GROUND WATER IN THE VICINITY OF AMARILLO AND LUBBOCK, TEXAS

By

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Most of the available supply of ground water of good quality in the Texas High Plains is in the Ogallala formation of late Tertiary (Pliocene) age. The Ogallala has an average thickness of about 300 feet in the South Plains, and approximately two-thirds of the saturated portion of the formation is composed of sand from which some wells yield as much as 2,000 gallons a minute. The Ogallala formation has been hydrologically isolated from the surrounding region by erosion, and the source of additions to the ground-water reservoir is from infiltration of water precipitated on the area itself. A few wells obtain water from the nonmarine Dockum beds of Triassic age, but the potential value of the Triassic ground-water reservoirs appears to be small. In a test hole at Lubbock, 3,000 feet deep, salty water (chloride 10,800 and dissolved solids 21,400 parts per million) was encountered in Triassic rocks at a depth of 953-999 feet. Some water is available in Cretaceous formations in the southwestern part of the area where in a few locations yields of 1,000 gallons a minute are obtained locally from porous Cretaceous limestones and basal sands. Deposits of Recent age yield only small quantities of water for domestic and stock use.

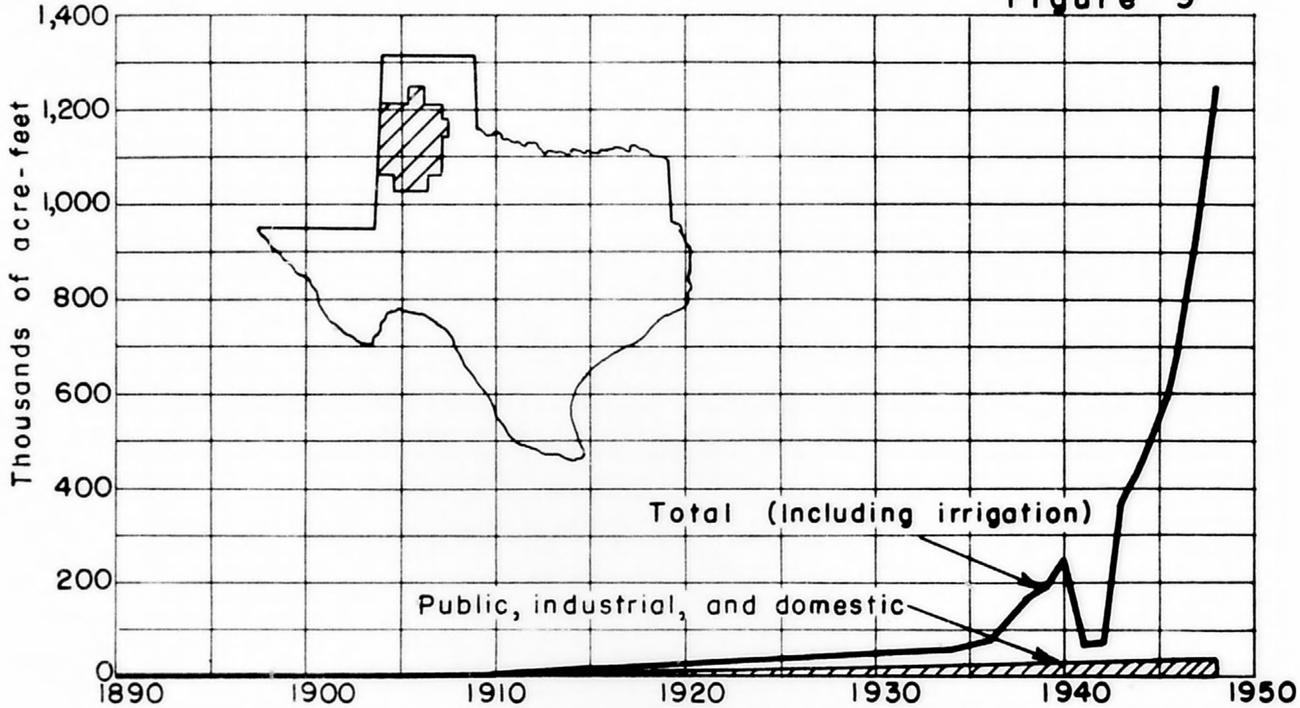
The average precipitation upon the irrigated districts of the South Plains is about 20 inches a year, and the average evaporation loss from a land pan is about 70 inches a year. Because a large part of the precipitation falls as showers of low intensity, most of the moisture is evaporated or temporarily retained in the uppermost soil and then is evaporated or transpired by native vegatation and cultivated crops. Most of the recharge to the ground-water reservoir occurs in periods of excessive rainfall by penetration from the surface in areas of sandy soil, and by seepage through the beds of intermittent streams and depression ponds. The average annual recharge to 9,000 square miles in the High Plains, which contained most of the irrigation wells in 1940, was estimated by White, Broadhurst, and Lang to be on the order of 30,000 acre-feet a year.

