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UNITED STATES DEPARTMENT OF THE INTERIOR

UNDERGROUND LEAKAGE FROM ARTESIAN WELLS IN THE LAS VEGAS AREA, NEVADA

Prepared in cooperation with the
STATE ENGINEER OF NEVADA, CLARK COUNTY
AND THE CITY OF LAS VEGAS

GEOLOGICAL SURVEY WATER-SUPPLY PAPER 849-D

UNITED STATES DEPARTMENT OF THE INTERIOR
Harold L. Ickes, Secretary

GEOLOGICAL SURVEY
W. C. Mendenhall, Director

Water-Supply Paper 849–D

UNDERGROUND LEAKAGE FROM ARTESIAN WELLS IN THE LAS VEGAS AREA, NEVADA

BY

PENN LIVINGSTON

Prepared in cooperation with the
STATE ENGINEER OF NEVADA, CLARK COUNTY
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Contributions to the hydrology of the United States, 1940
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UNDERGROUND LEAKAGE FROM ARTESIAN WELLS IN THE LAS VEGAS AREA, NEVADA

By Penn Livingston

ABSTRACT

During the study of artesian wells in the Las Vegas area, Nev., 42 wells were explored with a current meter designed for measuring the flow at various points in deep wells. Although this number is only a small percentage of the total number of wells in the basin, it is believed that the conditions found in them are representative of conditions in wells throughout the basin.

Of the 42 wells, 8 could not be explored to a satisfactory depth, 19 were apparently not leaking, and the remaining wells were leaking, in the aggregate, about 375 gallons a minute. About 315 gallons of this water escaped from 3 wells. In 4 wells the leakage was found to be 8 to 15 gallons a minute, and in the remaining 7 wells the leakage was very slight.

From these observations it is concluded that the aggregate leakage from wells is not great enough to be responsible for more than a small part of the serious decline in water levels and artesian pressure in the basin. However, great quantities of water are allowed to flow from the wells without being used beneficially or economically. It is believed that if the draft on the artesian basin were reduced and strict measures of conservation were applied, the pressure would increase noticeably, especially in the shallower sands.

INTRODUCTION

Purpose of the investigation.—In response to a request from Alfred Merritt Smith, State engineer of Nevada, to the Director of the Geological Survey, United States Department of the Interior, the writer was assigned to make a brief investigation of the underground leakage from artesian wells in the vicinity of Las Vegas, Nev. The project was financed in part by contributions from Clark County and the city of Las Vegas. It was thought by some people in Las Vegas that the underground leakage from artesian wells is very large and that the decrease in the artesian pressure that has been taking place from year to year is due largely to this underground leakage. One of the first steps in a conservation program, therefore, was a survey to determine the magnitude of the underground leakage. The field work, which was carried on from August 11 to September 13, 1938, consisted mainly of exploring wells with the deep-well current meter, but it included also measuring the discharge from flowing wells and determining their artesian pressures and making measurements of depths to water levels in wells that do not overflow.

Previous investigations.—The artesian water basin in the vicinity of Las Vegas has been the subject of several reports in recent years. In 1912, a study of the ground water in southeastern Nevada, including the Las Vegas basin, was made by Everett Carpenter,[1] and additional observations on wells in the basin were made in 1913 by O. E. Meinzer.[2] A report [3] by the United States Department of Agriculture on the character of the soil in the Las Vegas area contains a paragraph contributed by Hardman pertaining to the artesian basin. Hardman and others have been carrying on investigations in the Las Vegas area since about 1921 and have written several reports.[4] Reference to the Las Vegas artesian basin is made also in a report for the Bureau of Reclamation by Kerr.[5]

Acknowledgments.—Alfred Merritt Smith, State engineer, and his assistant, Hugh Shamberger, spent several days with the writer at Las Vegas in connection with the investigation. Valuable assistance was given by Walter Bracken, of the Las Vegas Land and Water Company; C. F. De Armond, of the Colorado River Commission of Nevada; C. D. Baker, city engineer; and the Las Vegas Chamber of Commerce. Harry Jameson assisted the writer in the field with the well explorations and other work. The local well owners cooperated in every way and gave access to their wells and permission to make the well explorations. Floyd Francis, James Filbey, Joe Evans, and John Frewalt, local well drillers, gave information concerning wells and furnished some equipment for making the well tests.

GENERAL GEOLOGIC AND HYDROLOGIC FEATURES OF THE ARTESIAN BASIN

As far as is known at the present time the artesian water that is found in the Las Vegas area probably falls as rain or snow on the Spring Mountain Range and moves into the alluvial deposits along the foot of the mountains. Some of the formations in the mountains consist largely of limestone containing cracks and crevices, and some of the precipitation on them may penetrate the rocks to considerable depth before the water moves laterally toward the valley; some of the precipitation runs on the surface for a short distance from where it falls before it sinks into loose material of the stream beds at places

[1] Carpenter, Everett, Ground water in southeastern Nevada: U. S. Geol. Survey Water-Supply Paper 365, 86 pp., 1915.

[2] Idem, pp. 42, 43.

[3] Carpenter, E. J., and Youngs, F. O., Soil survey of Las Vegas area, Nev.: U. S. Dept. Agr., Bur. Soils, Field Operations, 1923, pp. 243–244, 1926.

