TEXAS STATE BOARD OF WATER ENGINEERS

Prepared in cooperation with the United States
Department of the Interior, Geological Survey

GROUND WATER IN THE HIGH PLAINS IN TEXAS

By

W. N. White, W. L. Broadhurst, and
J. W. Lang

December, 1940

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INTRODUCTION

The High Plains in Texas are noted for their abundant supply of ground water. All the water for public and industrial supplies and nearly all the water used on the farms and ranches comes from wells, and in parts of the region irrigation on a large scale is accomplished with water from wells. It is very important that this natural resource should be utilized in such a manner that it will be of the greatest possible benefit for a long time to come.

Several general investigations of the ground-water resources of the region have been made in the past, and during the last three years a more intensive investigation has been in progress as part of a survey of the ground-water resources of Texas by the State Board of Water Engineers in cooperation with the Geological Survey of the United States Department of the Interior. The furnishing of information periodically regarding the extent of new ground-water developments, the quantity of water pumped from wells and the rise or fall of the water levels in the wells, is among the purposes of the present investigation. From these data conclusions can be drawn as to the average annual replenishment of the ground-water supply and the quantity of water that is withdrawn each year from natural storage.

The present studies have been made possible through appropriations by the State Legislature and allocations of Federal funds on an equal or nearly equal basis. The field work has been done by W. L. Broadhurst, J. W. Lang, and others, under the direction of Walter N. White, Senior Hydraulic Engineer, and under the general supervision of O. E. Meinzer, Geologist in Charge of the Division of Ground Water of the Geological Survey.

The statements which follow relate mostly to the source, replenishment, and natural discharge of the ground water; the withdrawal of ground water for irrigation, with special reference to the pumpage during the last three years; the fluctuations of water levels in wells in and near the heavily-pumped areas; and the changes that have occurred in recent years in the amount of water in storage within those areas. For convenience most of the discussion of pumpage and water-level fluctuations is given by districts, as follows: Plainview, Hereford, Muleshoe, and Lubbock-Littlefield.

Location and extent of area

The High Plains occupy an area of about 35,000 square miles in Texas, extending from the northern boundary of the Panhandle southward into Glasscock, Ector and Midland Counties, and from the New Mexico line eastward to a boundary which in most places is sharply defined by a bold escarpment several hundred feet in height (figure 1). The area is roughly rectangular in shape and averages about 300 miles from north to south and 120 miles from east to west. It is divided into two segments by the Canadian River, and the name Llano Estacado has usually been assigned by geographers and geologists to the southern or larger part. In popular usage, the Panhandle portion of the Plains is called the North Plains and the remainder or southern part the South Plains.

Acknowledgments

Acknowledgments are made to the Plainview office of the Texas Land and Development Company for free access to the Company's records; to Harry P. Burleigh and others of the Bureau of Agricultural Economics of the U. S. Department of Agriculture for their cooperation and general information; State Representative A. B. Tarwater for his unfailing interest and cooperation; to district representatives of the various pump companies for information regarding well drilling methods and new well development and to many well owners and operators throughout the High Plains for valuable information regarding their wells and pumping plants. Acknowledgment is also made to ranchers for free access to lands and for information regarding the location of springs along the High Plains escarpment.

Previous ground-water investigations

(See bibliography on page 32)

W. D. Johnson [1] spent several years on the High Plains just prior to 1900 and published his findings in the 21st and 22nd Annual Reports of the U. S. Geological Survey. These relate in part to the ground-water resources. The geology and ground-water resources of the northern 20 counties of the Texas Panhandle were studied by C. N. Gould in 1904-05 and the results published in Water-Supply Papers 154 [2] and 191 [3] of the U. S. Geological Survey. In 1909 O. E. Meinzer [4] made a brief study of ground water on the High Plains in Portales Valley, New Mexico, and gave his conclusions in a manuscript report. C. L. Baker [5] of the Texas Bureau of Economic Geology made a study of the geology and hydrology of a part of the region in 1914, and the following year published the results in Bulletin 57 of The University of Texas. His report includes two chapters on ground water, and tables of water-well logs and water analyses, including information on the depth to water in a considerable number of wells, a part of which he determined by measurements.

A study of the ground water on the High Plains near Portales, New Mexico has been in progress since 1931 under the direction of C. V. Theis of the Federal Geological Survey and the results have been published in four biennial reports of the State Engineer of New Mexico [6]. A reconnaissance investigation of ground water in the High Plains of Texas and also of Kansas, Colorado, New Mexico, and Oklahoma was made by C. V. Theis, H. P. Burleigh and H. A. Waite in 1933-34. In this investigation a large amount of preliminary data was obtained, including well records and measurements of water levels in wells, of which several were located in each of the pumping districts discussed in this report. A summary of the results is given in a mimeographed memorandum for the press, released by the U. S. Department of the Interior on October 30, 1935 [7]. A study of wells and irrigation with water from wells was made in 1936 by geologists and engineers of the Resettlement Administration in several localities in the High Plains, including the Plainview, Hereford, and Muleshoe pumping districts. The field work by that agency included measurements of static water levels in a considerable number of wells in each pumping district, the records of which have been available for study

in the present investigation.

During the last four years inventories of water wells have been made in all or parts of 25 counties of the Plains under an allocation of funds by the Work Projects Administration. This project is sponsored by the State Board of Water Engineers and has been carried out with the assistance of the U. S. Geological Survey under the direction of S. F. Turner and W. O. George and the Bureau of Industrial Chemistry of the University of Texas, under the direction of Dr. E. P. Schoch. The counties partly or fully covered by the inventories are Andrews, Armstrong, Bailey, Carson, Castro, Crosby, Dallam, Ector, Floyd, Glasscock, Hale, Hansford, Hartley, Hockley, Howard, Lamb, Lubbock, Martin, Midland, Ochiltree, Oldham, Parmer, Potter, Randall, and Roberts. The well inventories in Dawson, Deaf Smith and Swisher Counties and parts of Hale and Floyd Counties were made by employees of the Texas Board of Water Engineers in connection with the regular cooperative program. Mimeographed bulletins giving tables of well records, well logs and water analyses, together with a map showing the location of the wells, have been issued for all of these counties.

A progress report[8] summarizing the results of the present investigation to May 1938 was published on July 26, 1938. A memorandum for the press[9] giving a brief summary of the outstanding results to March 1939 was released on April 12, 1939. The results of water-level measurements in wells in the High Plains and other parts of Texas to December 31, 1939 are given in Water-Supply Papers 840[10], 845[11], and 886[12] of the Federal Geological Survey.

Copies of the water-well inventories, progress report and press release have been distributed to most of the colleges, high schools, public libraries, and chambers of commerce in the High Plains of Texas, and several hundred copies of the progress report of 1938 have been distributed to individual property owners. The present report gives the most important results obtained from the investigation to April 1, 1940. It includes records of water levels in observation wells obtained in July and November 1940 and a brief statement regarding the number of new wells completed and the decline of water levels to November 18, 1940.

SOURCE OF THE GROUND WATER

Most of the usable ground water in the Texas High Plains is found in the Ogallala formation, a sandy deposit lying at or near the surface throughout almost the entire region and in many places being between 200 and 300 feet thick. The formation is composed of silt and fine sand, with some coarse sand and gravel. The coarser sediments, which usually yield water freely to wells, are present at all horizons but are most prominent in the lower part of the formation. These sediments were deposited in part by streams, some of which had their headwaters in the Rocky Mountains, and part by the wind. The Ogallala rests on an uneven floor of older rocks which was eroded into valleys and ridges before the Ogallala was deposited. Nearly everywhere in the Texas High Plains the water encountered in these underlying rocks is highly mineralized and unfit for most uses.

The beds of the Ogallala formation once extended from the mountains of New Mexico eastward far into Texas, but they have been removed by erosion from much of the territory they once occupied. The areas in which the Ogallala formation is still present stand up almost like islands, being bounded by the escarpments of the Plains both on the east and on the west and being separated in Texas by the Canadian River, which is deeply entrenched in the older rocks. The Ogallala formation has been completely eroded away to the west of the western escarpment and to the east of the eastern one and from the canyon-like valley of the Canadian. The water-bearing sands and gravels of the Ogallala in both of these segments, therefore, are cut off in all directions from any underground connection except through the underlying older rocks which contain highly mineralized water entirely unlike the fresh water in the Ogallala.

In parts of the High Plains wells in the Ogallala yield large quantities of water and in some localities many such wells have been used for years. It is not surprising therefore that a popular theory has developed to the effect that the wells are tapping an inexhaustible supply of water in an underground river which flows beneath the Plains and has its source in the Rocky Mountains far to the west.

As a matter of fact, the high yield of the wells is explained by the relatively high permeability of the sands and gravels from which they draw water. The water is contained in interstices between the particles of gravel and grains of sand. Although it is moving, generally in a southeasterly direction, the movement is very slow--perhaps at an average rate of 200 to 300 feet a year. The movement, therefore, is scarcely comparable to that of a river. Inasmuch as the water-bearing beds are cut off in all directions from outside sources of water except through underlying rocks containing poor water, it follows that the source of the fresh water must be entirely within the High Plains themselves, and must be the rain and snow that fall on the surface of the Plains.

Most of the precipitation is dissipated by evaporation or by transpiration by grasses, shrubs, and cultivated crops, but a small part runs off and a small part moves downward to the underground reservoirs by direct penetration or by seepage from streams and depression ponds.

RECHARGE OF GROUND WATER

Most of the surface of the High Plains is underlain by sediments that are cemented with calcium carbonate and usually called caliche. These deposits probably prevent deep penetration of surface water over most of the Plains. In places, however, the caliche is thin or has been partly removed by solution, and in such areas the water may move downward to the water table. The principal area of ground-water recharge apparently are depressions or sinks, occupied by intermittent ponds; sandy stream beds and adjacent sandy flood plains; and sand dune areas.

Recharge from depression ponds

Depressions, or sinks, ranging from a few feet to 50 feet or more in depth, and from a few hundred feet to one mile or more in diameter are of common occurrence in the Texas High Plains. In some areas these depressions average as much as one to each square mile. During heavy rains ponds are formed in the depressions, ranging in area from a few acres to 100 acres or more.

Some of the ponds disappear in a short time, others remain for months. Several hundred test holes have been drilled in the beds of depression ponds on the High Plains in connection with the present investigation. These holes were drilled to an average depth of about 30 feet and spaced 100 to 300 feet apart in lines across the depressions. A few were drilled to a depth of about 100 feet. In some of the depressions relatively little caliche was encountered, in others caliche was found all the way across but was relatively soft, and in still others the caliche was so hard it could not be penetrated by the hand drill and was designated by the drillers as rock. In areas where the caliche was absent the sediments penetrated in many of the holes were relatively permeable from the surface to the bottom of the hole. (Graphic cross-sections illustrating the character of material encountered in some of the test holes are shown in several of the county well-inventory publications.)

The bottom of most of the depressions is covered with deposits of silt and soil, in places resembling gumbo and ranging from two to ten feet in thickness. After the ponds become dry, fractures and crevices several feet in depth frequently develop in their beds. In some of the depressions small sinks, apparently developed by solution channelling in the underlying caliche deposits, are present. These crevices and solution channels may provide a pathway for the downward movement of water for a time after the ponds are filled, although they may become sealed after water has stood over them for several days. The bottom area of most of the depressions is usually surrounded by a sandy belt which absorbs water readily. Gages were placed in several of the ponds during the summers of 1937 and 1938 and the rate of decline of the water levels observed at regular intervals for several months. In some of the ponds the rate of decline was small and apparently was due mostly to losses from evaporation. In others, it was quite rapid, amounting in some cases to two inches or more a day for 10 days or so after the rains and then gradually slowing down.

A considerable number of the observation wells are in the vicinities of intermittent ponds. Most of them display a rise in water levels after heavy rains

occur and the ponds become filled. The fluctuations of water levels in five widely-spaced wells near depression ponds in Hale, Floyd, Lubbock, and Deaf Smith Counties are shown graphically in figures 6 and 7, pages 50 and 51.

Recharge from streams

The streams that head in the High Plains of Texas are intermittent or ephemeral. After exceptionally heavy rains these streams carry large quantities of water but as a general rule only a comparatively small part of the water reaches the eastern escarpment or rim of the Plains. After heavy rains in May 1937, for example, the discharge of Running Water Draw at Plainview reached a peak of about 1,200 second-feet but the maximum flow 15 miles below Plainview was only about 80 second-feet. Apparently nearly all of the water was absorbed by the soil and a part percolated downward to the water table. Rains of almost cloudburst intensity fell in western Bailey County near the head of Blackwater Draw in June 1938, but no water flowed in the Draw in Lamb County, 30 miles to the east. Other examples could be cited if space permitted.

The two bottom graphs in figure 6, page 50 show fluctuations of water levels that occurred in wells 402 and 511 in Hale County in response to intermittent flows of storm water in Running Water Draw. The records are not continuous and therefore the graphs probably do not show the maximum variations in the levels during the period. Numerous other observation wells near streams in other parts of the region have shown substantial rises in water levels after freshets.

Recharge in sand hill areas

Sand dunes of wide extent occur in parts of the High Plains of Texas. They produce a rolling topography of low hills and ridges with intervening valleys of varying widths. Nearly all the rain that falls on the dune-covered areas is absorbed by the sand and on that account no lines of drainage, or only meager ones, have been developed. These conditions are favorable for ground-water recharge and the sand dune areas generally are believed to be among the best collecting areas for ground water in the Texas High Plains. Considerable evidence of this has already been obtained, and the subject is still under study. Among the largest of the

sand dune areas is one which extends eastward from Roosevelt County, New Mexico across Bailey and Lamb Counties and a part of Hale County, Texas. Sand dune areas of varying extent also cover parts of Yoakum, Terry, Lynn, Dallam, Hartley, and Oldham Counties and other counties of the region.

NATURAL DISCHARGE OF GROUND WATER

Before pumping was started, the ground-water reservoirs of the High Plains were in a state of approximate equilibrium. The average annual recharge was balanced by an approximately equal average annual discharge. The greater part of the natural discharge occurred through springs and seeps along the eastern escarpment of the High Plains and along the bluffs on either side of the Canadian River. A part of the water is discharged by evaporation and transpiration of trees, grasses and shrubs in shallow water-table areas on the Plains, and a small amount is lost by evaporation from water-table lakes.

Discharge of ground water from escarpment springs and seeps

Most of the springs along the escarpment, or rimrock, appear at or near the contact between the water-bearing sands and gravels and the underlying older clays and shales. They generally occur in the ravines and canyons, and in places give rise to streams of considerable size. In some places where the sands and gravels rest directly on older sandstone or conglomerate, the water issues from joints, fractures or solution channels in those rocks. The greater part of the springs occur within one to three miles of the top of the escarpment but a few, most of them small, appear along the streams at greater distances. An outstanding exception is Roaring Springs, in Motley County, which issues from conglomerate about nine miles to the east of the escarpment, and has a comparatively large discharge.

In 1938-39 studies of ground-water discharge were made along a 75-mile stretch of the escarpment extending southward from Quitaque Creek to Double Mountain Fork of the Brazos River, across parts of Briscoe, Floyd, Motley, Dickens, and Crosby Counties. This survey occupied the time of two to three men for several

weeks. All known springs and seeps were visited and the more important ones were mapped. (See figures 11 and 12, pages 55 and 56.) The discharge of the springs and seeps was measured or estimated and the losses of ground water by evaporation and transpiration which were not taken into account in the measurements, were estimated. From these data the total discharge of ground water along the 75-mile stretch of the escarpment was estimated as about 12,000 gallons a minute, or around 17 million gallons a day. This is the equivalent of about 53 acre-feet a day or about 19,000 acre-feet a year.

Discharge of ground water in shallow water-table areas on the High Plains

In connection with the investigation along the escarpment a study was made of ground-water discharge in a part of the High Plains themselves comprising about 9,000 square miles and extending approximately 120 miles to the northwest from the 75-mile stretch of the escarpment described in the preceding section. This is in the up-slope direction of the water table. The greater part of the irrigation wells in the Texas High Plains are located in this area.

Some natural discharge occurs in this area by evaporation from ponds in deep depressions. These ponds are fed in part by surface water and in part by ground water and on this account the amount of ground water discharged from them can not be accurately computed. The total discharge, however, is believed to be relatively small. Most of the ground-water discharge in the territory occurs in shallow water-table areas along the Double Mountain Fork of the Brazos River, Running Water Draw, and Tierra Blanca Creek. In the western and middle parts of the Texas High Plains these streams carry storm water only. Farther east near the escarpment they have cut deep canyon-like valleys, in places to a level below the water table, and have small perennial flows of spring water. This water, however, was taken into account in the computations of spring discharge along the escarpment. In numerous places along these streams ground water in considerable quantities is consumed by the growth of marsh grasses and sedges, subirrigated alfalfa, salt grass and various meadow grasses, and by trees of which cottonwood and willow are the most common.