It is estimated that during 1948 about one and a quarter million acre-feet of ground water was pumped on the South Plains of which about 97 percent was used for irrigation. The withdrawals for public, domestic, and industrial supplies were approximately 35,000 acre-feet of which about 20,500 acre-feet was pumped by the cities of Lubbock and Amarillo. (See fig. 9, page 3). 1/

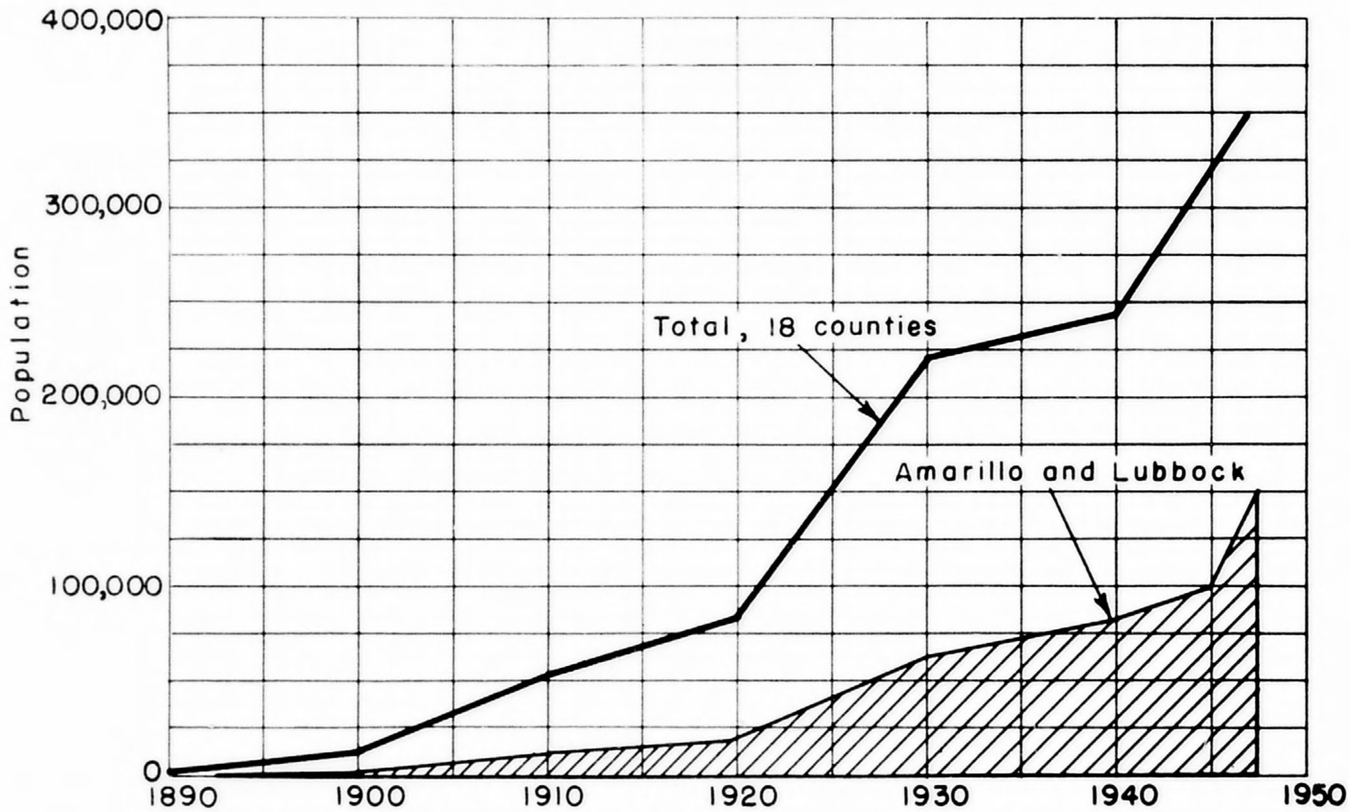
1/ Most of the illustrations in this report are reprints from "Geology and ground water in the irrigated region of the Southern High Plains in Texas, Progress Report No. 7", Texas Board of Water Engineers, March 1949.

During the 11-year period from March 1938 to March 1949 about 18 million acre-feet of saturated material was unwatered; the approximate extent of the net water-table decline in the South Plains was as follows:

