ALTITUDE OF THE BASE OF THE TRINITY GROUP IN THE GAINESVILLE AREA, COOKE COUNTY, TEXAS



EXPLANATION

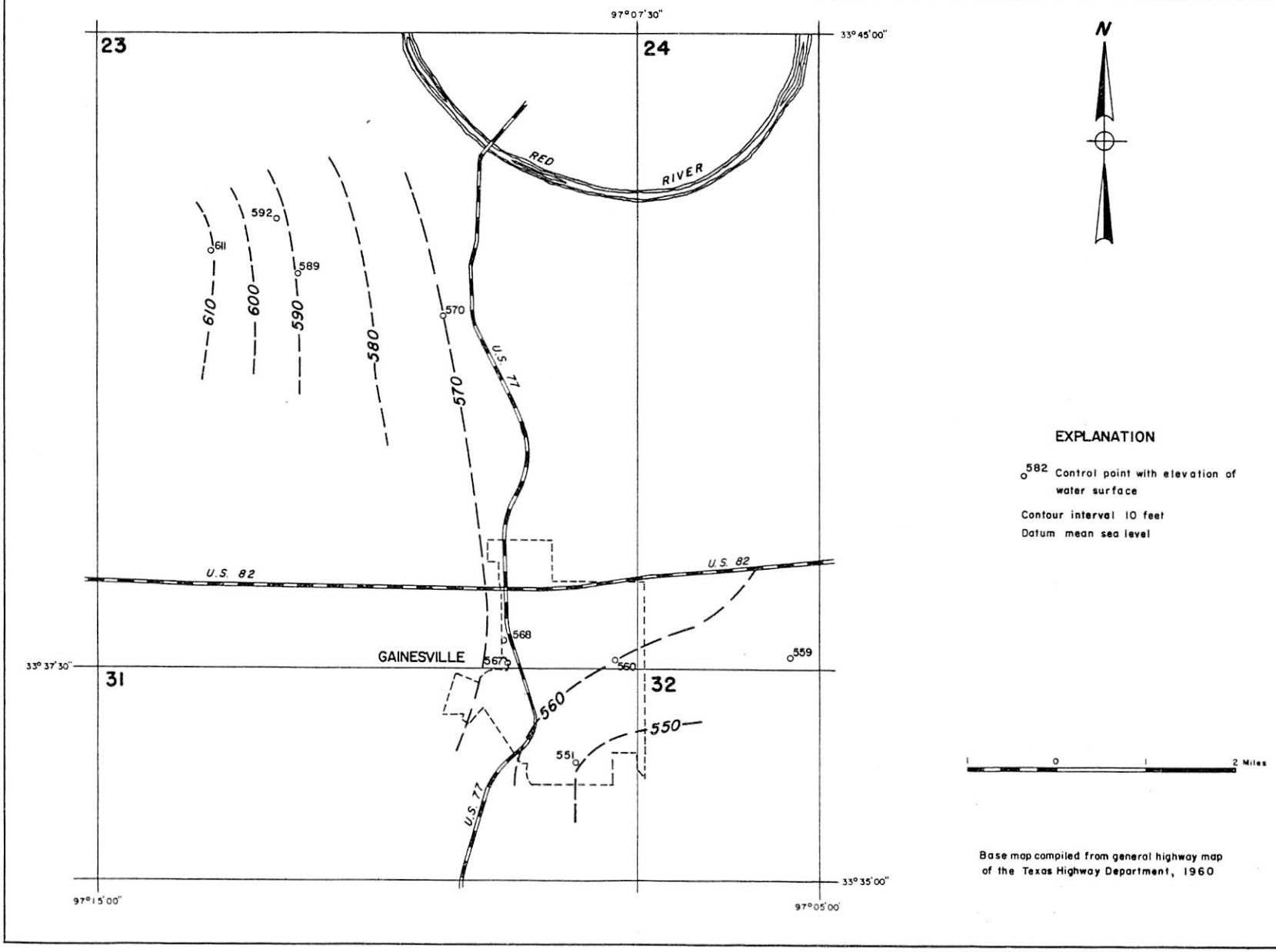
Map constructed from Plates 2 and 3

Contour interval 50 feet

1 0 1 2 Miles

Base map compiled from general highway map of the Texas Highway Department, 1960

MAP SHOWING THE APPROXIMATE THICKNESS OF THE TRINITY GROUP IN THE GAINESVILLE AREA, COOKE COUNTY, TEXAS



MAP SHOWING THE APPROXIMATE ALTITUDE OF WATER LEVELS IN WELLS IN THE TRINITY GROUP IN THE GAINESVILLE AREA, COOKE COUNTY, TEXAS