During the summers of 1937, 1938, and 1939 the lands covered by the different kinds of ground water using grasses and subirrigated alfalfa were roughly mapped and estimates were made of the amount of ground water they consume annually, in acre-feet to the acre. The marsh grasses and sedges, it is believed, use the most water to the acre. Subirrigated alfalfa probably comes next but in most places it has a rather light growth and apparently is using considerably less water than irrigated alfalfa in the adjacent territory. The salt grass and meadow grasses have a rather dense growth in places but on the average the stand is light and the consumption of ground water probably small. Considerable loss occurs from evaporation in the fields of marsh grasses and sedges but in the other areas considered the evaporation loss is small. Estimates are given below of the total number of acres in the area that are covered by the different kinds of ground water-using grasses and alfalfa, and the total amount of ground water in acre-feet consumed annually by each kind. About 3,000 trees, mainly cottonwoods and willows, were counted in the bottom lands of the area but no effort was made to compute the amount of ground water which they use.

Estimates of discharge of ground water by transpiration from area of 9,000 square miles

	Total No. of acres	Estimated depth of water consumed (feet)	Total (acre-feet)
Marsh grass and sedges	500	2	1,000
Subirrigated alfalfa	500	1.5	750
Salt grass and other grasses	12,000	0.5	6,000
Trees	--	--	--
Total			8,000±

Total natural discharge from the area

From the measurements and estimates described above the total natural discharge of ground water from the area has been estimated to be at the rate of 25,000 to 30,000 acre-feet a year representing only a small fraction of an inch over 9,000 square miles of the area.

HISTORY OF THE DEVELOPMENT OF GROUND WATER FOR IRRIGATION

Irrigation from wells in this region was started more than 30 years ago near Portales, New Mexico, situated on the High Plains about 15 miles west of the Texas-New Mexico boundary. The development soon spread to nearby areas in Texas. According to an early issue of a Plainview paper, the first successful irrigation well in that area was drilled on the farm of J. H. Slaton four miles west of Plainview in January 1911. During that year six or seven additional irrigation wells were put down. In 1912 Dr. Frederick Pearson, of New York, organized a syndicate known as the Texas Land and Development Company, purchased 60,000 acres of land near Plainview, and started the development of ground water on a large scale. By 1913 the syndicate had drilled and equipped 85 irrigation wells.

In the report of his investigation in 1914, Baker[8] lists 139 irrigation wells in the High Plains of Texas located as follows: 100 in the general vicinity of Plainview, in eastern Hale County, western Floyd County and southern Swisher County; 27 near Hereford, in southeastern Deaf Smith County; and 12 near Muleshoe, in northeastern Bailey County and northwestern Lamb County.

According to records of the Texas Land and Development Company, there were 160 irrigation wells in the Plainview district in 1918, of which 127 had been equipped by the Company and 33 by individual land owners.

During the World War there was a general decline in well water irrigation, due in part to the shortage and high cost of labor, and in part to the introduction of the tractor, which encouraged cultivation and cropping of large tracts by dry-farming methods. In the seven years following the war, 1919 to 1926, the rainfall in most of the region was above average and comparatively little irrigation was practiced. Interest was revived during a period of several years of low rainfall which began with 1927. According to Theis[9], there were 296 irrigation wells in the Texas High Plains in 1934, of which 180 were located in the Plainview district, 70 in the Muleshoe district, and 46 in the vicinity of Hereford. The rate of development, which had been relatively slow to 1934, increased materially in 1935.

It was accelerated to some extent in 1936 and became still more rapid in 1937. The rate of increase declined somewhat in 1938 and 1939, but was again accelerated in 1940. A part of the wells that were put down from 1935 to 1940 were located in the older pumped areas but many of them were drilled in new territory. Briefly summarized, the construction and equipping of irrigation wells occurred about as follows: 1911 to 1914 inclusive, 139 wells; 1915 to 1934, 157 wells; 1935 and 1936, approximately 300 wells; 1937, 550 wells; 1938, 350 wells; 1939, 200 wells; and 1940, 400 (?).

USE OF GROUND WATER FOR IRRIGATION, 1937-1939

In order to estimate the amount of water that is being withdrawn from the underground reservoirs of the High Plains, the record of new irrigation wells has been kept as nearly up to date as practicable, and each year since 1937 complete or partial inventories have been made of the amount of land under irrigation and the amount of water applied to the land. In 1937, practically every pumping plant in the territory was visited and the owner or pump operator was interviewed in regard to its use during the season. In most cases information could be obtained regarding the number of acres irrigated from the well, the length of time required to water each field and the number of times each field was watered during the year, but only a few of the operators knew the yield of their pumps or had kept records of the total number of hours the pumps were operated during the season. During the preceding year (1936), however, engineers of the Resettlement Administration had measured the yield of about 65 representative wells in the Plainview, Hereford and Muleshoe pumping districts, a part of them belonging to farmers who kept systematic records of the operations of their pumps. The results of the measurements were made available, and from this information and the farmers records of pumping operations, estimates were made of the average depth of water applied during the season to each kind of crop. From these estimates and data obtained in the field as to the number of acres irrigated in each kind of crop estimates were made of the total amount of water pumped in each district.

In 1938 and 1939 only a part of the irrigation wells were visited. From 10 to 15 percent of the wells in each district were selected for study, and during the two pumping seasons the yield of about 100 of these wells was measured with a weir or current meter. Daily records of pumping operations were obtained for a part of the wells, including records gathered by the office of the U. S. Bureau of Agricultural Economics, which were made available. Records were kept of practically all new irrigation wells and old wells that were not in operation.

Estimates are given below of the number of wells pumped for irrigation by counties and by districts and the number of acres irrigated in each district in 1937, 1938, and 1939.

Summary of estimated number of wells pumped for irrigation by counties in the High Plains of Texas in 1937, 1938 and 1939.

County	1937	1938	1939
Bailey	70	78	95
Briscoe	10	13	15
Castro	50	90	100
Crosby	8	10	10
Dallam	13	25	25
Deaf Smith	130	182	200
Floyd	230	250	265
Hale	280	330	375
Hockley	28	30	36
Lamb	100	130	150
Lubbock	100	155	190
Parmer	5	5	6
Randall	6	10	10
Swisher	120	180	200
Others	--	12	23
Total	1,150	1,500	1,700

Summary of estimated number of wells pumped for irrigation and total amount of land irrigated from them by districts, in High Plains of Texas in 1937, 1938, and 1939.

	1937		1938		1939	
District	Wells pumped	Acres irrigated	Wells pumped	Acres irrigated	Wells pumped	Acres irrigated
Plainview	630	100,000	790	115,000	855	130,000
Hereford	170	33,000	240	40,000	260	40,000
Lubbock-Littlefield	170	17,000	250	23,000	310	30,000
Muleshoe	90	6,300	100	5,500	125	12,000
Spring Lake	45)		63)		87)	
Texline	13)	3,700	25)	16,000	25)	18,000
Other wells	32)		32)		38)	
Total	1,150	160,000	1,500	200,000	1,700	230,000

According to these estimates, the total number of wells pumped for irrigation in the High Plains of Texas and the total amount of land irrigated from them during the last three years was as follows: 1937, 1,150 wells pumped, 160,000 acres irrigated; 1938, 1,500 wells pumped, 200,000 acres irrigated; 1939, 1,700 wells pumped, 230,000 acres irrigated. The total amount of water, in acre-feet, withdrawn from the underground reservoir during the period, is roughly estimated as follows: 1937, 130,000; 1938, 145,000; 1939, 165,000.

The irrigation development is discussed below by districts which have been arbitrarily bounded to include counties or parts of counties as follows: Plainview district -- Hale, Floyd, Swisher and Briscoe Counties; Hereford district -- Deaf Smith County and northwestern part of Castro County; Muleshoe district -- Bailey County and northwestern part of Lamb County; Lubbock-Littlefield district -- Crosby, Lubbock and Hockley Counties and southeastern part of Lamb County; Spring Lake district -- northeastern part of Lamb County and southern part of Castro County; Texline district -- Dallam County. Occasional irrigation wells are found in different parts of the High Plains outside of these district, but the total number is small. The maps on pages 52, 53, and 54 show most of the irrigation wells that were put down prior to the spring of 1939 in the Plainview, Hereford and Muleshoe districts, respectively.

Plainview district

In the Plainview district approximately 630 wells were pumped for irrigation and 100,000 acres of land were irrigated in 1937, 790 wells were pumped and 115,000 acres were irrigated in 1938, and 850 wells were pumped and 130,000 acres were irrigated in 1939. About 200 were drilled before 1935, 190 in 1935 and 1936, 250 in 1937, 150 in 1938, and 65 in 1939. The estimated average depth of water applied to the land, usually expressed in acre-feet to the acre, was about as follows: 1937, 0.8 foot; 1938, 0.8 foot; 1939, 0.75 foot. The locations of about 600 of the irrigation wells are shown on the map (p. 52).

Hereford district

In the Hereford district about 170 wells were pumped and 33,000 acres were irrigated in 1937, 240 wells were pumped and 40,000 acres were irrigated in 1938, and 260 wells were pumped and 40,000 acres were irrigated in 1939. About 40 of the wells pumped in 1939 were drilled prior to 1935, 30 wells were drilled in 1935 and 1936, 100 in 1937, 70 in 1938 and 20 in 1939. About 80 percent of the wells in the district are within an area of 270 square miles centering around Hereford. The area of heaviest pumping comprises about 100 square miles within a few miles of the town where there is an average of one well to each square mile. The average depth of water applied for irrigation in the district is estimated as about 0.8 foot in 1937, 0.65 foot in 1938, and 0.8 foot in 1939.

Muleshoe district

In the Muleshoe district about 125 wells were pumped for irrigation in 1939. Of these wells about 56 were drilled or dug before 1935, 20 in 1935 and 1936, 12 in 1937, 12 in 1938, and about 25 in 1939. Most of the wells are located in a rectangular-shaped area about 20 miles long in an east-west direction and three to four miles wide in which there is an average of one well to about 400 acres.

It is estimated that approximately 6,000 acres were irrigated in the district in 1937, 5,500 acres in 1938, and 12,000 acres in 1939. The average depth of water applied for irrigation is estimated as about 0.9, 1.0 and 0.7 acre-foot per acre in the three years, respectively.

Lubbock-Littlefield district

Approximately 310 wells were being pumped for irrigation in the Lubbock-Littlefield district by the end of 1939. The wells are located in an irregularly-shaped area comprising about 800 square miles, and, in general, are rather widely

spaced, the heaviest pumping being in the vicinity of Lubbock and in the territory between Lubbock and Littlefield. About 20 of the wells were drilled before 1935, 150 in 1935, 1936 and 1937, 80 in 1938, and 60 in 1939.

It is estimated that approximately 17,000 acres were irrigated in the district in 1937, 23,000 acres in 1938, and 30,000 acres in 1939. The average depth of water applied for irrigation apparently was around 0.6 foot, 0.6 foot, and 0.65 foot for the three years respectively.

Texline district

Approximately 25 wells are equipped with pumping plants in the Texline district in northwestern Dallam County. The first wells were drilled about 1932 but most of the development has taken place since 1936. No detailed records are available to indicate the number of acres under irrigation. The tendency in this locality is to water smaller tracts of land from each well than is the case in most of the irrigated districts in the Texas High Plains.

Spring Lake district

There are 87 wells in the Spring Lake district, practically all of them drilled since the spring of 1936. The average number of acres irrigated from each well in the district is comparable to that in adjoining areas to the north and east.

A few wells in other parts of the Texas High Plains are pumped to irrigate small tracts of land.

MEASUREMENTS OF WATER LEVELS IN WELLS

The water levels in wells are nearly always rising or falling in response to various influences, among which changes in the rate of ground-water intake or recharge and in the withdrawal of water through wells are the most important. Measurements of water levels in a considerable number of wells in the High Plains of Texas were made and recorded by different State and Federal Agencies in 1914, 1934, 1936, and in March 1937. Since the latter part of April 1937 the water levels in about 600 observation wells in the region have been measured at intervals ranging from one month to one year as part of the present program of investigation. The observation wells are irregularly spaced from the vicinities of Big Spring, Stanton, and Midland, northward to Oklahoma and from the eastern escarpment of the High Plains to New Mexico. Approximately two-thirds of them are within or near areas in which well irrigation of varying degrees of magnitude is being carried out and the remainder are remote from such areas. A part of the observation wells in both the irrigated and non-irrigated districts are near streams or depression ponds, or among sand hills, where conditions are favorable for the intake of water, and a part are on the uplands where such topographic features are absent. The observation wells have been carefully selected for the purpose of obtaining information regarding the location of areas of ground-water intake, the amount of intake and the effect that pumping has on the ground-water supplies. Unused wells have been selected for observation where they are available because the water levels in them are undisturbed by the effect of pumping from the well itself. Where such wells remain open they indicate the static level of the water table more accurately than used wells. In some cases, however, an unused well becomes partly filled up or the screens become clogged and the water level fails to indicate the true position of the water table. Approximately one-third of the observation wells are unused. A part of them are pumped for irrigation and a part are equipped with a windmill or hand pump and used for domestic purposes and stock. Wells with a pumping plant or windmill are measured only when the pumps are idle and when practicable the wells are shut down for several hours before a measurement is taken. In the irrigation districts as many measurements as

practicable are made during the late fall and winter when most of the pumping plants are shut down for the season. The depth to water measurements are made with a steel tape from a fixed reference point at or near the top of the well.

As previously mentioned the water-level measurements to December 31, 1939 are published in Water-Supply Papers 840, 845, and 886 of the Geological Survey. The records are to be released in mimeographed form by the Texas Board of Water Engineers in cooperation with the Federal Geological Survey and it is expected that copies will be kept on file at most of the chambers of commerce and public libraries of the High Plains.

FLUCTUATIONS OF WATER LEVELS IN PUMPING DISTRICTS

In heavily-pumped districts records of the water levels in wells and of the amount of water withdrawn from wells over a period of years, when studied together and properly interpreted, give the best available information regarding the safe yield of the underground reservoirs. Baker [10/] gives the depth to water below the land surface, as recorded in the winter of 1913-14, in approximately 100 wells of the Plainview, Hereford and Muleshoe districts. He obtained his information mostly from reports of well owners but a few of the wells were measured, of which about 25 are included among the present observation wells. The water levels in 27 of the observation wells were measured by Theis [11/] and party in 1934, of which 14 are in the Plainview district, five in the Hereford district, and eight near Muleshoe. Engineers of the Resettlement Administration measured the depth to water in 130 of the observation wells in April, May and June 1936, and made measurements in 18 of them in March 1937. The present well-measuring program was started in the latter part of April 1937. Considerable pumping had been done previous to the spring measurements, both in 1936 and 1937, and the water table had probably declined considerable before the measurements were made.

Records of the measurements in most of the observation wells in the Plainview, Hereford, and Muleshoe pumping districts are given in the table on pages 33 to 44

of this report. A description of most of the observation wells has been published in the water-well inventory report for Hale, Floyd, Swisher, Deaf Smith, Castro, Lamb, and Bailey Counties, copies of which are on file at offices of the chambers of commerce, county officials, and many of the college, high school, and city libraries throughout the High Plains. A few copies of these county reports are available for distribution and may be obtained from the Texas Board of Water Engineers, Austin, Texas. The hydrographs in figures 2 to 5 (pp. 46 to 49) show graphically the water-level fluctuations in 19 widely spaced wells in the three pumping districts.

In most sections of the country where well irrigation is carried on the pumps are idle during a part of the year, usually in winter, and the most dependable information regarding the stage of the underground reservoirs is obtained by comparing the water level measurements made in successive years during the latter part of the idle season. In the High Plains of Texas irrigation is practiced during all four seasons and in some years the pumps are operated practically every month in the year. Cotton, feed crops and vegetables are irrigated during the spring, summer and early fall, and winter wheat during the fall, winter and spring; the amount of winter irrigation, however, varies greatly with the rainfall from year to year. Taking the area as a whole, the winter is the slack season and a comparison of measurements made in successive years during the late winter or in the early spring is most informative, although in interpreting the measurements, allowance must be made for yearly variations in the amount of winter irrigation. In the discussion that follows particular consideration is given to the January to March measurements.

Plainview district

About 125 of the observation wells are within a radius of 15 miles from Plainview (see map, p.52). For a comparison of water-level fluctuations, with relation to pumpage, the district has been divided into three areas as follows: north and northeast, east and southeast, and west and south of Plainview.

North and northeast of Plainview.-- Forty-four of the observation wells are in the territory north and northeast of Plainview in northern Hale, southern Swisher and northwestern Floyd Counties (see pp. 33 and 34 for detailed records of measurements in 39 of the wells). The area is rather heavily pumped, a part of the development being 20 to 25 years old and a part comparatively recent. Sixteen of the observation wells are pumped for irrigation, five are pumped with windmills for domestic use or stock, and 23 are unused.

From January-March 1939 to March 1940 there was an average decline of 1.1 feet in the 32 wells for which measurements are available for comparison. From January-March 1938 to March 1940 the same wells had an average decline of 1.8 feet. In 10 wells with records for April 1936 and March 1940, there was an average decline of 2.6 feet. In five wells with records for April 1934 and March 1940 there was an average decline of 3.3 feet. In one well which had records for the winter of 1914 and for March 1940 there was a decline of 11.4 feet.

East and southeast of Plainview.-- Periodic measurements have been made in 47 observation wells, east and southeast of Plainview, in eastern Hale and western Floyd Counties. (See pages 35 and 36 for detailed records of measurements in 40 of the wells). This is the most heavily-pumped area in the Texas High Plains. About 65 of the irrigation wells in this area were drilled in 1913-17, mostly within an area of 50 square miles centering around Aiken in western Floyd County. Most of these wells were operated only a part of the time until about 1934. Since 1934 the number of irrigation wells east and southeast from Plainview has increased more than 200 percent.