Figure 9



A. GROUND WATER USED IN 18 COUNTIES IN THE HIGH PLAINS IN TEXAS, 1890-1948.



B. POPULATION IN 18 COUNTIES IN THE HIGH PLAINS IN TEXAS, 1890-1948.

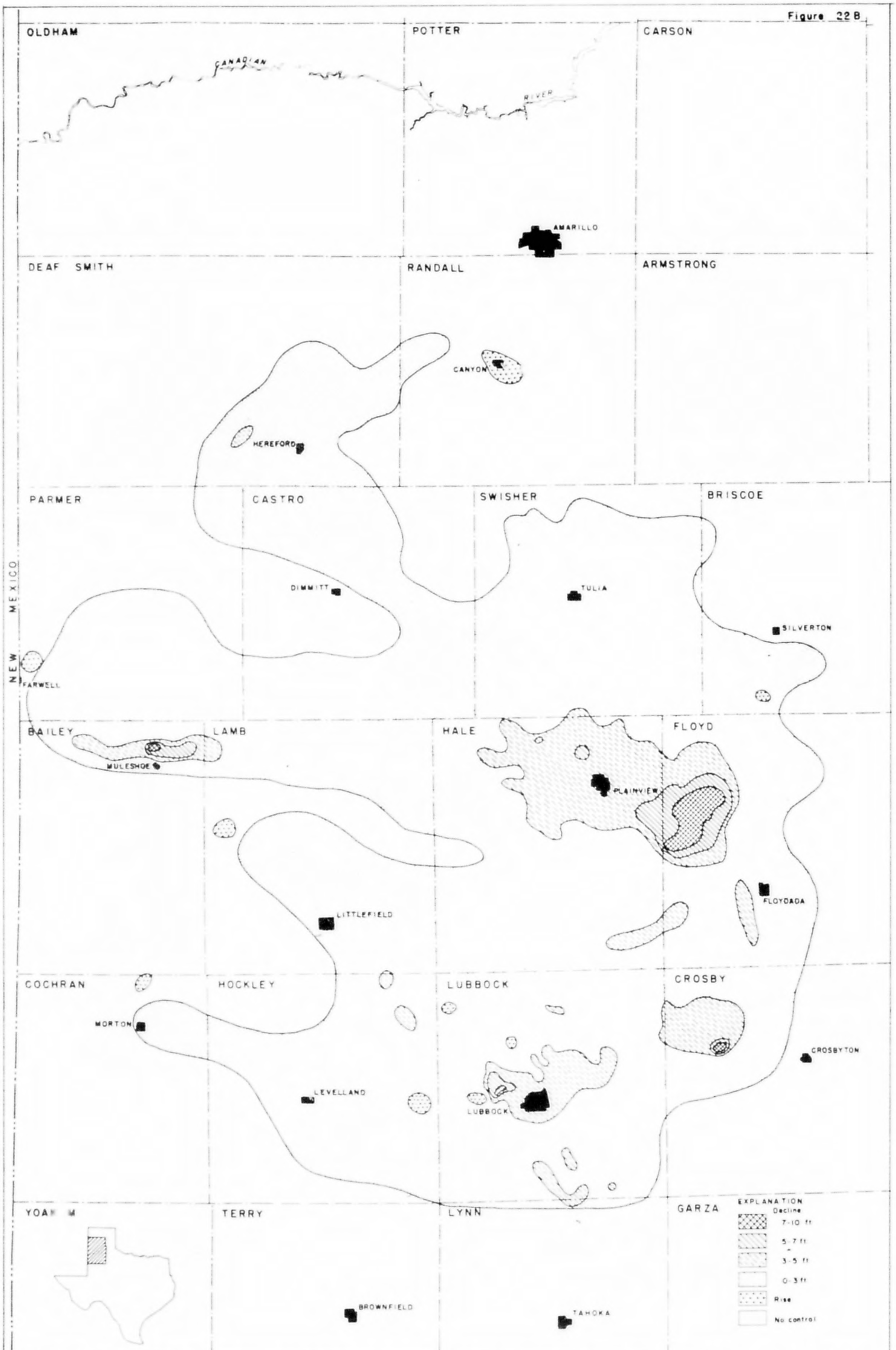
Area affected in acres	Decline in feet 1938-1949 2/
1,100,000	0 - 5
700,000	5 - 10
500,000	10 - 15
118,000	15 - 20
29,000	20 - 25
11,400	25 - 30
7,400	30 - 35
3,700	35 - 40
3,400	40 - 45
2,800	45 - 50

2/ See fig. 22A, page 5.

The success of irrigation on the High Plains has shown that the chemical character of the ground water is satisfactory for most crops. Analyses of water from several thousand wells, which have been published in individual county reports, show that in general minerals that are harmful to the soil are present in relatively small amounts. The water, although hard, is usually acceptable for industrial and public supplies; although in many parts of the region the concentration of fluorides is excessive and mottling of teeth is prevalent.

Ground water is considered to be a replenishable resource, but the rate of ground-water recharge in the High Plains in Texas is so small compared to present pumpage that for practical purposes all withdrawals may be considered as coming from storage. In several areas, irrigation wells and municipal wells are so closely spaced that mass interference is reducing the yields of most wells in those areas during the pumping seasons and as a result the pumping costs are increasing.

Figure 22B



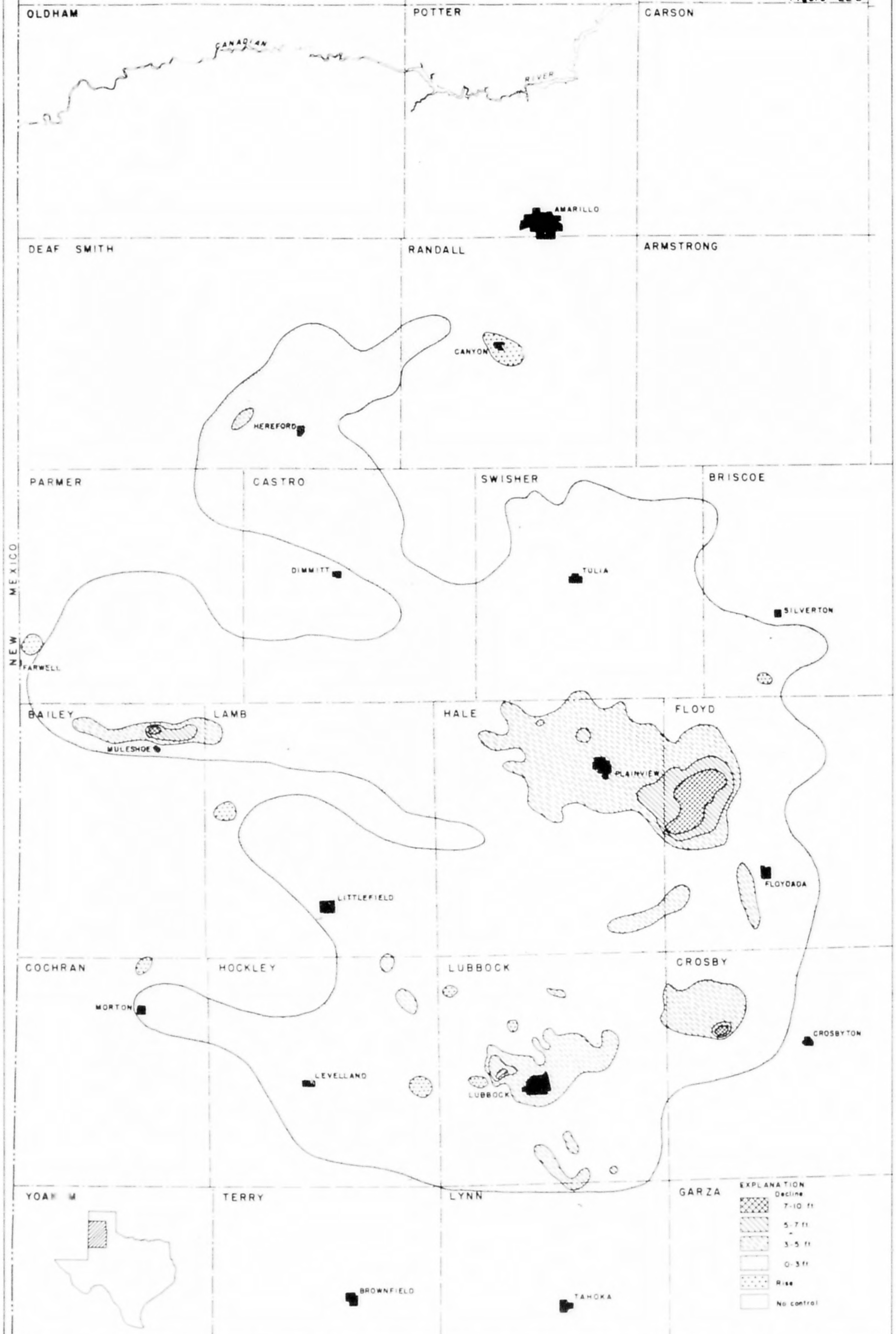
APPROXIMATE DECLINE OF WATER TABLE IN THE SOUTHERN HIGH PLAINS IN TEXAS, MARCH 1948 TO MARCH 1949