Nineteen of the observation wells are not used, 21 are pumped for irrigation and four are equipped with a windmill. From January-March 1939 to March 1940 there was an average net decline of 1.6 feet in the 34 wells for which comparable measurements are available. From January-March 1938 to March 1940 the same wells had an average decline of 2.6 feet. The seven wells measured during March-April 1937 and in March 1940 showed an average decline of 2.3 feet. Eight wells measured in April

1936 and in March 1940 had an average decline of 3.5 feet. From April 1934 to March 1940, the five wells measured had an average decline of 6.5 feet. From 1914 to March 1940, 10 wells showed an average decline of 9.6 feet. The greatest decline 14.2 feet, occurred near the center of the old pumped area.

South and west of Plainview.-- Forty of the observation wells are south and west of Plainview where the pumping is somewhat lighter than in the other parts of the district, and most of the wells have been put into operation since 1935. Twenty-three of the observation wells are not used, 11 are pumped for irrigation, 5 are equipped with windmills, and one is equipped with a hand pump (see pp. 37 and 38 for detailed records of measurements in all these wells). From March 1939 to March 1940 there was an average decline of 0.8 foot in 28 wells for which records are available. Twenty-three wells measured in March 1938 and March 1940 had an average decline of 1.3 feet. Three wells measured in March 1937 and March 1940 had an average decline of 1.2 feet. Four wells measured in April 1934 and March 1940 had an average decline of 1.5 feet. Of five wells measured in 1914 and February-March 1940 four had an average decline of 0.8 foot and one a rise of 3.8 feet.

A summary giving the minimum, maximum and average decline of water levels in the Plainview district for the different periods is given in the following table.

Decline of water levels in observation wells in Plainview district, Texas

	Period	Number of wells	Net decline of water levels in feet			Remarks
			Minimum	Maximum	Average	
North and northeast of Plainview	1939-40	32	0.2	2.5	1.1	
	1938-40	32	0.6	3.7	1.8	
	1936-40	10	1.4	4.2	2.6	
	1934-40	5	2.0	5.4	3.3	
	1914-40	1	-	-	11.4	
East and southeast of Plainview	1939-40	34	0.4	2.7	1.6	
	1938-40	34	0.6	4.6	2.6	
	1937-40	7	1.6	3.3	2.3	
	1936-40	8	1.6	5.7	3.5	
	1934-40	5	4.7	8.3	6.5	
	1914-40	10	5.7	14.2	9.6	
South and west of Plainview	1939-40	28	0.1	1.5	0.8	
	1938-40	23	0.3	2.9	1.3	
	1937-40	3	0.9	1.5	1.2	
	1934-40	4	1.4	1.6	1.5	
	1914-40	5	0.2	1.5	0.8	Rise of 3.8 feet in one well.

Hereford district

About 70 of the observation wells are in this district, most of them within 12 miles of Hereford (fig. 9, p. 53). In this district the rainfall during the early part of 1937 was exceptionally small and apparently more water pumped than during corresponding periods in 1938 and 1939. This was reflected in the water-level measurements and a comparison of the spring measurements in 1937 with those in 1938 and 1940 therefore tend to give figures on the net decline in water levels which are less than the true net decline.

North and northeast of Hereford.-- Most of the older irrigation wells and many of those that were put down from 1936 to 1939 are located in the area north and northeast of Hereford, which is now the most heavily pumped part of the Hereford district.

Of the 31 observation wells in the area, 18 are pumped for irrigation, 11 are unused and 2 are equipped with a windmill. Twenty-one of the wells are located in or bordering the area of most intensive pumping, and 10 are located where pumping is light to moderate (see pp. 39 and 40 for detailed records of measurements). From March 1939 to March 1940 there was an average decline of 1.4 feet in the 24 wells for which measurements are available. From January-March 1938 to March 1940 the same wells showed an average loss of 1.3 feet and one well a net rise of 1.7 feet. Water levels recorded in April to June 1936 and in March 1940 show an average decline of 2.3 feet in 12 wells and a rise of 0.1 foot in one well. Of two wells measured in November 1934 and in March 1940 one had a decline of 2.5 feet and the other a decline of 1.3 feet. One well (No. 261, Deaf Smith County) about three miles north of Hereford had a decline of 5.8 feet from 1914 to March 1940.

South and southeast of Hereford.-- The area south and southeast of Hereford is heavily pumped but the draft is not quite so great as it is in the area to the north and northeast. Of the 20 observation wells in this part of the district four are unused (see p. 41 for detailed records of measurements). From March 1939 to March 1940 there was an average decline of 1.2 feet in the 16 wells for which

measurements are available. From January-March 1338 to March 1940, the same wells show an average decline of 1.1 feet. One well measured in March 1937 and in March 1940 had a decline of 2.8 feet. A comparison of the highest water levels recorded in April to June 1936 with measurements made in March 1940 show an average decline of 2.5 feet in seven wells and an average rise of 0.5 foot in three wells.

West and southwest of Hereford.-- Most of the irrigation wells west and southwest of Hereford have been put in during the last three or four years, and in general they are rather widely spaced. Ten of the observation wells are in this area of which four are unused (see p. 42 for detailed records of measurements), three are pumped for irrigation, and three are equipped with windmills. From March 1939 to March 1940 there was an average decline of 0.8 foot in six wells for which measurements are available. From March 1938 to March 1940 the decline in the same wells was practically the same as it was from 1939 to 1940. One well(No. 283, Deaf Smith County) showed a decline of 3.2 feet between May 1936 and March 1940. A summary giving the minimum, maximum and average decline of water levels in the Hereford district for the different periods is given in the following table.

Decline of water levels in observation wells in Hereford district, Texas

	Period	Number of wells	Net decline of water levels in feet			Remarks
			Minimum	Maximum	Average	
North and northeast of Hereford	1939-40	24	0.1	2.7	1.4	
	1938-40	24	0	2.2	1.3	Rise of 1.7 feet in one well.
	1936-40	13	0.2	6.7	2.3	Rise of .01 foot in one well.
	1934-40	2	1.3	2.5	1.9	
	1914-40	1			5.8	
South and southeast of Hereford	1939-40	16	0.2	3.1	1.2	
	1938-40	16	0.1	2.8	1.1	
	1937-40	1	-	-	2.8	
	1936-40	10	0.5	4.0	2.5	Average rise of .5 foot in 3 wells.
South and west of Hereford	1939-40	6	0	2.0	0.8	
	1938-40	6	0	1.1	0.6	
	1936-40	1			3.2	

Muleshoe district

Measurements have been made in about 40 observation wells in the Muleshoe district at intervals ranging from one to four months. Thirty-three of the wells are pumped for irrigation and seven are unused.

East of Muleshoe.-- Twenty-two of the observation wells are in the pumped area east of Muleshoe which comprises about 40 square miles (see p. 43 for detailed records of measurements). From March 1939 to March 1940 there was an average decline of 0.7 foot in 17 wells for which comparable measurements are available. The 16 wells measured during January-March 1938 and in March 1940 showed an average decline of 0.5 foot. From January-May 1937 to March 1940 the 16 wells measured had a decline of 0.4 foot. From November 1934 to December 1939, six wells showed an average decline of 2.4 feet. From 1914 to March 1940, 10 wells had an average decline of 2.8 feet.

West of Muleshoe.-- The pumped area west of Muleshoe comprises about 25 square miles. Sixteen of the observation wells are in this area, of which 13 are pumped for irrigation and three are unused. From March 1939 to March 1940 the 16 wells had an average decline of 0.8 foot. From January-March 1938 to March 1940, 14 of them had an average decline of only 0.2 foot. Seven wells measured during January-May 1937 and in March 1940 showed an average rise of 1.1 feet. Of two wells measured in November 1934 and in December 1939, one had a decline of 0.2 foot and the other a rise of 1.8 feet.

Lubbock-Littlefield district

Observations of water levels are being made at intervals ranging from one to four months in about 30 wells in the Lubbock-Littlefield district, comprising northern Lubbock, northeastern Hockley, and southeastern Lamb Counties. Of 27 wells measured during the winter of 1938-39 and during corresponding months in 1939-40, 22 had declines ranging from 0.2 foot to 2.2 feet and averaging 0.7 foot, while five wells had an average rise of 0.46 foot. Four of the five wells displaying

a rise are near intermittent ponds or the valley of Yellowhouse Draw. Twenty-nine wells measured in December or January 1938 and in corresponding months in 1939-40 had an average decline of 0.5 foot.

Texline district

In the Texline district in Dallam County, water-level measurements are being made in about 25 observation wells, of which 18 were measured monthly in 1939. Of 18 wells measured in March 1939 and in March 1940, 12 had an average decline of 0.5 foot, and six an average rise of 0.1 foot. One well had a decline of 1.3 feet from November 1934 to March 1940.

EFFECT OF PUMPING ON THE GROUND-WATER SUPPLY

There has been a general decline in the water table in the principal pumping districts of the High Plains during the last few years. The decline has been spread over large areas and the total volume of formerly saturated material that has been unwatered by the decline is large. The water that has drained out as the water table declined has moved downward to replace the pumped water and represents a loss from the volume formerly in storage. The interstices in sand and gravel are comparatively large, and consequently the effect of molecular attraction in them tending to resist the pull of gravity is comparatively slight. Therefore a large part of the water which they contain in a saturated condition drains out as the water table declines. In other words, their specific yield is high. The pore spaces in silt and clay loams are very small, and the effect of molecular attraction in them is correspondingly great. These materials therefore retain a much higher proportion of water as the water table declines than is retained by sand and gravel. The process of drainage in fine materials continues for a long time, although at a greatly reduced rate. If on the average the saturated materials in the pumping districts of the High Plains have a specific yield of 15--that is, if they yield a volume of water equivalent to 15 percent of their own volume as they are unwatered, a total of 96 acre-feet is removed from storage in each square mile for each foot of decline.

In an area of about 300 square miles southeast of Plainview, the water table apparently declined an average of about 1.5 feet from March 1938 to March 1940. If a one-foot decline in the water level removed 96 acre-feet from storage for each square mile, a decline of 1.5 feet over 300 square miles must have removed about 43,000 acre-feet. The records show that in the two-year period a total of about 80,000 acre-feet of water was pumped in this part of the Plainview district.

Approximately 90 percent of the wells in the entire Plainview district are within an area of about 700 square miles. In this area the water table apparently had an average decline of about 1.2 feet from March 1938 to March 1940. Making the same assumption as above regarding the specific yield, this would indicate that approximately 84,000 acre-feet of water was removed from storage in the area during the two years. The pumpage in the area during the period is estimated at about 170,000 acre-feet. Approximately 80 percent of the wells in the Hereford district are in an area of about 270 square miles. In this area the water table had an apparent average decline of one foot from 1938 to March 1940. On the same basis as above this would indicate that about 26,000 acre-feet were removed from storage. The pumpage in the 270 square miles during the two years, it is estimated, was about 44,000 acre-feet. Quantities of water were also withdrawn from storage in areas surrounding those described above as water moved toward the depressions in the water table produced by the pumping. The observation wells in the adjoining areas are few and widely spaced and the amount of the withdrawals cannot be computed.

Further investigation will be required to correlate the above estimates precisely with the results obtained as to natural discharge and recharge. The records are conclusive, however, in showing that the pumped water is in large part taken from storage.

In the High Plains before any water was pumped from wells the yearly discharge of ground water by natural process was doubtless about equal to the average amount added yearly from the rain and snow falling on the region. The pumping has represented an additional amount of water taken from the underground reservoir without any increase in the amount of replenishment. Hence the development of the ground-water

resources of the region will necessarily cause lowering of the water level except as natural discharge is decreased.

CONCLUSIONS

A very large quantity of water, that has accumulated over a long period of time, is stored in the natural underground reservoir formed by the beds of sand and gravel that lie below the High Plains in Texas. A small part of this water is discharged each year by the flow of springs or by evaporation and the growth of plants in the localities where the water table is near the surface. This natural discharge is approximately balanced through a long term of years by water derived from that part of the rainfall upon the area which penetrates to the water table. The average annual replenishment is only a small part of the average annual rainfall.

In the last 30 years water has been pumped from wells in this region in large quantities, chiefly for irrigation. The annual pumpage has been increased greatly in the last six years. In 1937 it amounted to about 130,000 acre-feet; in 1938 to about 145,000 acre-feet; and in 1939 to about 165,000 acre-feet.

There has been a general and persistent decline of the water table in the pumping districts during the last few years. A large part of the water that has been pumped from wells in this region has been derived by reduction in underground storage

A question in the mind of many of the owners of irrigation wells in the High Plains is this: What are the limits of safe pumping in my neighborhood? How much water should be pumped and how closely should the wells be spaced? The investigation shows that this is largely a question of economics. With increased pumping the rate of decline of the water table and the pumping lift will increase. Moreover, as the uppermost sands and gravels are unwatered, the wells that draw from them probably will decline in yield. The farmers of the High Plains, with their water supply, are in a position similar to that of a man who has a large capital but who uses a part of his capital each year.

Obviously, the problem of the conservation of the stored ground water for future as well as present beneficial use deserves serious consideration.

POSTSCRIPT

This report is devoted mostly to the results obtained from the investigation prior to April 1, 1940. However the results of measurements of water levels in wells in the more heavily pumped areas made to the middle of November 1940 have been included in the tables of water-level measurements on pages 33 to 44. These records show that the observation wells have had a greater average decline in water levels during the summer and fall of 1940 than they ever had before during corresponding seasons of the period of record. On the basis of a partly completed inventory it is estimated that about 400 wells will have been put down and equipped for irrigation in the Texas High Plains in 1940. This represents a greater development than has taken place in any year except 1937.

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Water levels in wells in Plainview district, Texas
North and northeast of Plainview

(Depth in feet below measuring point)

Date of measurement	Hale County — Well number (For location of wells see map on page 52)																		
	202	210	212	220	223	231	232	238	246	263	307	314	316	317	321	330	338	346	370
1914			52.5																
1934 Apr.	64.1			50.2							61.6			49.4					
1936 Apr.					49.6		51.8	50.7				42.6	49.9			44.6	45.5	45.3	41.8
May	67.8	63.6				45.3			45.7						62.5				
June								50.8							62.6			46.1	
1937 Apr.						46.1			46.0										
May					55.2							43.5			63.2			47.1	
June		65.8			52.4	46.3	51.9	53.4	46.3				50.3		63.5	44.9		48.0	
July					51.6	46.4	52.8		46.2	42.3		43.6			64.1	44.7			
Aug.	67.6					46.5	52.6		46.3	42.5		44.0			63.6	44.8	45.9		43.3
Sept.	67.6			55.8				56.3	46.5	43.0	66.5	44.0	50.4	52.2	63.8		45.9		43.3
Oct.	66.1				52.9	46.6			46.6			44.0	50.5		63.7	44.9	45.7	46.8	43.3
Nov.	65.7				52.1	46.7			46.7	42.8			50.5		63.7	44.9	45.6		43.2
Dec.	65.3			53.3		46.7			46.7			43.9	50.5		63.7	44.8	45.5	46.4	43.1
1938 Jan.	65.2	64.9		53.1		46.7	49.7	52.3	46.7	43.0			50.6	51.1	63.6	44.9	45.5	46.2	43.0
Mar.	65.2		62.5	53.7	51.7	46.5		52.1	46.7		63.4	43.7	50.6	51.1	63.7	45.4	45.5		42.9
Apr.	67.2	64.5		53.4	51.8	46.5	49.4	52.2	47.0	43.2			50.6	51.1		45.4	45.6	49.2	42.9
May		65.2									67.1	44.5	50.7		63.8	45.4	46.2	49.7	43.0
June	67.4	64.9	64.7	55.6	52.9	46.8	53.7	52.5	47.3	43.6	64.6	44.5	50.7	52.3	63.8	45.5	45.9	48.3	43.1
Aug.						47.0			47.7	43.2		44.5	50.7		63.9	45.2		47.7	43.2
Sept.	67.4								47.8			44.7	50.8	53.2	63.9	45.7			
Oct.			67.2	55.3	53.5	47.1		52.7	47.9	43.5		44.8	50.8	52.1	63.9	45.3	46.1	48.1	43.0
Dec.	66.6	65.2				47.1			48.0	43.7	64.4	44.5	50.8	51.6	64.0	45.2	46.0	47.5	43.0
1939 Jan.		65.1	63.7	54.9		47.1	50.5	52.6	48.0		64.3	44.5	50.9	51.6		45.3	45.9	47.3	43.0
Feb.	66.1			54.2	52.3	46.9		52.5	47.8			44.3	50.9	51.5	64.2		45.9	47.0	42.9
Mar.		64.8								43.7	63.9								
June	69.8	65.4				47.3		53.1	48.2	44.0		45.3	51.0	55.9	64.4		46.8	51.1	43.5
July												45.4	51.0	52.8	Dry,				43.5
Aug.		66.6				47.6		53.1	49.5	44.3		45.6	51.1		64'	45.7	48.3		
Oct.	68.1	66.3	73.6		57.9	47.9		53.5	50.9	44.7		46.3	51.2	52.9			47.8		43.8
Dec.	67.0	66.1	67.3	56.4	54.6	48.2	55.2	53.6	50.5	45.0	66.2	46.3	51.3	53.3		47.2	47.2	52.0	44.0
1940 Mar.	66.7	65.8	63.9	55.6	53.8	48.3	52.6	53.5	49.7	45.1	65.1	45.7	51.4	52.3		46.0	47.2	49.5	44.0
Nov.	68.6	67.3	69.4	58.5	57.1	Below 49.0	59.9	55.9	54.6	46.4	68.4	48.9	52.2	53.9		46.7	48.7	Dry 50.5	45.3