The available supply of water in the Southern High Plains is estimated to be on the order of 150 million acre-feet, which means that the present annual withdrawal of approximately one and a quarter million acre-feet will not exhaust the entire underground reservoir within the near future. However, declines in yields and pumping levels will effectively limit the line of large-scale pumping where withdrawals are concentrated in small areas. Furthermore, the saturated sections in some areas (perhaps only 50 to 100 feet in thickness) are much thinner than the average. It is possible for such areas to be completely unwatered by lateral movement toward heavily pumped areas in adjacent territory where the sands are deeper. However, the lateral movement of the ground water is so slow that many years may elapse before the thinner sands are drained. During 1948 some small areas were materially affected by overpumping, and if present trends of pumping-level and water-level declines continue those areas and other parts of the irrigated region will be seriously affected within 5 to 10 years. (See fig. 22B, page 7). In some other large areas within the irrigated region, where the wells are widely spaced, the water-level declines have been small and mutual interference has been negligible; and if the wide spacing and present rate of withdrawals per well are maintained the life of large-scale pumping may be extended for a much longer period of time. Records of water-level measurements in several wells outside the irrigated region and remote from pumping show that there has been no material rise or decline of the water table for many years.

Amarillo area

Amarillo municipal water supply.- The first large-scale pumping in the area took place when Amarillo developed its Palo Duro well field about 16 miles southwest from the city. This development consists of a reservoir and 10

Figure 22B



APPROXIMATE DECLINE OF WATER TABLE IN THE SOUTHERN HIGH PLAINS IN TEXAS,
MARCH 1948 TO MARCH 1949

5 0 5 10 15 20 Miles

wells (nos. 51 to 60), and a 30-inch pipe line for conveying water to the city. (See map, page 9). The reservoir is formed by a dam about 40 feet high on Palo Duro Creek and is said to have a capacity of about 5,000 acre-feet, or about 1,630,000,000 gallons. The reservoir, wells, and pipe line were completed in 1927, but the reservoir did not fill until 1931 and it is said to have reached a level above the spillway only twice. Water is not diverted from the reservoir, the function of the reservoir being to replenish the sands and gravels from which the adjacent wells are supplied. The wells are near the reservoir, part of them being immediately below the dam and the others along the shores of the reservoir not far upstream from the dam. The most distant well is about a quarter of a mile from the north shore. According to records of several pumping tests that were made within the first seven months of operation, the yields of the wells ranged from 460 to about 700 gallons a minute.

In 1931 five wells (nos. 71 to 75) were drilled about 5 miles southwest from the city in what is now known as the McDonald well field. Four of these wells are along the pipe line at intervals of about 2,000 feet, and the fifth well is about 2,000 feet west of the pipe line. According to tests made by the city, these wells yield about 750 gallons a minute each.

Between 1943 and 1945, 12 additional wells were drilled along the pipe line, one (no. 77) between the McDonald well field and the city and the others (nos. 61 to 70 and 76) between the McDonald and Palo Duro well fields, According to tests made by the city, the yields of these wells range from 700 to 1,340 gallons a minute and five of them yield more than 1,000 gallons a minute each. Records indicate that 38 wells were available for municipal use in 1948.