Water levels in wells in Plainview district, Texas
North and northeast of Plainview

(Depth in feet below measuring point)

Date of measurement		Swisher County													Floyd County					
		Well number (For location of wells see map on page 52)													Well number					
		226	254	258	332	337	339	352	354	362	368	370	380	383	385	5	14	32	44	57	71
1934	Apr.													72.2							
1936	Apr.															49.0					
	May	45.0	36.9	51.1		56.3	47.0	59.4	61.6	70.0	74.0	72.6	54.5	74.6	71.6	50.4	58.9		63.0	61.1	
	June					56.3		58.5	61.6	70.1	73.6	72.7									
1937	Mar.													74.3							
	May	45.4	37.3			57.0	47.6	59.9	61.9	69.9	74.9		54.6	77.7			59.7	91.2	63.8	60.9	82.5
	June	45.4	37.3	51.7	64.8		47.9	60.0	61.9	69.9	74.4	73.4	54.5	75.4		51.8		89.6			81.8
	July	45.1	37.2					60.1	62.0	70.0		73.1		74.4			59.8	91.3			86.5
	Aug.	45.0	37.1					60.2	62.1	69.9		73.4	54.3	78.1		53.3	59.9	91.7		61.3	83.5
	Sept.	45.2	37.2		65.8			60.3	62.1		75.3	73.9	54.3	75.6	72.3	51.9	59.3	90.1			82.4
	Oct.		37.2										54.2	74.8		51.7	59.4	89.7			81.7
	Nov.	45.1	37.2				48.9						54.1	74.3		51.6	59.7				81.2
	Dec.	45.1	37.2										54.1	73.9			59.9		64.3	61.5	80.9
1938	Jan.	45.1	37.3	52.2	60.7			60.1	62.2		74.1	73.2	54.2	73.6		51.6	60.1	89.4			80.8
	Mar.		37.5							70.2	74.8		54.5	74.2		51.8	60.3				83.1
	Apr.		37.5	52.1	70.3		49.6	60.2	62.2		74.8	73.5	54.4	74.4	71.9	51.7	60.6		64.8		85.3
	May		37.7	52.8							75.0	73.6	54.5	74.5		52.2	60.7				84.3
	June	45.6	37.8	52.7		75.1	50.1	60.3	62.2	70.6	74.8	73.5		73.7	73.0		60.9	90.3		61.8	83.0
	Aug.		37.9				50.5	60.5	62.2	70.5	74.7	73.5			72.8		61.0			62.2	
	Sept.															52.5		90.2			83.8
	Oct.	45.8	38.0		65.3		51.1	60.7	62.3					74.2	73.0	52.3			65.6		
	Dec.	45.9	38.2	52.5		65.4	51.1	60.7	62.3		74.7	73.3		73.8		52.1			65.7		82.1
1939	Jan.	46.0	38.3	52.5	63.3		51.0	60.7	62.3		74.7	73.3	54.6	73.5		52.1		89.4	65.7		83.0
	Feb.		38.3	52.5									54.8	73.3	72.7	51.9			65.6		82.1
	Mar.				63.2	63.3	50.8	60.6	62.4		74.6	73.4									
	June	46.3	38.6		70.8	63.8	50.6	60.9	62.4							53.5			66.8		Dry
	Aug.				81.6		Dry, 49'	61.0	62.4		76.1	73.9				54.1			67.5		
	Oct.	46.5	39.0	54.0	72.7			61.2	62.5	71.0	76.6	74.1		79.2	74.7			92.6			
	Dec.	46.6	39.2		65.3	66.0		61.5	62.6	71.2	76.4	74.2	55.1	75.3	74.7	53.3			67.7	62.6	
1940	Jan.										76.3	74.2									
	Mar.	46.7	39.4	53.8	64.4			61.4	62.7	71.3	76.1	74.1	55.2	74.2	74.4	53.1	62.8	90.2	67.7	62.8	
	July		39.8					61.7	62.8	71.5							63.1				
—	Nov.	Dry 47'	40.5	55.1		74.0		62.2	63.0	72.9	78.2	75.2	55.7	76.8	77.6	54.5	63.9	91.5	70.2	63.9	

Water levels in wells in Plainview district, Texas
East and southeast of Plainview

(Depth in feet below measuring point)

Date of measurement		Hale County								Floyd County											
		Well number								Well number (For location of wells see map on page 52)											
		357	422	427	428	454	459	462	463	106	108	111	112	124	139	140	143	150	153	157	161
1914							36.6	36.5			50.0					47.0	51.4				
1934	Apr.									55.9					53.0					49.5	
1936	Apr.			49.0									55.2	38.2			57.7		53.3	59.3	58.3
	May	36.2			52.5		40.4	42.6									58.2	46.6			
	June						39.7	40.8													
1937	Mar.			47.7				42.0													
	Apr.						40.1	42.1				64.7	64.5	40.3					55.8		
	May			50.6	49.9							54.8	55.0					48.3	54.1	58.3	61.2
	June	36.6		50.0	48.9		40.3						52.1	40.3	57.9		61.2	48.0	53.3		61.1
	July	35.2		50.4	48.7	53.7	39.8					71.7		40.5				48.7	56.7		62.5
	Aug.			50.3	49.1		39.6					75.8		40.7				49.5	54.3		62.0
	Sept.	35.2		49.6	48.9				34.6			53.8	53.8	40.9			63.1	48.3	53.5		60.6
	Oct.	35.3	38.2	49.3	48.8		39.3	39.6	34.6			54.5		40.9			62.5	47.9		57.5	60.1
	Nov.	35.7	38.5	48.6	48.1		39.0		34.5	58.2		53.0		41.0	58.5		61.6	47.1		55.6	59.5
	Dec.	35.8	38.7	48.3	47.9		38.8	39.4	34.6	58.2		52.7		41.1	58.7		61.1	46.6		55.1	59.2
1938	Jan.	35.9	38.9	48.0		50.5	38.6	39.6		58.0		52.5		41.2	58.2		60.6	46.1	52.3	54.7	59.0
	Mar.	36.1		47.8	47.8		38.7	39.9		60.6	58.3	53.9	53.0	41.3	58.9	53.0	60.6	45.9	54.7	54.1	58.9
	Apr.	36.2		48.9	49.7	59.0	39.2	40.8	36.9		68.8	64.6	63.2	41.6	Dry,	53.2	62.3	46.8	53.6	55.2	
	May	36.6	39.7	48.9			40.0	41.4		59.6	58.2	54.0	53.2	41.8	59'	53.2	62.6	47.5			60.7
	June	36.7	40.1	48.9	49.2	52.1	40.0	41.7	36.8	59.5	58.0	54.1	53.4	44.2		53.3	61.8	47.5	54.3	57.4	60.3
	Aug.	36.4		50.0	52.0		41.1					64.9				54.4		48.3			
	Sept.											60.5		42.1			63.2				
	Oct.	36.7	40.9	49.6	49.5	52.6	41.1	42.6	37.8	59.5		53.8	53.1			53.9	62.3	47.7	53.9	56.0	60.6
	Dec.	36.8		49.8		52.8	40.7	42.2	37.6	58.9		53.3	52.6			53.9	61.7	47.4		55.5	60.1
1939	Jan.	37.0	41.2	49.7	50.2	52.1	40.6	42.2	37.5	58.9	57.3	53.3				53.8	61.5	47.3	53.7	55.3	60.5
	Feb.	37.0										52.9	52.2								
	Mar.		41.0	49.2			40.4	41.8	37.1	58.5				42.5		53.8	61.0	46.9	53.2	55.0	59.8
	June	37.6	41.5	50.6				46.2				63.8	63.2	43.0		54.8	65.0	48.9	55.0	59.0	62.7
	July	37.6		51.3														50.0			
	Aug.	37.7				59.1	43.3	45.0	39.6												
	Oct.	38.1	42.0	51.7	52.7	62.9	43.7	45.8	40.9	62.4	61.9	57.7	57.3	43.5		55.4	66.4	49.8		58.7	63.4
	Dec.	38.2		51.3	52.1	55.3	43.8	44.4	39.8	64.6		61.3	60.7			55.3	64.0	49.5	55.9	57.5	62.1
1940	Mar.	38.4	42.4	50.7	50.6	54.1	42.3	44.1	39.5	60.6	58.9	54.9	54.1	43.9		55.3	63.0	48.8	54.9	56.8	61.5
	Nov.	40.0	43.8	53.4	53.3	57.0	45.3	48.0	42.2	63.6		57.8	57.3	45.6		58.0	69.4	51.8	58.1	62.9	65.5

Water levels in wells in Plainview district, Texas
East and southeast of Plainview

(Depth in feet below measuring point)

Date of measurement		Floyd County																			
		Well number (For location of wells see map on page 52)																			
		401	409	410	414	416	421	428	435	439	441	442	446	459	462	463	467	509	510	519	525
1914				41.7	50.0	51.2		45.2		45.7											
1934	Apr.						53.5							44.3		46.4					
1936	Apr.		50.7	49.4			57.0								50.6						
	May																			48.9	
	June	55.1													51.0						
1937	Mar.						58.5														
	Apr.	55.8	52.5	51.8																	
	May		52.7												52.1			39.6		50.0	41.0
	June	55.9	52.1				58.9		58.1				43.3			51.1		39.3	41.5		41.0
	July						59.9		58.5				43.4				39.9				41.1
	Aug.		53.0				60.6							48.6	52.7		39.6	39.2		50.6	41.3
	Sept.		52.4				60.1						43.6	47.5	52.7		39.7	39.1		50.5	41.1
	Oct.		52.2				59.6				62.9			47.2	52.3		39.0	38.9		50.7	41.1
	Nov.	56.2	51.9				59.3		57.8		62.9	36.8	43.6	47.0	51.7		38.5	38.9		50.6	40.9
	Dec.	56.3	51.6				59.0				62.9	36.3	43.4	46.9		49.7		39.0	41.2	50.2	40.8
1938	Jan.	56.3	51.4				58.9				63.0	35.9	43.4	46.9	51.3	49.3	37.8	39.1	41.2	50.3	40.8
	Mar.	56.5	51.3	52.4	61.5		59.0	51.5		53.8	63.1	35.3	43.4	47.8	51.0	49.4		39.4		50.3	40.6
	Apr.	56.7	53.3				59.2		58.3	55.9	63.1	35.4	43.5	49.4	51.5			39.7			40.9
	May										63.2	35.1	43.6				40.4	40.0		50.8	41.0
	June	56.6	52.8	50.7	61.7	65.6	60.1	51.5	58.4	54.1	63.2	35.8	43.6	49.2	52.3	51.7	39.7	40.1	43.0	50.9	40.9
	Aug.	56.6	54.7						59.2		63.2	36.1	43.5		52.8						41.0
	Oct.	56.8	52.9	50.3	62.1	64.1	60.5	51.6	59.3	54.0	63.5	36.7	43.7	49.2	53.0	51.7	39.9	40.4		51.3	40.8
	Dec.	56.9	52.6	50.1	61.2	63.2	60.3	51.3	58.8	53.7	63.5	37.2	43.7	48.4	52.8	51.1	39.6	40.5	43.7	51.4	40.9
1939	Jan.	56.9	52.6	50.5	61.6	63.7	60.2	51.1	58.6	53.6	63.6	37.5	43.7	48.4	52.6	50.9	39.6	40.5	43.6	51.4	40.8
	Mar.	56.9	52.3	49.6	60.9	63.0	60.1	51.0	58.4	53.5	63.7	37.9	43.7	48.3	52.3	50.4	39.4	40.7	43.1	51.5	40.9
	May		54.5																		
	June			52.5			61.9	52.5	59.7	54.9	64.0	38.5	43.9	50.2				41.5	47.4	51.4	41.4
	July				64.1				60.0		64.0	38.2									
	Aug.	57.2	54.9								64.1	38.3	44.0	50.5	Dry,			41.8		51.9	41.5
	Oct.	57.3	55.7	54.4	66.0	66.0	63.2	55.3	61.1	58.4	64.2	38.6	44.1	50.6	53'			42.2		52.2	41.6
	Dec.	57.5	55.0	53.5	63.6	65.8	62.3	52.8	60.4	56.0	64.3	38.8	44.1	49.7		53.4		42.3	47.3	52.4	41.6
1940	Jan.										64.4	38.9	44.2								41.6
	Mar.	57.6	54.1	51.5	63.6	65.4	61.8	52.5	59.9	55.0	64.5	39.2	44.2	49.6		52.4	42.2	42.6	45.8	52.6	41.6
	July										64.8	39.3						43.9			42.2
	Nov.	58.3	58.0	55.1	69.5	71.5	66.4	55.5	63.9	57.3	65.2	39.5	45.2	51.9		55.7	45.7	45.1	51.9	53.9	42.4

Water levels in wells in Plainview district, Texas
West and south of Plainview

(Depth in feet below measuring point)

Date of measurement		Hale County																		
		Well number (For location of wells see map on page 52)																		
		102	103	105	112	115	123	125	255	259	261	402	436	445	449	467	470	477	508	510	511
1914							62.5		20	23.7				48	57.5						22
1934	Apr.			49.5																	
1936	Apr.	48.7	50.6			53.2	60.8			19.4										37.8	21.4
	May												52.8	47.8	57.8			38.6	47.0		21.1
	June																55.6				
1937	Mar.			49.7									54.4								
	Apr.													48.1	59.0			39.0		36.2	20.3
	May	48.9				54.2							53.9	48.3				39.1		36.4	20.4
	June	49.2	49.1			54.4	62.9	80.5		18.0			52.2		58.3					36.4	15.1
	July	49.9	48.5	52.9	52.5	54.2	65.3	80.0					52.5	48.4	58.2			38.9		35.8	16.1
	Aug.	49.0		53.2	52.5	54.3		79.8	17.6	17.9	14.3	18.5	53.1		58.2		33.0	38.7	47.1	35.5	16.6
	Sept.	49.2			52.5						13.9	17.5	52.4			34.6	33.0	38.7		35.4	16.8
	Oct.	49.1	48.0		52.8						13.6	18.6	51.9			34.4	33.0	38.5		35.3	17.2
	Nov.	48.9			53.0						13.8	18.9	51.6			34.2	33.0	38.4		35.3	18.0
	Dec.	48.8			53.2						13.9	19.2	51.3			33.9	32.9	38.3		35.3	18.5
1938	Jan.	48.7	46.9	50.2	53.3	53.7	61.6	79.2		17.5	14.2	19.4	51.1	48.4	57.6	33.6	32.8	38.1	46.7	35.3	18.9
	Mar.	48.9	47.6	49.6	53.4		62.2			17.8	14.6		51.1	48.6	57.8	33.3	32.8	38.2		35.4	19.5
	Apr.	48.8		50.0	53.5	54.4	61.9	80.1	18.7	18.0	14.9		51.8	48.7	57.8	33.2	32.8	38.2	46.9	35.5	19.8
	May							81.1		18.2		19.9	52.2							35.6	20.2
	June	49.1	47.9	56.4	53.7	55.1	62.5	80.7	18.7	18.2	15.5	17.5	52.0	48.9	58.3	33.2	32.9	38.6	47.0	35.7	19.8
	Aug.	49.0		57.4	54.0	55.3		80.6	19.0		15.9	18.6			58.2	33.4	33.0	38.6	47.2	35.7	20.1
	Oct.	49.0			54.1	55.4	62.8				16.1	19.4	52.7	49.8	58.6	34.2	33.0	39.0	47.4	36.1	19.3
	Dec.	49.0		51.4		55.1		80.8	18.7	18.5	15.8	19.9	52.6	49.9	58.4	34.4	33.1	38.8	47.4	36.0	20.3
1939	Jan.			51.0	53.7	55.2	62.2	80.7	18.3	18.5	15.9	20.1				34.4	33.1	38.8	47.5	36.0	20.7
	Mar.	49.0	47.3	50.4	53.8	54.9	62.1	80.5	18.8	18.6	15.6	19.9	52.2	49.4	58.3	34.2	33.1	38.7	47.5	36.0	20.3
	Apr.				53.8				18.8		16.1	19.9								36.1	20.3
	June	49.2	47.5	54.7	54.2	56.1		81.9		18.9	16.2	20.6		50.6	58.8	34.9	33.2	39.2	47.7	36.3	21.2
	July								18.8	21.5		19.5						39.0	47.9	36.3	19.3
	Aug.	49.3	48.3		54.2	56.6	64.5	82.3			16.0	20.3	54.8	51.1	59.1	37.3	33.3	38.9			20.8
	Oct.	49.3	47.7		54.4	57.2	65.0	82.5		19.7	16.4	21.2	54.9		59.1	37.1	33.3	39.0	48.2	36.6	21.5
	Dec.	49.6	47.8	52.4	54.8	56.8	63.1	81.9	20.2	19.7	16.7	21.6	54.3		59.4	36.0	33.4	38.7	48.3	36.9	22.0
1940	Feb.			51.1						19.9	Dry	21.9								37.2	22.7
	Mar.	49.7	47.9		55.1	56.4	63.1	82.0	20.2						59.0	35.5	33.5	38.8	48.5		
	July	50.2			55.4	57.9						22.5								37.5	22.7
	Nov.	50.9	48.7	56.0	61.0	58.7	66.3	84.5	21.6	21.7		23.6	57.3		61.9	39.8	33.7	39.7	50.1	38.1	23.9

Water levels in wells in Plainview district, Texas
West and south of Plainview

(Depth in feet below measuring point)

Date of measurement		Hale County																			
		Well number (For location of wells see map on page 52)																			
		526	533	539	542	547	549	552	553	564	567	569	816	822	825	834	835	906	923	936	956
1934	Apr.							58.4	53.4												
1936	May	52.0	52.2		36.1	50.6	55.7	61.3	56.5		52.4	54.5	55.5					39.3		43.2	
	June				30.4																
1937	Mar.					51.2			53.9												
	Apr.	52.9	53.8		36.3	51.3	56.2	59.9	54.9		52.9	55.9	56.3							44.5	
	May					51.5		60.2	54.9									45.8			
	June	53.0	54.5		36.2		56.2				52.9	56.2	56.4		65.9	77.2		42.8		46.1	
	July				35.6	51.3	56.2	60.2	54.2		52.7	54.4	56.2		65.9	77.3	59.6	42.3		45.3	
	Aug.				35.6	51.3	56.4	59.4	55.0	56.4	52.7	53.6	56.3		65.9	77.3	59.6	43.1	55.1	45.3	
	Sept.				35.3	51.2		59.1	54.0	56.4	52.5		56.4					41.6	55.1	45.3	
	Oct.			56.8	34.6	51.0		58.9	53.8	56.4	52.3		56.3	51.7				41.1	55.1	45.0	66.6
	Nov.				34.3	50.9		58.7	53.7	56.4	52.3		56.3					40.8	55.1	44.8	
	Dec.				34.3	50.7		58.6	53.5	56.3	52.1		56.3					40.6	55.0	44.7	
1938	Jan.				34.7	50.7	55.8	58.6	53.5	56.3	52.0	53.1	56.3					40.4	55.0	45.5	
	Mar.				35.0	50.8	55.8	58.6	53.4	56.3	52.2	53.1	56.3		66.0		59.4	40.5	55.0	44.4	
	Apr.			57.6	35.1	50.8	55.8	58.7	53.5	56.2	52.2	53.1	56.3			77.2		41.4	55.0	46.2	
	June	53.1	55.3	57.4	35.4	51.3	56.1	66.2	54.2	56.3	52.4	54.3	56.5	51.8		77.3	59.5	41.1	55.3	47.0	66.6
	Aug.			58.0	35.2	51.4	56.2	62.4	60.3	56.3	52.6	53.6	56.6	51.6	65.8	77.3	59.4	41.1	55.4	46.7	
	Oct.			58.1	36.1	51.6	56.5	59.6	54.4	56.5	52.8	53.8	56.6	51.7	65.8	77.3	59.5	41.2	55.5	46.0	66.5
	Dec.	53.5	57.4	58.1	36.3	51.7	56.5	59.5	54.3	56.5	52.8	53.6	56.8					41.2	55.5	46.0	66.3
1939	Jan.				36.4			59.4	54.2												
	Mar.	53.8		57.6	36.5	51.7	56.6	59.3	54.1	56.6	52.8		56.5	51.8	65.8	77.3	59.6	41.2	55.4		66.0
	June			59.2	36.8	52.2	56.9	67.5		56.7	53.1	54.5	56.8	51.9	65.9	77.4	59.7		55.7		
	July			58.9	36.8			61.9	56.8	56.8	53.3	54.5							55.7	47.6	66.7
	Aug.			58.6	37.0	52.3	57.1	60.7	55.4	56.9			56.6					45.5	55.7		
	Oct.	54.0		59.6	37.0	52.5	57.3	61.1	55.9	57.0	53.3	54.5	56.9	51.9		77.4	59.7	42.9	55.8	48.4	67.8
	Nov.				37.0													42.7			
	Dec.	54.3	59.3	58.5	37.1	52.5	57.4	60.2	55.0	57.0	53.2	54.6	56.7	51.9	66.1	77.4	59.8	42.7	55.8	47.8	67.1
1940	Jan.				37.2																
	Feb.				37.3																
	Mar.			58.4	37.4	52.7	57.5	60.0	54.8	57.2	53.6	54.8	56.8	52.0	66.0	77.5	59.9	42.4	55.9	47.3	66.5
	July				37.7											75.5	60.0				
	Nov.	57.8		60.0	38.2	58.2	59.4	61.3	56.2	57.7	53.9	56.2	57.4	52.2	66.6	77.9	60.2	44.4	56.7	50.1	69.0

Water levels in wells in Hereford district, Texas
North and northeast of Hereford

(Depth in feet below measuring point)

Date of measurement		Deaf Smith County																		
		Well number (For location of wells see map on page 53)																		
		150	207	212	217	219	220	224	226	230	234	235	236	237	241	245	247	248	251	258
1934	Nov.													42.7		43.4				
1936	Apr.			71.4					53.7											55.5
	May			72.8	84.9				51.9			54.6		42.5		43.2			50.0	
	June		54.1	71.6					50.3	43.3		53.4		42.2					51.3	
	Dec.															44.4				
1937	Mar.													44.0		44.5				
	May		58.7		92.8											44.2			53.2	58.3
	June				88.9						50.2		46.7			44.3		45.0	50.5	55.8
	Aug.		55.7				85.4	58.3		45.1	51.2		47.1			44.3	20.8	43.7	61.9	
	Sept.				94.1		85.3	58.2			51.3		47.2				21.2	43.9		
	Nov.		54.6	71.3		79.6						52.9		45.4	47.3	44.5	21.8	44.0		
	Dec.				105.4						51.3		47.1		47.1	44.6				56.0
1938	Jan.						88.4				51.2	52.7	47.0		47.2					
	Feb.				95.6		86.9	59.0			51.2		47.2	45.3	47.3	44.5				
	Mar.		54.4	72.5	93.3	75.6	86.4	58.6	49.8	45.3	51.3	52.7	47.2	44.2	47.3	44.7	22.3	44.3	48.3	54.3
	Apr.										51.3					44.4			48.9	
	May	96.7	55.4	76.3	94.2	77.5	89.6	60.0	50.8		51.5	53.8	47.4	44.3	47.2	44.6	22.0	44.6	51.0	56.7
	June				92.3		88.1	58.8	49.8	48.8	51.7	56.2	47.4	45.6	47.4	44.5				57.8
	July	96.8															22.3	44.6		
	Aug.		55.2													44.3				
	Sept.		55.4	72.3	96.8		86.9			47.2	52.0		47.7			44.4	22.7	44.7		
	Oct.	96.9				76.4			51.7		50.8				47.2	44.3	21.9	44.7	49.2	
	Nov.		55.0	72.1	92.3	76.2					51.2	53.4		44.7		44.4				
	Dec.	96.7					85.2			46.1	51.3		47.6		47.2		22.2	44.6	48.6	54.3
1939	Mar.	96.5	54.5	71.7	88.9	75.4	84.6	58.3		45.2	51.2	53.1	47.6	44.1	47.2	44.1	22.6	44.8	48.3	53.8
	June	96.3	55.3	75.7	92.1			61.1	51.3	47.9	51.7	53.9	47.8	45.7		44.4	23.3	45.1	49.1	54.5
	Sept.	96.5	57.2			83.5		58.3		49.6	52.2	56.0	48.2		47.5	44.5		45.2	59.6	59.6
	Dec.	96.6	55.1	75.6	93.7		87.5	57.7		48.5		54.0	48.1		47.3	44.8	23.7	45.4	58.6	55.4
1940	Mar.	96.8	55.0		91.6	76.8	85.7		51.1	47.5		53.7	48.1	45.2	47.3	44.7	23.8	45.7	49.9	55.7
	July												48.7					45.9		
	Nov.	98.3	56.1	81.7		79.9		57.8		50.5	53.0	55.9	49.4	48.9	48.5	56.4		46.3	53.2	59.0

Water levels in wells in Hereford district, Texas
North and northeast of Hereford

(Depth in feet below measuring point)

Date of measurement		Deaf Smith County Well number (For location of wells see map on page 53)												
		260	261	264	265	272	276	277	278	281	288	291	301	302
1914			47.0											
1934	Nov.	54.2												
1936	Apr.	54.3									60.0			
	May		53.6			66.6						55.8		53.3
	June					66.5								
	Oct.	55.8												
1937	Mar.	54.5												
	May		54.8		66.1	67.0					70.3	56.5		
	June				64.9	67.1					66.9		46.6	
	Aug.		56.1	49.1		67.2						58.1	47.2	
	Sept.			49.1	69.3		36.5	17.9	72.1				47.9	54.5
	Oct.	55.9	52.1			67.4				64.8	67.8	55.2		
	Nov.				64.6									53.8
	Dec.		51.2	50.1		67.5	37.4		71.8		64.7		47.0	
1938	Jan.												46.9	
	Feb.		54.1	49.3		67.9	38.3	23.4	71.7		64.1		47.4	53.4
	Mar.	56.4	52.7	49.3	63.9	67.9	38.2	23.4	71.8	65.7	63.6	54.8	47.3	53.3
	Apr.	56.4	51.8	49.5		68.1					62.8		47.2	
	May			49.9		68.2	37.7	22.3	71.8	69.9	67.9	56.6	47.3	53.3
	June	57.6	53.4			68.4				66.8	71.2	56.8	47.4	53.2
	July						39.0	22.4	71.9					
	Aug.	56.9	58.4	50.3		68.4	38.8		71.8		76.7			
	Sept.	57.2	53.4	50.3		69.3	38.4	20.0	71.8			55.7	48.1	53.2
	Oct.	57.3	54.5	50.2		69.2	37.8	18.4	71.7	65.7	72.1	55.7	47.2	
	Nov.	56.7	53.6		65.0	69.1	37.7	19.6					47.3	53.2
	Dec.		52.9	49.3		68.9	37.7	20.3	71.7		64.1	55.4	47.3	
1939	Mar.	56.0	51.0	49.0	64.1	68.1	38.1	22.0	71.5	65.5	61.9	55.2	47.3	53.1
	June	56.8	53.8	49.1	64.7	69.5	38.7	23.5	71.3	67.0	68.2	55.9		54.9
	Sept.	Dry		49.9		72.8	39.4	24.1	Dry,	71.8		56.6		
	Dec.	57'	53.1	Dry	66.7	70.0	39.8	24.3	71'			56.1	48.4	54.8
19 0	Mar.		52.8	50'	65.2	70.1	40.0	24.8		67.4	65.0	55.8	48.1	54.2
	July							25.0						
	Oct.						40.9	25.3						
	Nov.		55.8		76.1	83.2		25.5			72.6	59.3	49.9	55.7

Water levels in wells in Hereford district, Texas
South and southeast of Hereford

(Depth in feet below measuring point)

Date of measurement		Castro County											Deaf Smith County									
		Well number (For location of wells see map on page 53)																				
		8	12	20	31	32	36	40	46	48	52	53	308	311	315	317	322	326	331	336	339	340
1934	Nov.													54.8		62.3						
1936	Apr.											58.2								88.3		73.6
	May			71.0	61.2	65.2				66.4		59.5	47.8	55.8	60.8	62.3	70.2				81.7	73.7
	June			70.5	61.3	64.9				63.4		58.9	46.5	52.0	55.4	62.4	71.2				80.2	73.8
	Dec.															62.8						
1937	Mar.													48.9		62.9						
	May				66.9	64.8							48.6		56.1	65.9	71.3			88.6		74.5
	June					64.0							48.3		55.4	63.9	71.4			86.5	82.6	
	Aug.												48.9			64.6			80.0			
	Sept.												48.9			64.5	71.6		79.6			
	Oct.	73.4	100.7	72.8									49.1			64.3	71.7	89.6				
	Nov.	76.6			62.3	63.8	87.1	64.8	76.1	69.0					56.4					87.4		
	Dec.		100.7				84.8				72.1		49.0			64.5	71.9	89.7	81.0			
1938	Jan.												49.0									
	Feb.												49.0			64.3						
	Mar.	73.2	100.5	73.0	62.3	63.6	83.7	64.4	74.2	62.4	71.8	58.8		51.5	55.8	64.2	72.4	90.2	80.3	87.5	81.2	77.6
	Apr.													58.3		64.1	72.1					
	May	74.7	100.5	73.8		64.3	85.8	65.7	75.1	70.2	71.7	59.9	49.0	54.1	56.9	63.6	72.1	90.3	81.7	88.0	83.0	79.1
	June			74.5	63.3	65.1	86.4	65.2	74.8			59.7		57.7	56.5	64.4	72.2	90.3	80.9	87.0	81.7	80.1
	July										71.7											
	Aug.			75.1						66.1	71.6		49.4	67.5			72.2	90.5	80.6		91.3	
	Sept.			73.2		65.0		65.4		63.0	71.7		49.6				72.3	90.6	80.7			
	Oct.	77.2	101.0	72.9				64.8			71.7		49.3	53.6			72.3	90.6		87.0		79.8
	Nov.	74.7			62.7	64.4	84.3		74.8	62.7			49.5	52.5	56.2	64.7	72.5	90.7		86.9		
	Dec.		100.8	72.4							71.6	59.9	49.5	51.7	56.0		72.4	90.6	80.9		80.8	78.6
1939	Jan.	75.0						64.2														
	Mar.	74.6		72.1	62.3	63.7	83.2	64.0	74.4	61.3		58.6	49.1	50.5	55.5	64.1	72.6	90.6	80.5	86.8		77.2
	June	75.6	100.8	73.2	63.9	64.7	87.6	66.5	76.3	68.7	71.7	60.1	49.3		56.6		74.6	90.9	81.7	86.9	82.8	79.0
	Sept.		101.0			75.6		86.5	76.6	74.7	71.6		49.8	59.4	62.0		73.9	91.0	81.3			
	Dec.	75.2	101.1	76.1	63.7	64.9		66.4	75.5	79.2	71.6		50.0	52.4	56.2	66.4	73.2	91.3	81.0	87.9	82.7	83.5
1940	Mar.	74.8	101.3	73.3	63.3	64.5	85.2	65.8	75.2	64.4	71.6	61.6	49.6	51.7	55.9		73.3	91.8	81.4	87.5		
	July												50.3									
	Nov.		102.7	79.1	66.5	68.2	92.4	68.7	75.3	78.9		64.4	51.4		60.2	68.3	75.6	95.5	83.6	88.7		86.0

Water levels in wells in Hereford district, Texas
West and southwest of Hereford

(Depth in feet below measuring point)

Date of measurement		Castro County	Deaf Smith County								
			Well number (For location of wells see map on page 53)								
		4	283	319	410	431	433	502	506	513	514
1936	May		61.5								
1937	Mar.					68.9					
	Aug.	103.9	64.4	61.0			111.0		74.5		
	Sept.	103.9			61.1	68.8	111.0				106.4
	Oct.										
	Nov.		65.1		61.4			94.3		79.3	
1938	Jan.	103.8				68.9	111.1				
	Feb.	103.6				68.9	111.1				
	Mar.	103.9	64.6	60.7		68.9	111.2	96.2	74.8	79.4	105.4
	May		66.2	60.9	62.4	69.2	111.7	97.1	74.8	79.5	
	June	104.2	66.2	61.1	62.6		111.7	96.5	74.9	79.4	107.8
	Aug.	104.3					111.9			79.4	
	Sept.	104.1		61.4			112.0		74.8		106.6
	Oct.	104.2	65.6		63.1		112.1	96.0	74.7	79.5	
	Nov.		64.7			69.4					
	Dec.	104.1	64.3	61.2	62.3		112.1	95.6	74.7	79.5	
1939	Mar.	104.1	63.4	61.0	63.0	69.3	112.0	96.3	74.7	79.5	105.8
	June	104.2		61.2		69.6	111.9	96.8	74.7	79.5	106.1
	Sept.			61.4	64.0	70.1	111.9	99.6	74.9	79.6	
	Dec.			61.6	64.4	70.0	112.1	96.7	75.1	80.8	
1940	Mar.		64.7	61.6	65.0			96.2	75.3	79.9	
	Nov.	104.9	70.7	62.8	66.4	72.5		103.1			

Water levels in wells in Muleshoe district, Texas
East of Muleshoe

(Depth in feet below measuring point)