The pumpage from 1928-29 to 1948-49 is given in the following table:

Pumpage by the City of Amarillo, Texas
(From city records for fiscal years 1928-29 through 1947-48)

Fiscal Year	Number customers	Total production per year (gallons)	Acre-feet
1928-1929	8,873	1,005,910,000	3,087
1929-1930	8,962	1,142,090,000	3,505
1930-1931	9,219	1,269,294,000	3,895
1931-1932	8,910	1,372,162,000	4,211
1932-1933	8,692	1,215,100,000	3,729
1933-1934	9,121	1,387,550,000	4,258
1934-1935	9,279	1,470,900,000	4,514
1935-1936	9,291	1,432,308,000	4,396
1936-1937	9,461	1,528,198,000	4,690
1937-1938	9,739	1,677,497,000	5,148
1938-1939	10,094	1,691,572,000	5,191
1939-1940	10,532	1,959,690,000	6,014
1940-1941	11,112	1,950,876,000	5,987
1941-1942	11,711	1,807,960,000	5,548
1942-1943	12,133	2,485,386,000	7,627
1943-1944	12,502	2,602,800,000	7,988
1944-1945		2,888,700,000	8,865
1945-1946		3,309,900,000	10,158
1946-1947		3,239,300,000	9,941
1947-1948		3,595,300,000	11,033

As shown by the table, pumpage by the city increased from 3,087 acre-feet in 1928-29 to 11,033 acre-feet in 1947-48, or from an average of about 2,750,000 gallons a day to an average of 9,840,000 gallons a day.

Irrigation development.- Irrigation from wells in the area is said to have been started about 1933 by W. D. Muncey, a local well driller. In 1940 the irrigation wells in the area numbered 24 and in the spring of 1946 the number had reached 72. The rate of development has been rapid during the last two years and it is reported that about 180 wells were used during 1948. In the spring of 1946 the measured yields from 13 of the wells ranged from 150 to 1,140 gallons a minute. Accurate information is not at hand as to the total number of acres under irrigation in the area or the total amount of water pumped for irrigation. In the South Plains as a whole it is estimated that the pumpage averages about 120 acre-feet per well per year. On this basis the total pumpage during 1948 from the 180 irrigation wells would amount to 21,600 acre-feet, which is the equivalent of about 19,280,000 gallons a day throughout the year.

Decline of water levels.- The table below gives net changes in water levels in 19 wells in the area. The figures give the changes between 1946 and 1949 in 15 wells and changes between other years and 1949 in 4 wells. All the wells except well 2 showed a decline of varying proportions, and all the larger declines were in the heavily pumped districts in the eastern part of the area.

Decline of water levels in wells in Amarillo area,
Randall County, Texas

Well	Water level below land surface, in feet: 1946 May or July	1949 April 23	Decline (-) Rise (+)	
1	134.0 a/	145.0	- 11.0	Irrigation well.
2	139.3 a/	137.2	+ 2.1	Do.
32	109.6 a/	117.0	+ 7.4	Do.
34	147.9 a/	148.8	- 0.9	Do.
37a	142.6 a/	146.9	- 4.3	Windmill well.
41	125.5 a/	126.6	- 1.1	Do.
43	101.5 a/	101.9	- 0.4	Do.
44	157.8 a/	158.5	- 0.7	
49	155.0 a/	156.4	- 1.4	Windmill well.
50	135.0 a/	135.9	- 0.9	Do.
122	104.7 a/	104.4	+ 0.3	Do.
129	136.5 b/	140.6	- 5.1	Do.
322	106.9 c/	122.6	- 15.7	Irrigation well.
323	117.5 c/	131.6	- 13.1	Do.
148	147.1 d/			Do.
148a		154.5	- 9.0	Well 148a is 500 ft. from and 1.5 feet below well 148.
160	164.3 a/	172.3	- 8.0	Irrigation well.
142	165.0 a/	180.9	- 15.9	Do.
138	153.7 c/			Do.
138a		171.7	- 15.0	Well 138a is 1/4 mile from and 2.5 feet above well 138.

a/ Measurements in March, May or July 1946; b/ measurements in June 1937; c/ measurements in March 1943; d/ measurements in February 1942.

The table below gives changes in the water levels in several city wells to 1949. (Data furnished by city of Amarillo).