Date of measurement		Lamb County Well number 3-A	6	7	13	16	19	30	Bailey County Well number (For location of wells see map on page 54) 69	79	92	95	116	117	120	130	131	132	135	136	137	141	143
1914							0.2									0.5	18.3	20.0	14.0	15.0	1.5	1.5	+2.5
1934	Nov.	28.0		14.0	22.2								20.1	35.4	25.8					14.2			
1936	Jan.												21.9										
	May	34.2		15.6	21.3	37.6		24.0	16.8	24.6	24.1	25.7	22.6	35.7	27.6			24.0		16.2	3.3	1.9	
	June								16.3		22.5	24.7									3.4		
	July								17.0		22.4	24.8									3.4		
	Aug.			15.6																			
	Sept.													35.5	28.7	2.9	21.9	23.3		15.2			0.5
	Oct.	30.7			19.9		2.0	24.5	16.3	24.2	23.3	24.7	22.7							15.4	3.8		
1937	Jan.	30.8		15.5	19.6	36.5	1.8			24.0			22.7	35.5	28.4	2.5	21.3		17.0	15.1			
	Feb.							23.7													3.6		0.4
	Mar.		2.6											35.8	27.3					15.5	3.1		
	May													35.7								2.3	
	June	32.6		14.8	19.0	36.9		23.3	15.9	21.6	22.2	24.9	22.8	36.8	28.5			23.5				1.0	
	Aug.									23.2												2.1	
	Sept.											25.4		35.8									
	Nov.								16.4	23.4	21.9	24.2		35.6	28.4	2.0	21.0	22.2	16.7	14.7		2.1	+ 0.5
1938	Jan.									23.4												2.2	0.0
	Mar.	29.8		14.8	18.7	36.0	1.4	23.1		23.6	22.1	24.4		35.7		2.1	21.2	22.3	16.6	16.9		2.4	0.5
	June		3.7		19.6	36.5	2.2			23.8	23.4	25.4		36.8	28.6	3.7	22.6	24.1	17.1			2.5	2.0
	Sept.	31.0		16.2	19.9		2.2	24.1		22.6	22.0	24.8		35.6		3.1			17.2				1.1
	Oct.	30.8	3.3	16.0	19.8		2.0	23.8	15.6	22.8		24.4		35.7		3.0	22.1	23.0	17.2				
	Nov.										21.6												
	Dec.	30.4		15.8	19.7						21.5	24.6		35.3		2.8		22.7	17.1	15.5			
1939	Jan.									22.9													
	Mar.	29.9	2.6	15.4	19.5		1.8	23.3	15.5	22.8	21.1	24.4		35.9		2.4	22.2	22.4	16.7	15.4	3.7	2.6	0.4
	July	32.0	3.3	16.2	20.1		2.1	23.6	18.3	23.4	21.7			36.8		3.3	22.3	23.5	17.4	17.1	4.4	3.2	
	Sept.	39.9	3.2		21.2	36.9	2.3	23.7		23.9	23.0	25.4		36.9	28.9	3.6		23.1	17.5			3.2	0.9
	Dec.	30.8	3.0	16.3	20.2	36.5	2.2	23.6	16.7	24.3	22.3	25.1	23.8	36.7	28.0	3.1	21.9	23.0	17.5	16.3	4.6	3.4	1.1
1940	Mar.		3.0		20.1	36.3	2.1	23.7	17.5		22.0	24.9	23.1	36.6	27.8	2.8	21.8	22.8		17.1	4.4	3.3	1.1
	Apr.									24.4													
	Oct.			17.3						25.4										17.6			
	Nov.	32.6	4.2	17.3	21.1	37.5	2.9	24.0	17.9	25.5	24.7	26.3	25.3	39.1	29.7	4.4	23.6	24.3		18.7	5.9		

Water levels in wells in Muleshoe district, Texas
West of Muleshoe

(Depth in feet below measuring point)

Date of measurement		Bailey County																
		Well number (For location of wells see map on page 54)																
		5-A	9	11	25	31	33	34-A	35	35-A	36	45	49	53	62	63	66	67
1934	Nov.												24.3			26.0		
1936	May												26.2	26.3	29.6	31.8	23.2	21.2
	June																22.9	20.4
	July																23.0	20.6
	Sept.					17.1					20.9						22.0	22.5
	Oct.		40.4	26.4		16.1	28.2				19.6				26.3			
	Nov.			25.5	23.3								25.1	26.5		29.4		
1937	Jan.		40.0										24.8		23.7	26.7		
	Mar.												24.8			26.4		
	May				25.3		30.4		27.5			20.8		26.4				
	June	64.6						43.8						26.2		27.1		19.8
	Sept.	64.6						43.8	27.7			20.1	25.0					20.5
	Nov.	64.5	39.8	25.5	22.3	15.1	29.0	43.5	25.6		17.9	20.0	23.9	25.5	23.6			19.8
1938	Jan.	66.0	39.7				28.1	43.4	25.6			19.7	23.7	25.5				
	Mar.		39.7		22.5	15.2	28.8		26.0	26.0	17.6	19.9	23.9	25.9	23.3	24.8	20.9	19.9
	June	64.4				15.3	29.1	43.4	26.1	25.3			28.5		27.3		21.7	22.0
	Sept.	64.4	39.7	25.4		13.0	28.0	43.2	24.8	23.9		19.2						
	Oct.	64.3	39.5	25.1	21.2	13.1		43.2		24.1	16.8		23.6		23.7	25.8		
	Nov.												23.7					
	Dec.	64.4	39.3	24.9	20.8	13.2	29.0	43.2		24.2	17.0	19.6				24.9		19.6
1939	Mar.	64.2	39.1	24.8	20.4	13.8	28.7	43.1		24.5	17.2	19.1	23.1	25.1	22.9	24.0	20.4	19.4
	July	64.2			21.0	13.8	30.9	43.1		24.9	17.9	20.3	24.9	25.4	25.0		21.2	20.0
	Sept.	64.2	40.2		26.4	14.5	32.4	43.1		25.2	19.4	21.1				29.7	21.9	20.4
	Dec.	64.2	39.3	25.9	22.0	15.2	30.9	43.2		25.4	19.0	20.6	24.5		23.6	25.2	21.7	20.4
1940	Feb.										18.8	20.3	24.2					
	Mar.	64.1	39.1	25.6	21.9	15.2	30.1	43.1		25.6					23.1	24.6	21.5	20.3
	Oct.															29.4		
	Nov.	64.3	40.2	27.2	24.9	15.8	33.3	43.4		26.6	20.0	21.8	27.0	28.9	27.1	30.8	23.6	22.8

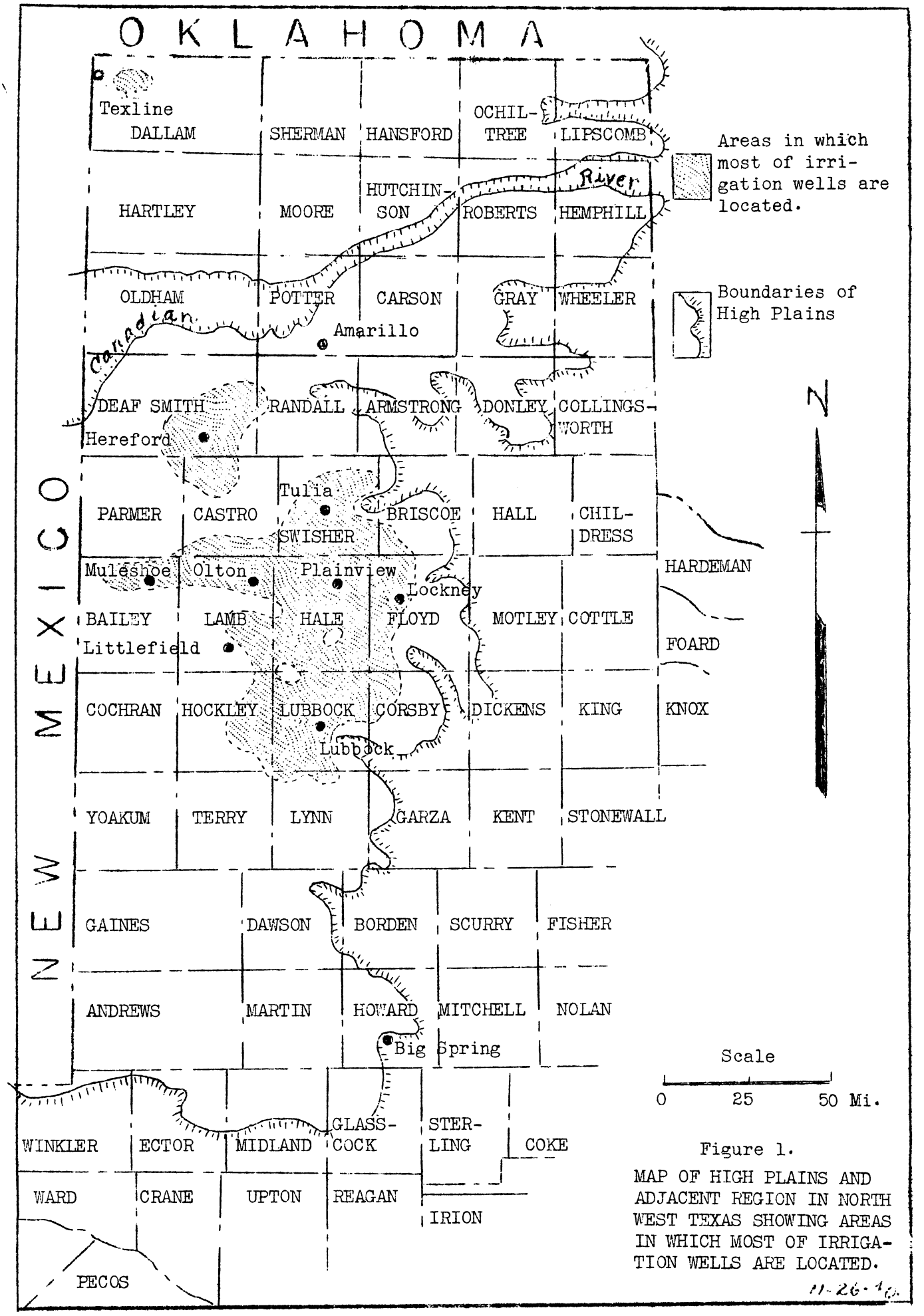


Figure 1.

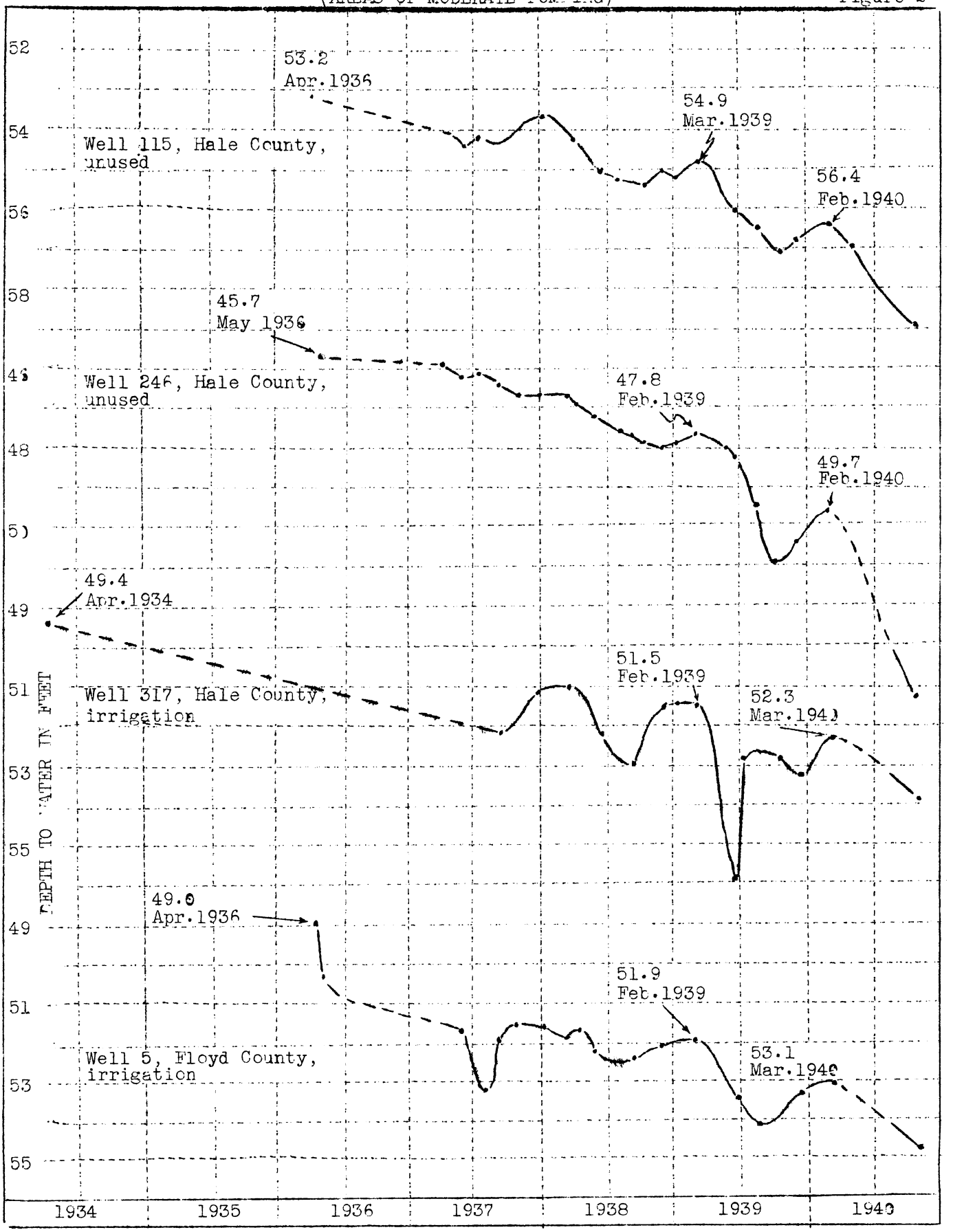
MAP OF HIGH PLAINS AND ADJACENT REGION IN NORTH WEST TEXAS SHOWING AREAS IN WHICH MOST OF IRRIGATION WELLS ARE LOCATED.

11-26-40

DEPTH TO WATER IN WELLS IN PLAINVIEW DISTRICT, HALE AND FLOYD COUNTIES, TEXAS

(AREAS OF MODERATE PUMPING)

Figure 2

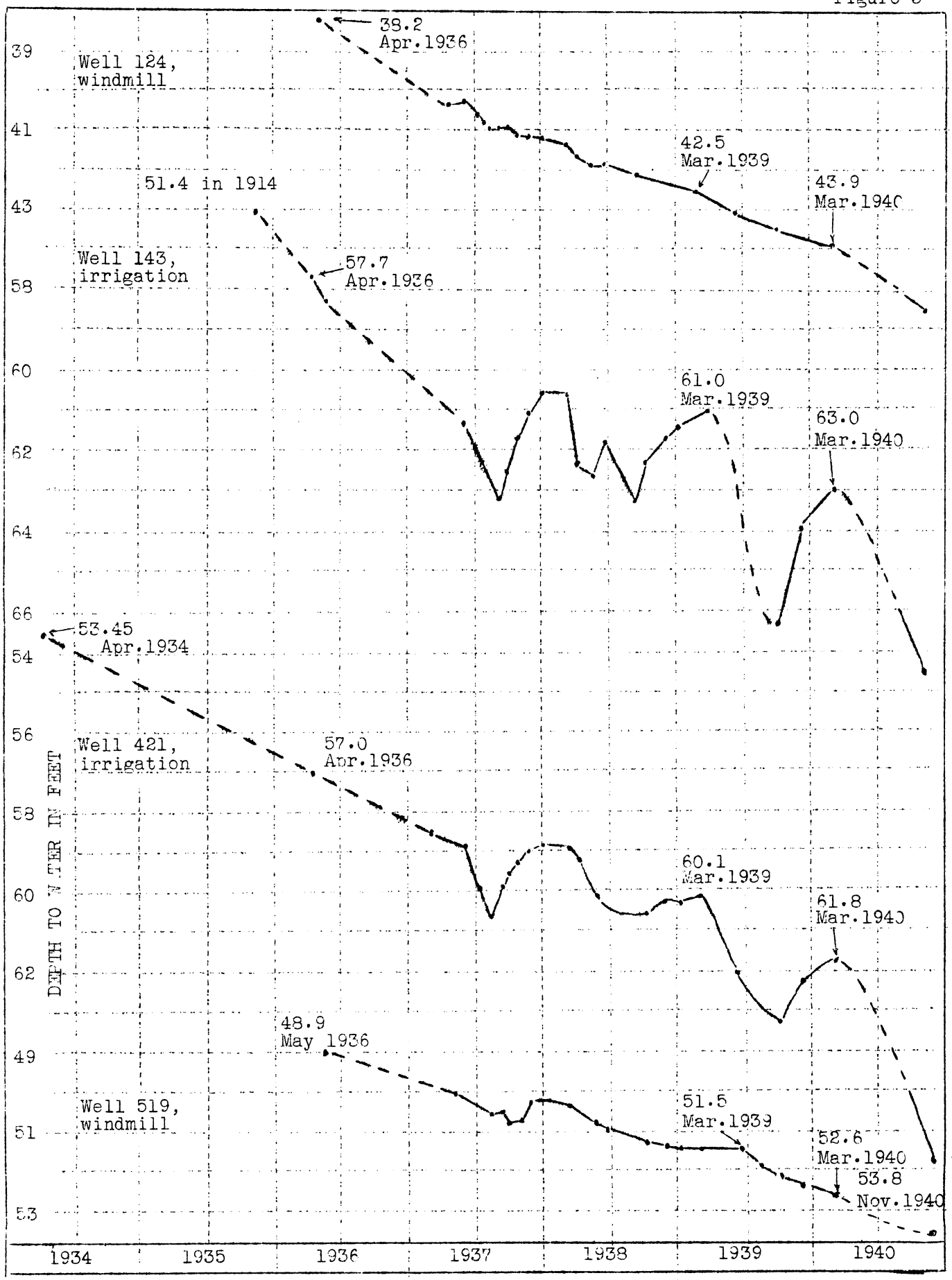


• Measurements recorded in tables of water-level fluctuations.

DEPTH TO WATER IN WELLS IN PLAINVIEW DISTRICT, FLOYD COUNTY, TEXAS

(AREAS OF HEAVY PUMPING)

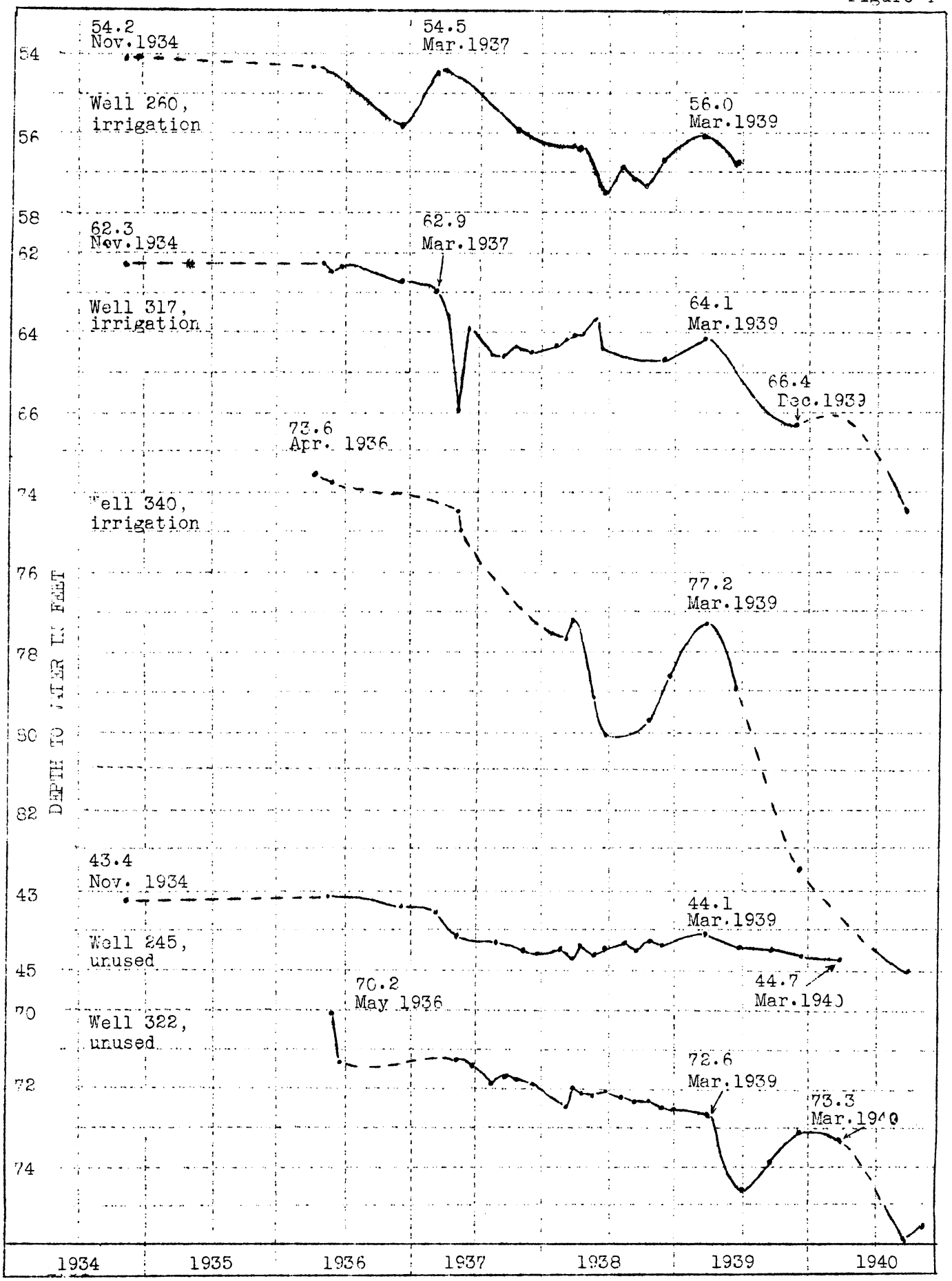
Figure 3



• Measurements recorded in tables of water-level fluctuations.

DEPTH TO WATER IN WELLS IN HEREFORD DISTRICT, DEAF SMITH COUNTY, TEXAS

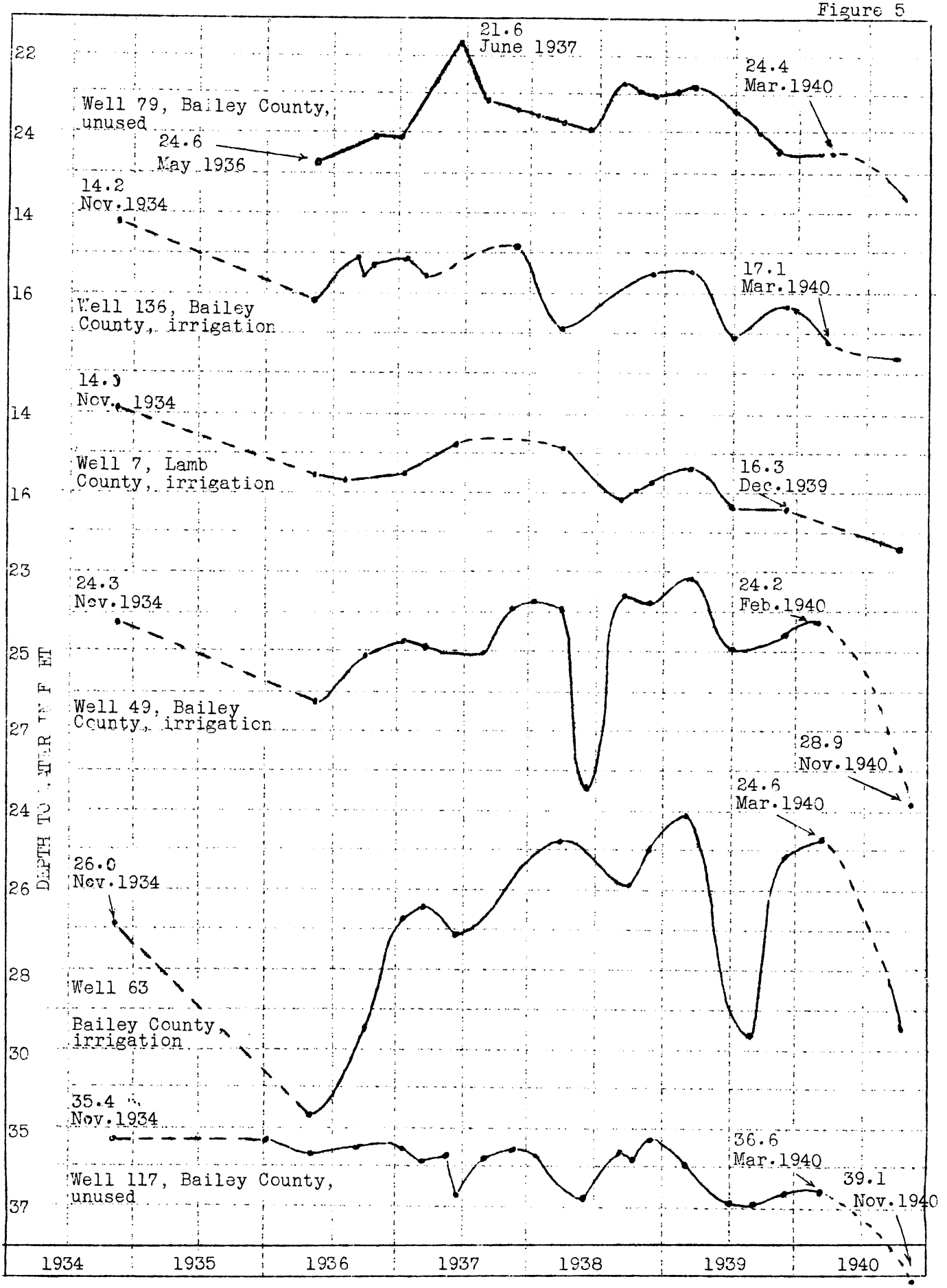
Figure 4



• Measurements recorded in tables of water level fluctuations.

DEPTH TO WATER IN WELLS IN MULESHOE DISTRICT, BAILEY AND LAMB COUNTIES, TEXAS

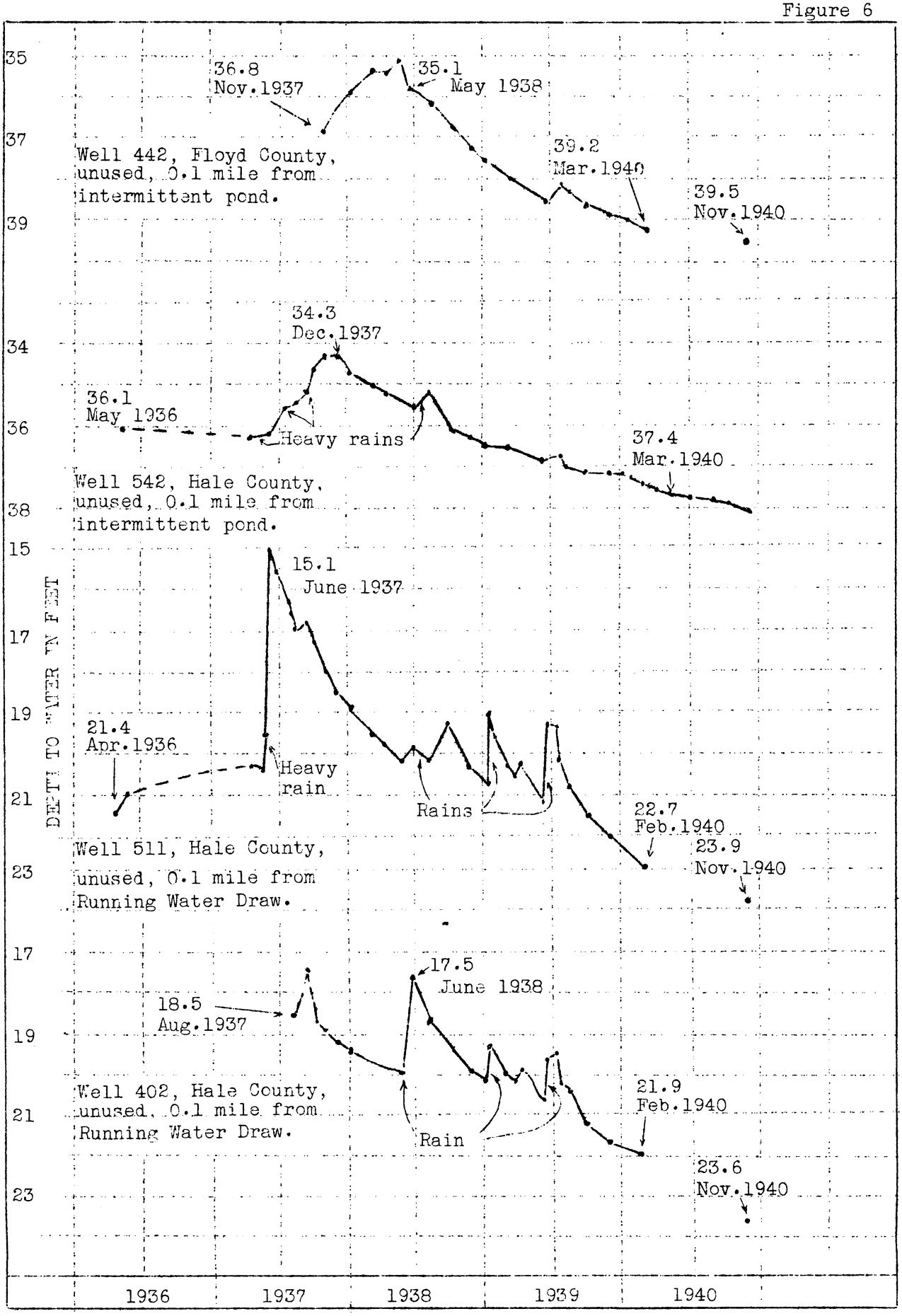
Figure 5



• Measurements recorded in tables of water-level fluctuations.

DEPTH TO WATER IN WELLS IN AREAS OF GROUND-WATER INTAKE,
FLOYD AND HALE COUNTIES, TEXAS

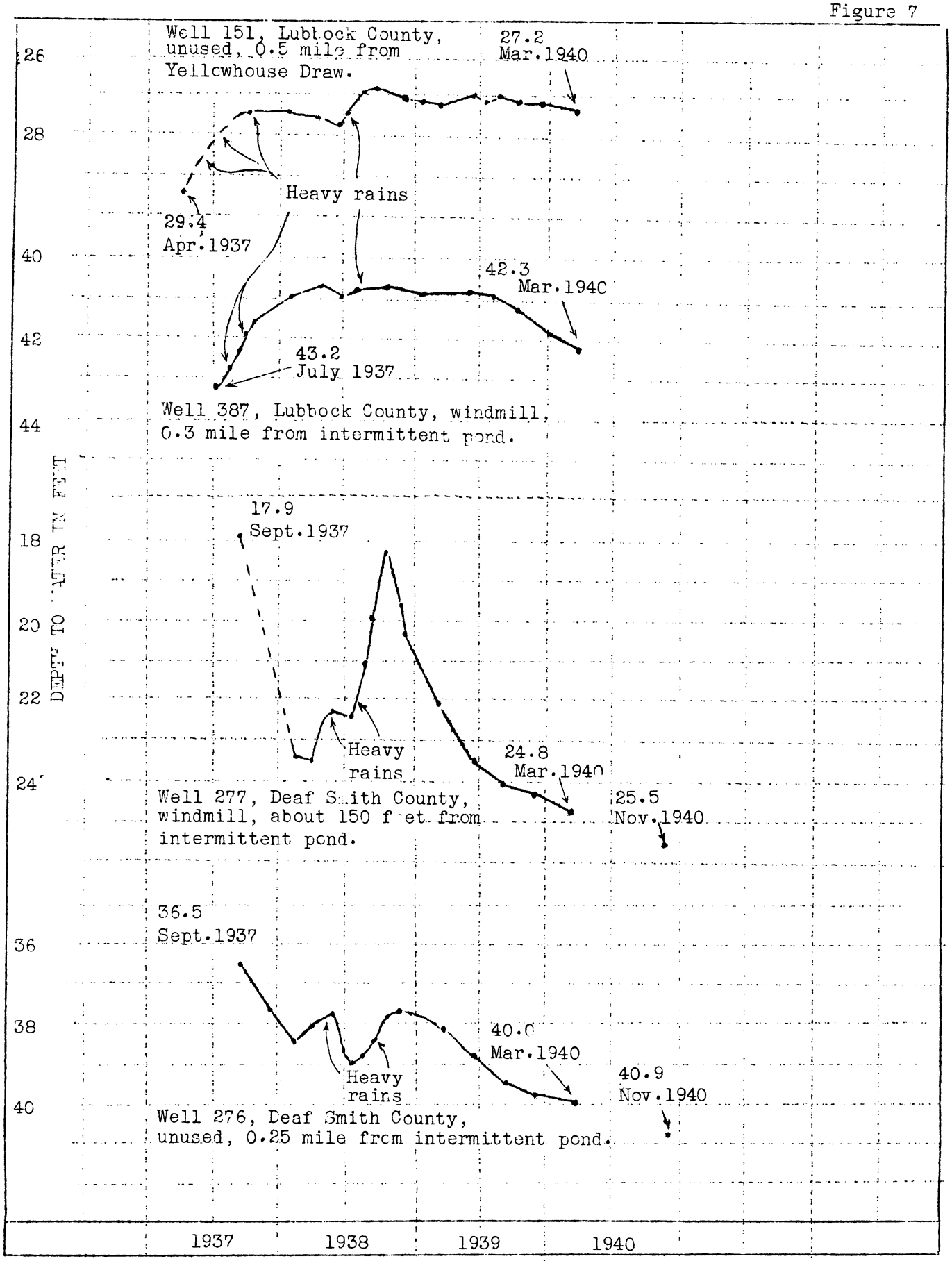
Figure 6



• Measurements recorded in tables of water-level fluctuations.

DEPTH TO WATER IN WELLS NEAR AREAS OF GROUND-WATER INTAKE, LUBBOCK AND DEAF SMITH COUNTIES, TEXAS

Figure 7



• Measurements recorded in tables of water-level fluctuations.