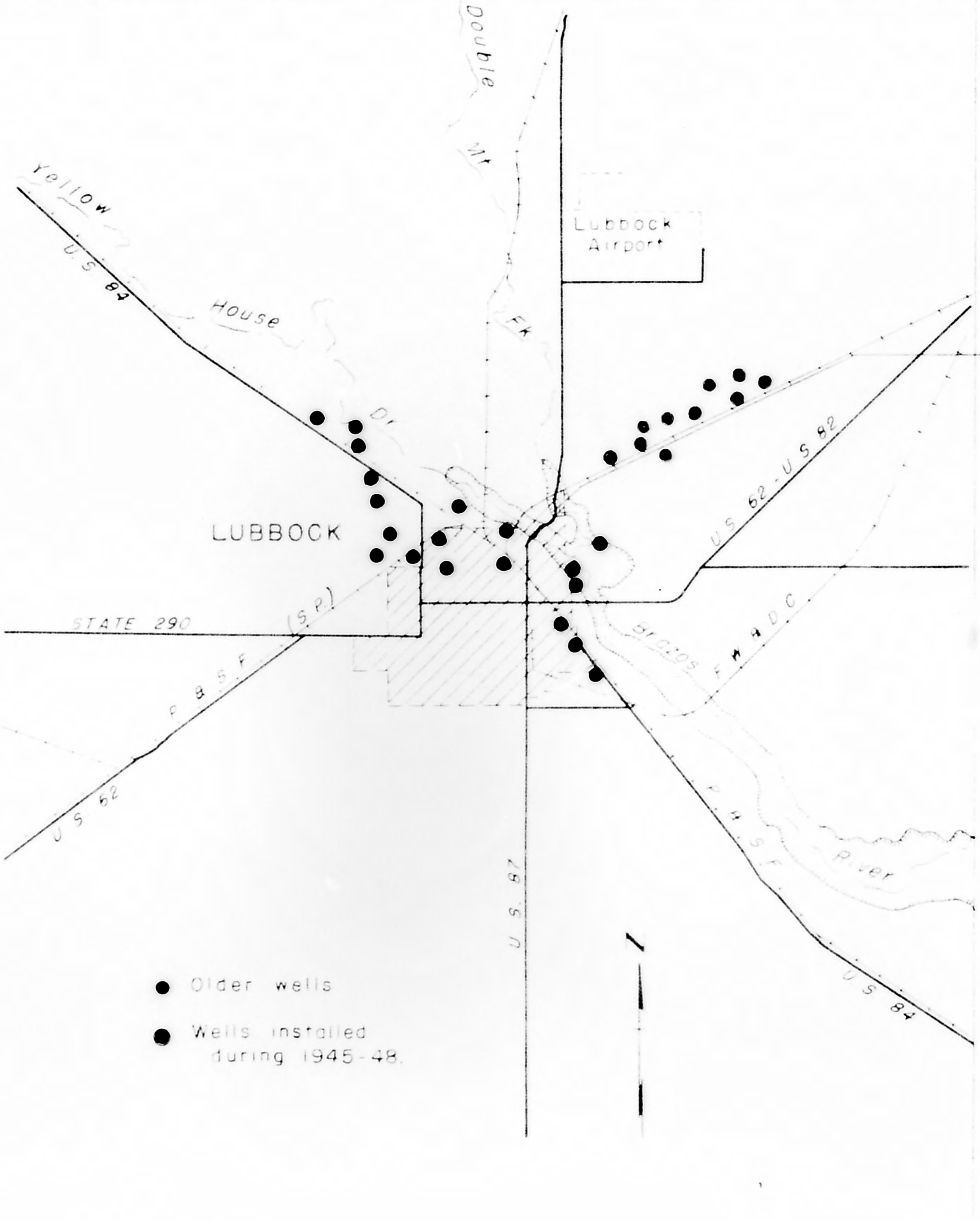
Summary.- The city of Amarillo does not have adequate supplies of ground water within the city limits or adjacent thereto. The first major development in the present water-supply system took place in 1927 when the city drilled 10 wells in the Palo Duro well field 16 miles southwest from the city. Since then the city has drilled 29 additional wells in 13 sections of the northwestern part of Randall County. The expansive distribution of wells and lengthy pipe line system is a costly system for the city. Further development of ground water for the city in northwestern Randall County will require further expansion of the well field. Other sources of ground water for the city can be found in Carson County about 30 miles east of Amarillo. The development of ground water in this area, however, would be costly owing to the long distance of transmission and to a pumping lift of about 500 feet. It is concluded that Amarillo can develop a considerable amount of additional ground water in either northwestern Randall County or Carson County. However, the development of any large quantity of additional water from these areas will be costly.

Irrigation in northwestern Randall County adjacent to the city well field has increased rapidly to an estimated withdrawal of 21,600 acre-feet in 1948. Such large rate of pumping causes mutual declines in the Amarillo city well field and the irrigation wells, thus accelerating the decline in yield of the wells for both purposes.

Lubbock area

Lubbock municipal water supply.- The city of Lubbock has had a phenomenally rapid growth. In 1920 it was a small town with a population of 4,051. The population increased to 20,520 in 1930, to 31,853 in 1940, and, according to an estimate by the Texas Almanac, the population had reached 45,000 in 1949.

The Lubbock water supply always has been obtained from wells; in the early days the community depended upon individually owned wells. The first city owned well was put down about 1917. The city wells numbered 1 in 1920, 5 in 1930, 13 in 1940, 19 in 1945, and 29 in 1948. The locations of the wells of the system in 1948 are shown on the map on page 14. Well symbols in black indicate wells that were installed before 1945, and those in red indicate wells that were installed between 1945 and January 1, 1948. The wells have been fairly widely spaced, both to minimize interference between the wells themselves and to reduce drawdown effects on irrigation wells. The total pumpage from 1939 to 1948 is given in the following table in gallons and in acre-feet per year.



CITY WELLS AT LUBBOCK, TEXAS IN 1948.

Pumpage by the city of Lubbock, Texas (From city records)

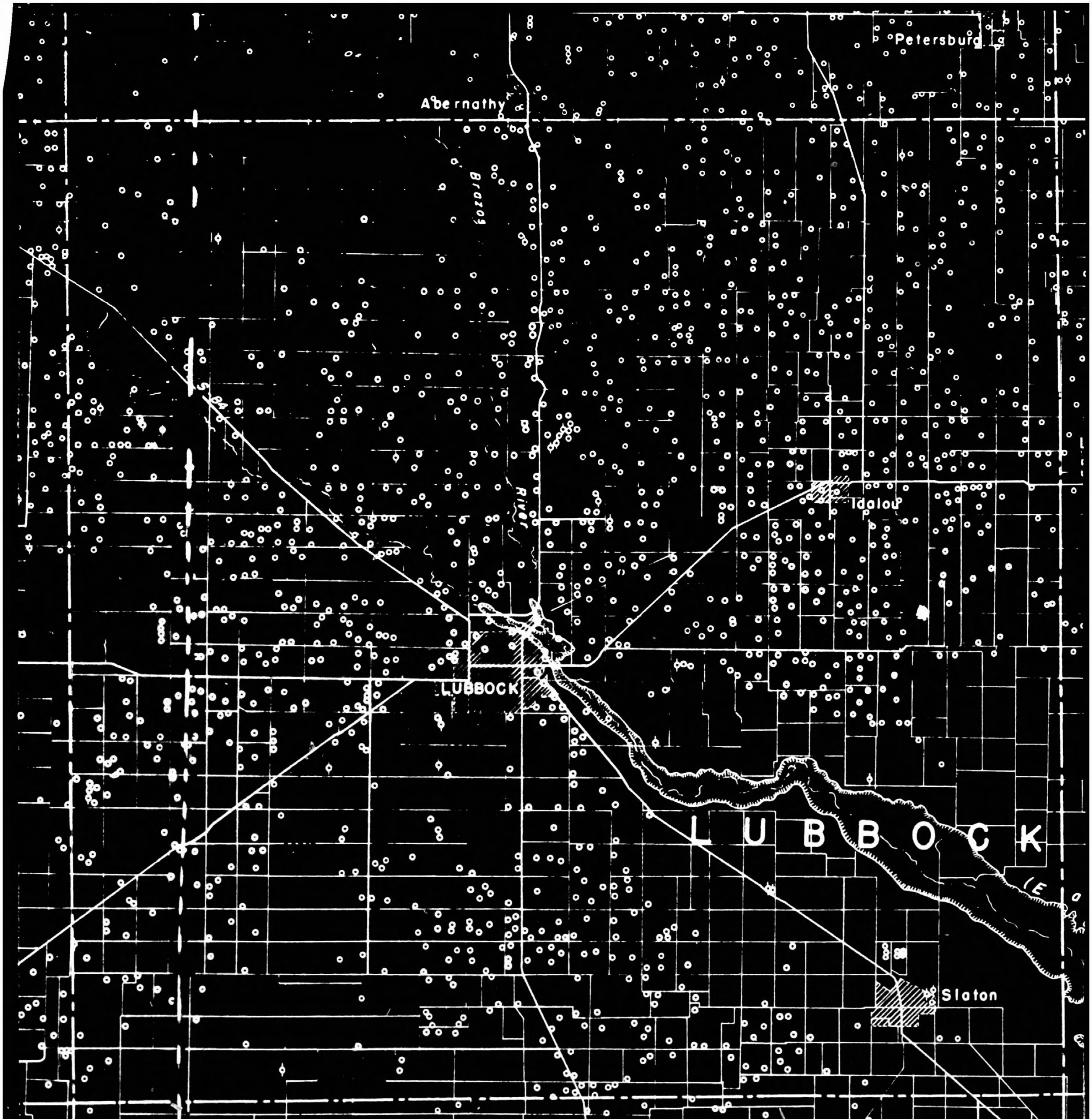
Year	Number of customers	Total production per year (gallons)	Total production per year (acre-feet)
1939	6,932	1,197,746,000	3,676
1940	6,735	1,328,256,000	4,076
1941	7,637	1,047,966,000	3,216
1942	8,272	1,340,025,000	4,112
1943	8,525	1,604,353,000	4,924
1944	8,642	1,454,658,000	4,464
1947	-	2,475,527,000	7,597
1948	-	3,083,900,000	9,464

The above records show that the city pumpage in 1948 was about two and one-half times that in 1939, about twice that in 1944, and one and one-fourth times that in 1947. Outstanding in the record is the great increase between 1944 and 1948.

Irrigation development.- The increase in the city pumpage accompanied a phenomenal expansion of well irrigation in the county, which has been unprecedented anywhere in this country outside of the High Plains. The estimated number of irrigation wells in the county at various times is as follows:

Year	Number of wells
1937	100
1939	190
1944	535
1945	590
1947	1,232
1948	1,600 (estimated)

The map on page 16 shows the locations of irrigation wells that were in existence on January 1, 1948. At that time there was an average of 1.7 irrigation wells per square mile in the county as a whole. In the areas of very



Irrigation and municipal wells in Lubbock County, Texas
in January 1948.

County boundary

heavy pumping the number was greater; for example, the wells averaged about 2.2 per square mile in the northeast quarter of the county, and 2.4 per square mile in an area of 50 square miles immediately west of Lubbock. The total number of irrigation wells that were in operation or equipped for operation at the end of 1948 is based on partial records and may be considerably in error; thus far no map showing the locations of the wells at the end of 1948 has been compiled. If the estimate of a total of irrigation wells is correct and the average pumpage from them is 120 acre-feet a year (the estimated average for the High Plains as a whole) the current irrigation pumpage must amount to about 180,000 to 190,000 acre-feet or 19 to 20 times the amount pumped by the city in 1948.

It is impossible to foretell the future of irrigation pumping in the county. With high prices for farm products it is possible for a new irrigation development to pay out in a relatively short ~~period of~~ time. If favorable prices continue and no regulatory ~~control~~ measures are taken, it appears inevitable that the irrigation pumpage will continue to expand at a rapid rate.

Decline of water levels.- From the spring of 1943 to the spring of 1948 the water levels in 32 widely spaced observation wells in Lubbock County showed an average decline of 6.57 feet. A relatively large part of this decline occurred between the springs of 1948 and 1949, the water levels in 96 observation wells showing an average decline during the year of 2.4 feet. The decline by areas between the springs of 1948 and 1949 is given in the following table and is shown graphically in fig. 22B on page 7.

Decline of water levels in wells in Lubbock County by areas 1948-49
(Total area of county 892.0 square miles)

Decline (feet)	Area affected (square miles)	Estimated volume of material unwatered (acre-feet)
0 - 3	756.5	726,000
3 - 5	109.4	280,000
5 - 7	6.7	29,000
7 - 10	1.0	5,000
Small rise	6.9	--
Not included	11.5	--
	892.0	1,040,000

In reaching the estimates of the volume of material unwatered given in the above table, it was assumed that the decline in water levels in each area was the mean of the figures shown in the first column of the table. If it is further assumed that the average effective porosity of the unwatered material is 17½ percent, the amount of water removed from storage during the year becomes 1,040,000 X .175 = 182,000 acre-feet. This figure closely approximates the estimated combined pumpage from irrigation and municipal wells in the county during the year and tends to show that the recharge during the year was practically negligible.