Figure 8

MAP OF PLAINVIEW DISTRICT, TEXAS

SHOWING IRRIGATION, CITY AND TOWN AND OBSERVATION WELLS

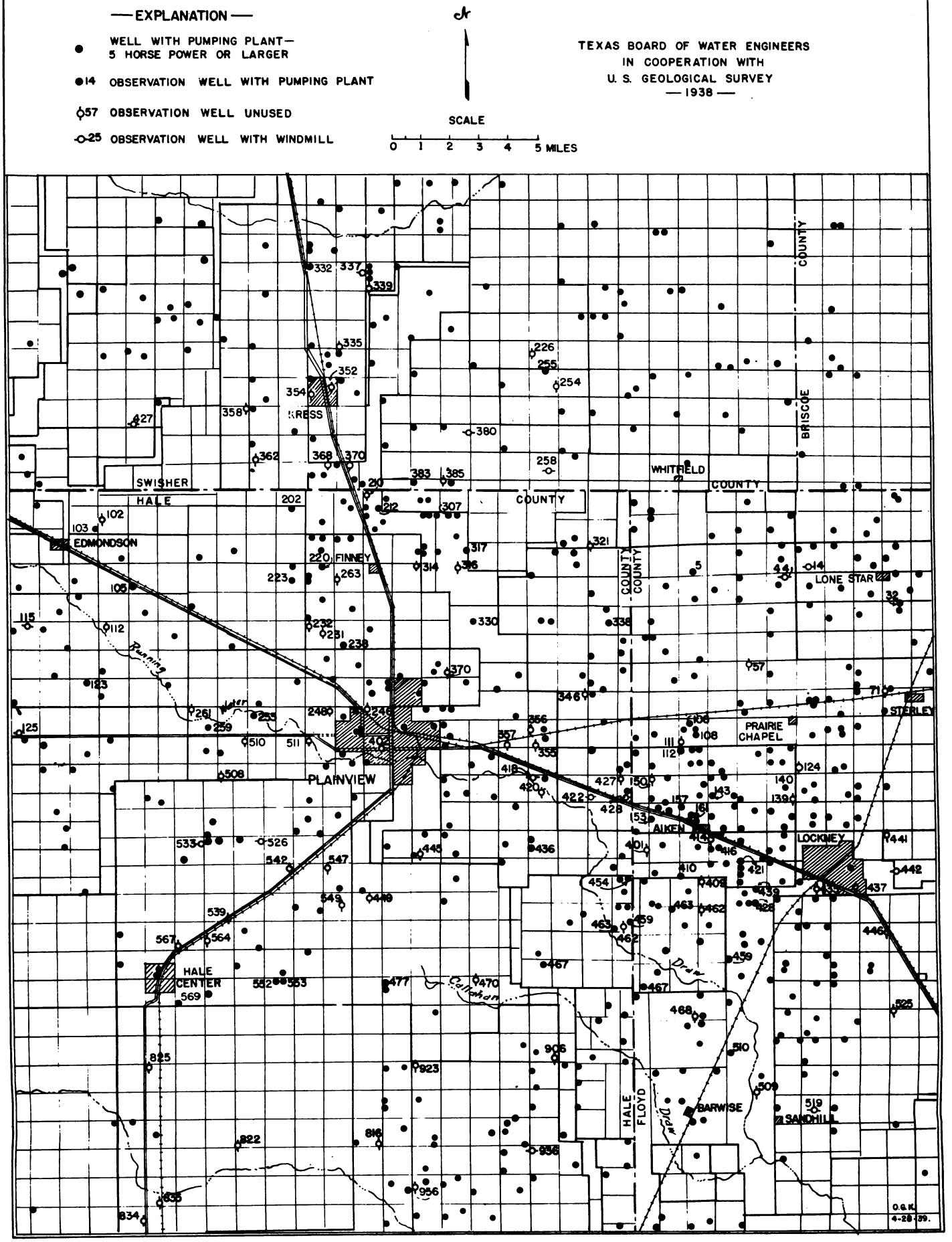


Figure 9

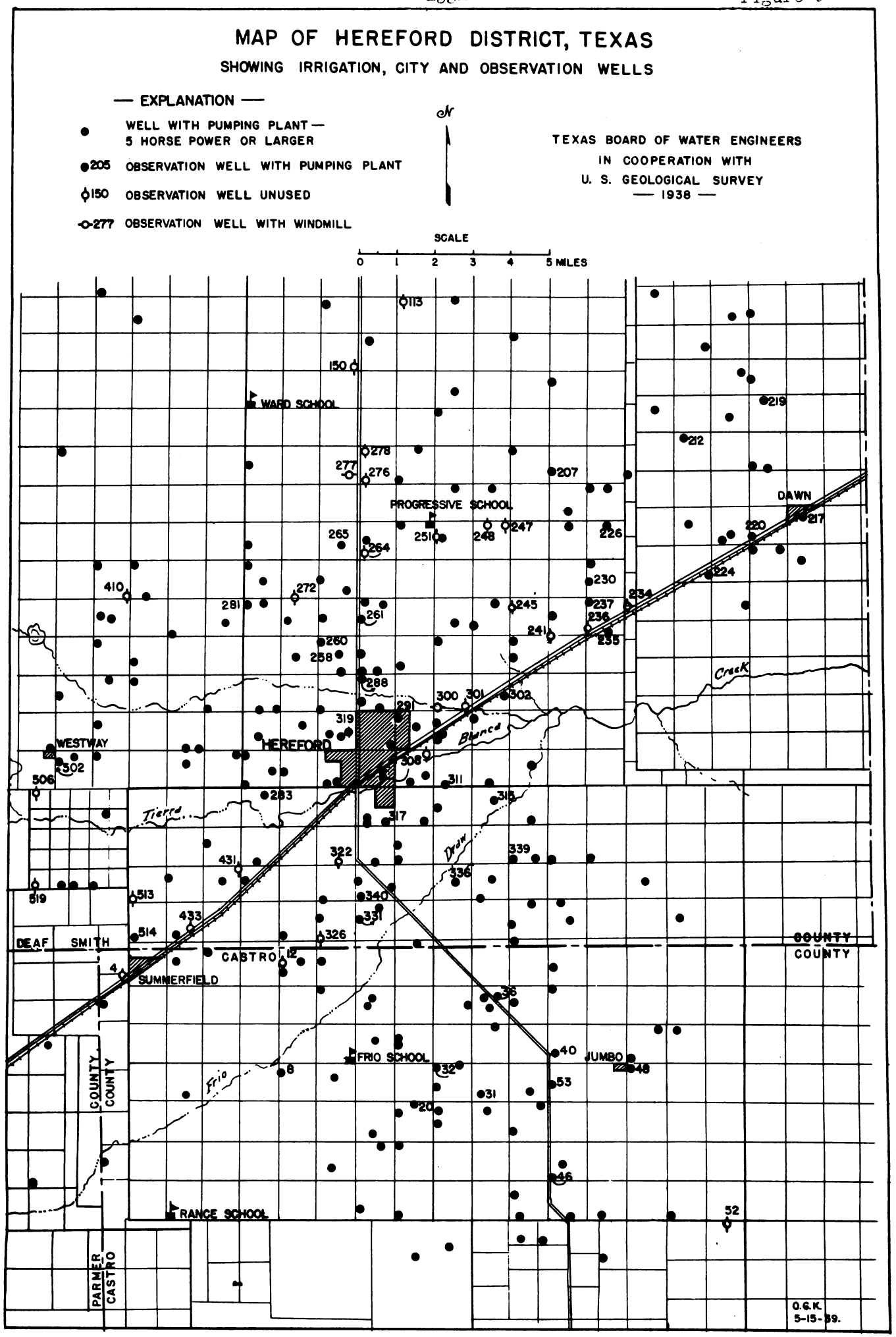

MAP OF HEREFORD DISTRICT, TEXAS
SHOWING IRRIGATION, CITY AND OBSERVATION WELLS
— EXPLANATION —
WELL WITH PUMPING PLANT — 5 HORSE POWER OR LARGER
205 OBSERVATION WELL WITH PUMPING PLANT
150 OBSERVATION WELL UNUSED
277 OBSERVATION WELL WITH WINDMILL
N
TEXAS BOARD OF WATER ENGINEERS
IN COOPERATION WITH
U. S. GEOLOGICAL SURVEY
— 1938 —
SCALE
0 1 2 3 4 5 MILES
WARD SCHOOL
PROGRESSIVE SCHOOL
FRIO SCHOOL
RANCE SCHOOL
HEREFORD
WESTWAY
DAWN
JUMBO
SUMMERFIELD
DEAF SMITH
CASTRO
PARMER
COUNTY
Tierra
Blanca
Creek
Draw
Frio
O.G.K.
5-15-39.

Figure 10

MAP OF MULESHOE DISTRICT, TEXAS
SHOWING IRRIGATION AND OBSERVATION WELLS

—EXPLANATION—

- ● WELL WITH PUMPING PLANT— 5 HORSE POWER OR LARGER
- ●53 OBSERVATION WELL WITH PUMPING PLANT
- ◊42 OBSERVATION WELL UNUSED
- ○5-A OBSERVATION WELL WITH HAND PUMP

TEXAS BOARD OF WATER ENGINEERS
IN COOPERATION WITH
U. S. GEOLOGICAL SURVEY
— 1938 —

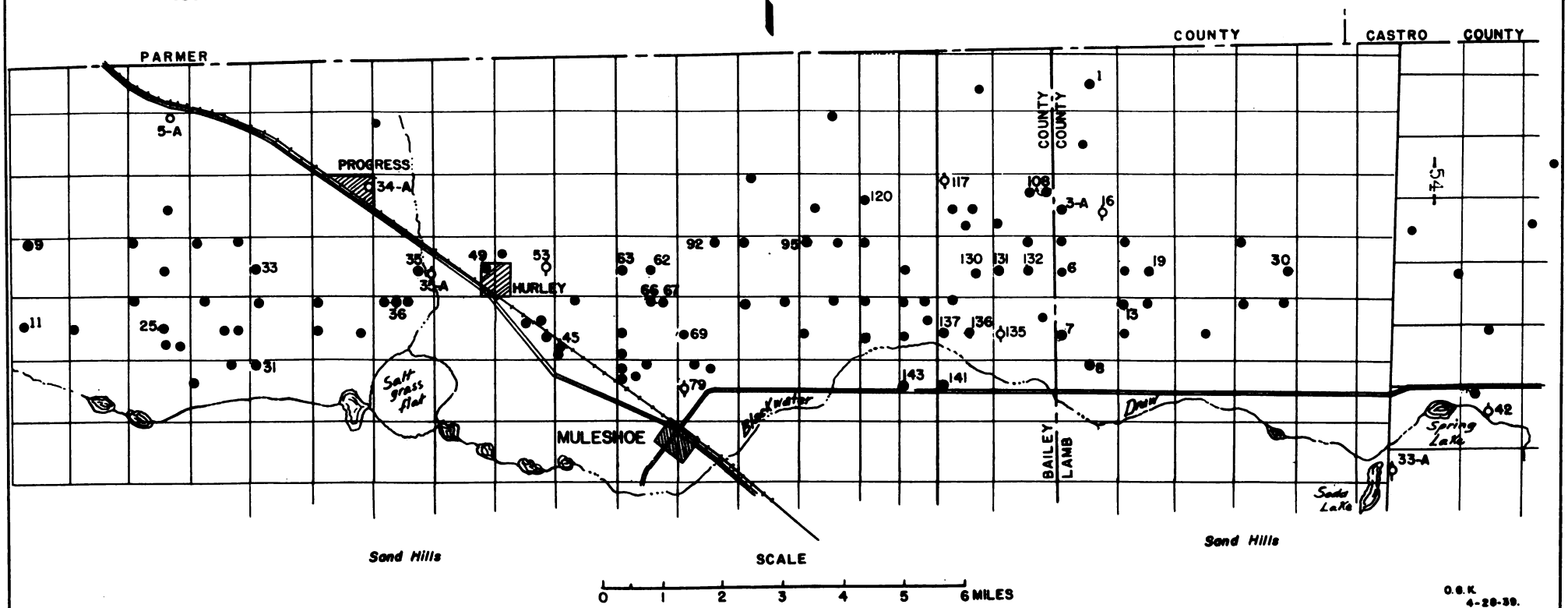
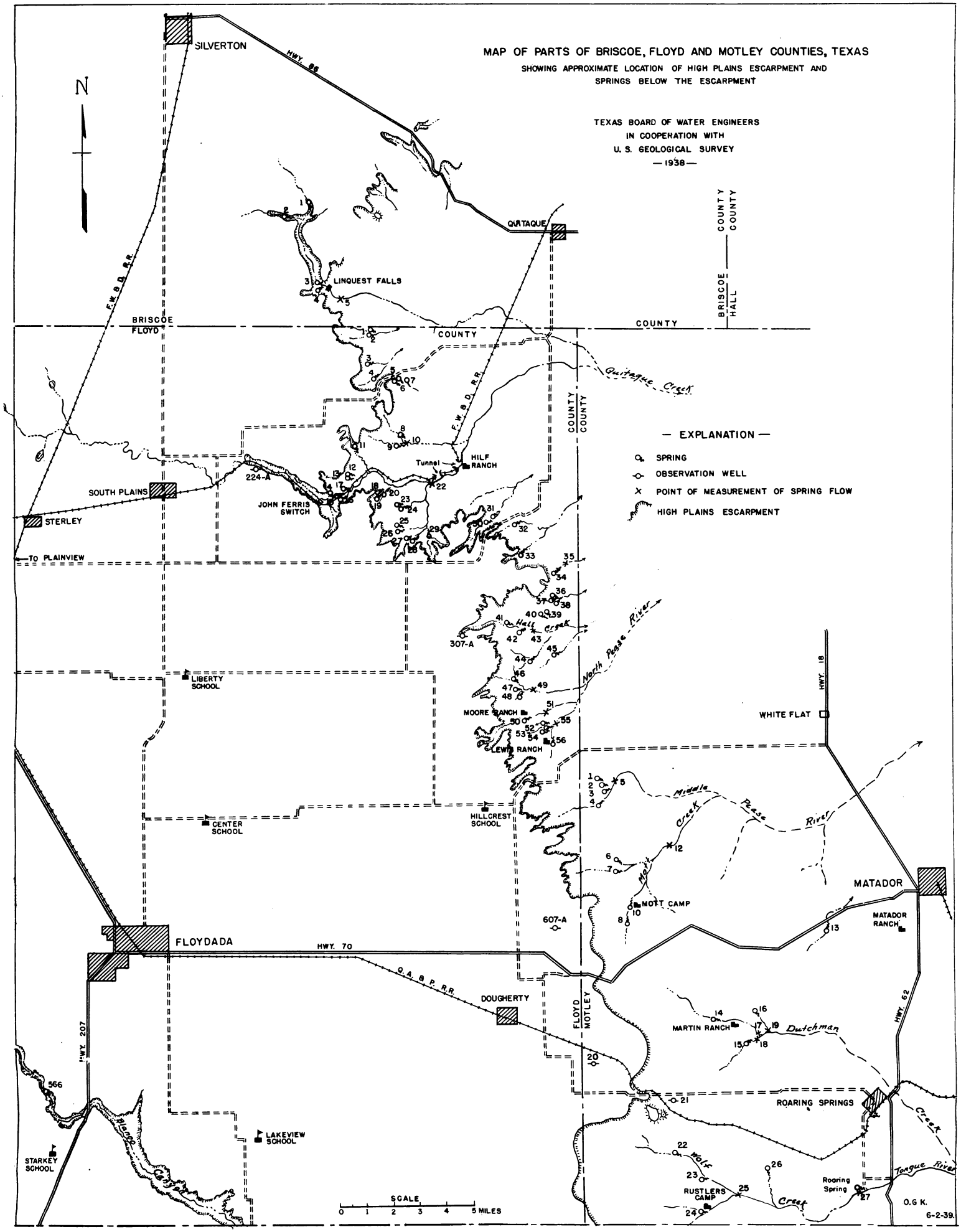


Figure 11


MAP OF PARTS OF BRISCOE, FLOYD AND MOTLEY COUNTIES, TEXAS
SHOWING APPROXIMATE LOCATION OF HIGH PLAINS ESCARPMENT AND SPRINGS BELOW THE ESCARPMENT
TEXAS BOARD OF WATER ENGINEERS
IN COOPERATION WITH
U. S. GEOLOGICAL SURVEY
—1938—
N
SILVERTON
HWY. 86
QUITAQUE
LINQUEST FALLS
F.W.B.D. R.R.
BRISCOE
FLOYD
COUNTY
BRISCOE COUNTY
HALL COUNTY
Quitaque Creek
HILF RANCH
Tunnel
224-A
SOUTH PLAINS
JOHN FERRIS SWITCH
STERLEY
TO PLAINVIEW
— EXPLANATION —
SPRING
OBSERVATION WELL
POINT OF MEASUREMENT OF SPRING FLOW
HIGH PLAINS ESCARPMENT
307-A
Hall Creek
North Pease River
LIBERTY SCHOOL
MOORE RANCH
LEWIS RANCH
HILLCREST SCHOOL
CENTER SCHOOL
HWY. 18
WHITE FLAT
Middle Pease River
Mott Creek
MOTT CAMP
607-A
MATADOR
MATADOR RANCH
FLOYDADA
HWY. 70
Q.A.&P. R.R.
DOUGHERTY
FLOYD
MOTLEY
HWY. 207
HWY. 62
MARTIN RANCH
Dutchman Creek
ROARING SPRINGS
Wolf Creek
Rooring Spring
Tongue River
RUSTLERS CAMP
566
Blanco Canyon
STARKEY SCHOOL
LAKEVIEW SCHOOL
SCALE
0 1 2 3 4 5 MILES
O.G.K.
6-2-39.