<u>Conclusion</u>.- Withdrawals of water for irrigation in the Lubbock area have "skyrocketed" during the past decade, and if present trends of expansion continue the ultimate failure of well irrigation in parts of the county will be speeded up and large areas of irrigated land will revert to dry farming. This situation will not be materially helped by a supplementary supply of surface water that is practicable to bring to the area to meet future municipal requirements. The municipal supply does not appear to be seriously threatened

by overdevelopment for irrigation because the ~~city can afford to pump many~~ wells that may have high lifts and small yields. If necessary, new city well fields can be developed within reasonable transmission distances in areas where present pumping lifts tend to preclude long-time irrigation pumping. In short, it is believed that the city has little cause for worry over its own public water supply; but it has good reason to fear the uncertainty that is sure to accompany failure of well irrigation.

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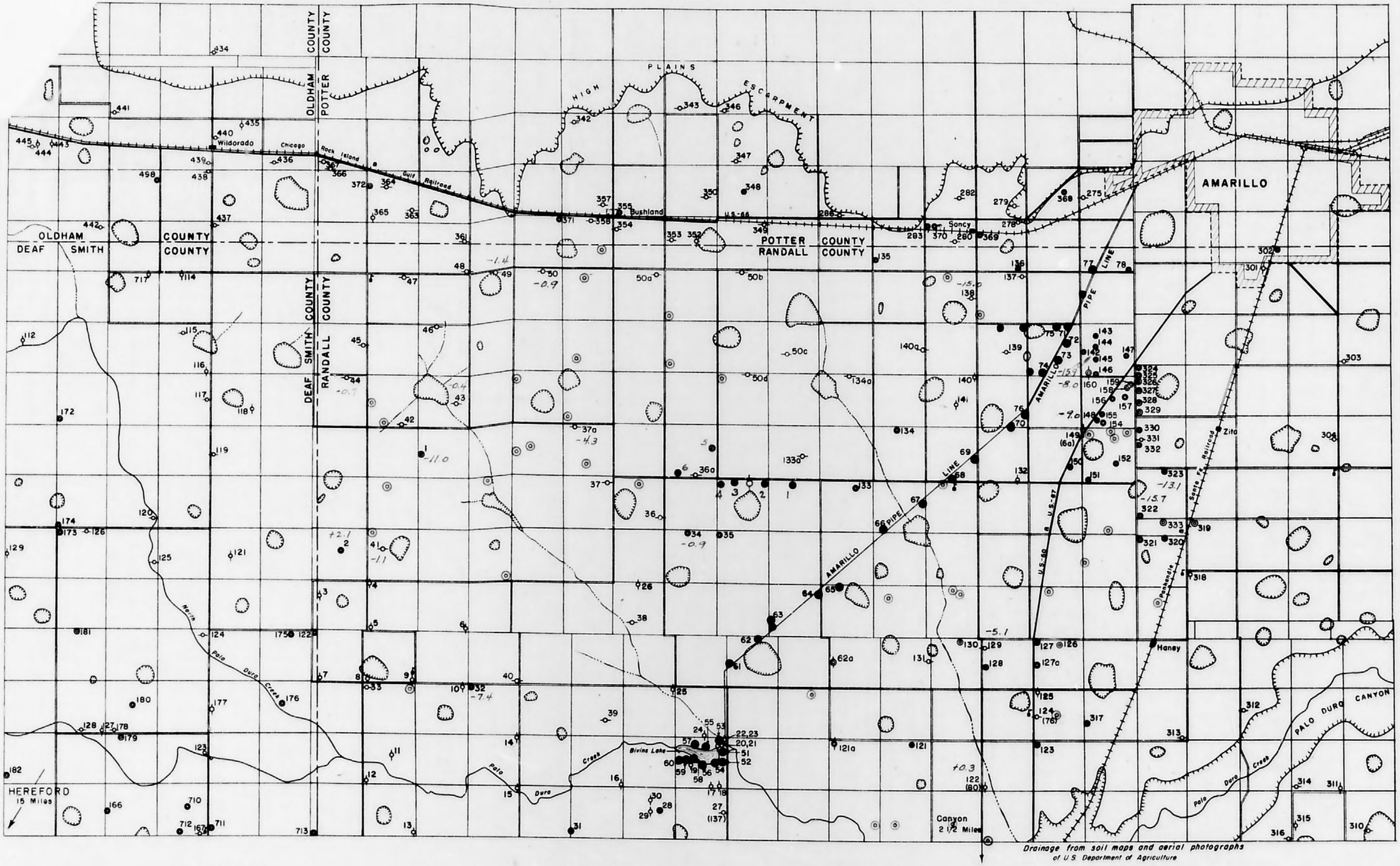

WELLS IN AMARILLO AREA, TEXAS

EXPLANATION

- Well with windmill or small power pump
- Well with pumping plant - 5 horsepower or larger
- Unused well
- Spring
- School
- Sink
- (137) Observation well number
- New irrigation wells (Jan. 1, 1948)
- New city wells (Oct. 1, 1948)
- Old city wells
- 10.0 Rise (+) or decline (-) of water level.

SCALE

1 0 1 2 3 Miles

N

TEXAS BOARD OF WATER ENGINEERS
IN COOPERATION WITH THE
U.S. GEOLOGICAL SURVEY
AUGUST 1946