[4] Bixby, F. L., and Hardman, George, The development of water supplies for irrigation in Nevada by pumping from underground sources: Nevada Univ., Agr. Exper. Sta., Bull. 112, 1928. Hardman, George, and Miller, M. R., The quality of the waters of southeastern Nevada, drainage basins and water resources: Nevada Univ., Agr. Exper. Sta., Bull. 136, 1934. Hardman, George, memorandum on the artesian water supply of the Las Vegas valley and the proposed supplemental supply from the Colorado River: Resettlement Administration, Land Utilization Div., unpublished report, 1936.

[5] Kerr, J. N., Report on Las Vegas pumping projects, Nevada: U. S. Dept. Interior, Bur. Reclamation, mimeographed report, 1936.

where they cross the coarse outwash from the mountains. Beds of clay separating beds of sand and gravel serve to confine the water to these permeable beds, and owing to their inclined position they give rise to artesian conditions. According to Carpenter,[6] the deposits range from coarse material close to the mountains to sands and finer material farther away and finally to clay and fine sediments near the center of the valley. In general, wells drilled in the finer sediments in the lower part of the valley yield less water than wells farther up the slope to the west, where the deposits are coarser.

The following logs show the kind of material penetrated by the drill.

Log of well 4, Syndicate No. 1

[Reprinted from Water-Supply Paper 365, p. 34]

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Lime (first water at 28 feet)	28	28	Hard streak	6	185
Lime and clay	12	40	Lime and clay	4	189
Hard cemented lime	10	50	Hard rock	10	199
Lime and clay mixed	20	70	Clay and lime rock	4	203
Hard cemented lime	15	85	Hard lime rock, porous	8	211
Clay mixed with lime	20	105	Clay with rock	2	213
Very hard material	5	110	Hard streak	12	225
Clay and lime mixed	20	130	Rock	5	230
Lime rock	15	145	Sand and pebbles	6	236
Clay and soft lime (water at 174 feet, flowed)	34	179			

Bottom of 12-inch casing at 194 feet; bottom of 10-inch casing at 214 feet.

Driller's log of well 13

[Owned by Pat Cline. Drilled by James Filbey in August 1938]

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Sandy loam	6	6	Red clay	43	335
Lime rock	22	28	Lime rock	7	342
Blue clay	17	45	Clay	28	370
Lime rock	7	52	Sandstone	10	380
Blue clay	28	80	Clay	31	411
White clay	35	115	Sandstone (small flow at 420 feet)	9	420
Red clay	12	127	Red clay	5	425
Pink clay	32	159	Sandstone	12	437
Clay	61	220	Red clay	51	488
Lime rock	1	221	Sand and clay	14	502
Clay (small flow of water)	32	253	Sand	48	550
Lime rock	4	257	Sand and gravel	40	590
Red clay	30	287	Sand and gravel	10	600
Lime rock	5	292			

Well has 90 feet of 8-inch casing and 595 feet of 6-inch casing.

[6] Carpenter, Everett, Ground water in southeastern Nevada; U. S. Geol. Survey Water-Supply Paper 365, p. 40, 1915.

Driller's log of well 18

[Owned by M. D. Kidder. Drilled by Floyd Francis in 1925]

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Gypsum and lime conglomerate	2	2	Loose gravel	2	222
White marl	13	15	Cement gravel	54	276
Lime	4	19	Loose gravel	4	280
Loose lime and clay	5	24	Cemented gravel	27	307
Yellow sandy clay	86	110	Loosely cemented gravel	63	370
Red sand	8	118	Lime rock; bad to wash into well	1	371
Sandy clay	30	148	Loose gravel	14	385
Cement gravel	72	220			

Water throughout cemented formation. Well has 262 feet of 8-inch casing; 132 feet of 6-inch casing from 213 to 345 feet; and 87 feet of 4-inch casing from 294 to 381 feet.

Driller's log of well 25 (Sund well)

[Owned by the Lindsay estate. Drilled by Floyd Francis in May 1914]

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Surface rock, clay, and talc	130	130	Sand	6	420
Rock	5	135	Clay	4	424
Sandy clay and talc	52	187	Cement sand	2	426
Lime rock	3	190	Clay	4	430
Clay and lime rock	10	200	Cement sand	2	432
Lime rock	3	203	Sand, water	17	449
Sandy clay and talc	65	268	Cement sand	3	452
Conglomerate	59	327	Clay	28	480
Red sand	8	335	Sand, sand rock, and clay (flow at 546 feet)	66	546
Sand and gravel	61	396	Cement sand	39	585
Sand rock	2	398			
Sandy clay	16	414			

Well has 136 feet of 8-inch casing and 341 feet of 6-inch casing from 61 to 402 feet.

Driller's log of well 32

[Owned by State Highway Department. Drilled by Joe Evans in 1935]

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Gravel	6	6	Gravel (total flow, 22 gallons a minute)	3	547
Hard gyp	2	8	Red sandy clay	217	764
Layers of rock and clay	416	424	Cement gravel (total flow, 33 gallons a minute)	106	870
Blue clay	36	460	Red clay	30	900
Quicksand (flow, 11 gallons a minute)	10	470			
Red sandy clay	74	544			

Well has 150 feet of 10-inch casing; 200 feet of 8-inch casing; and 200 feet of 6-inch casing. Bottom of casing at 550 feet.

Wells that penetrate these beds of sand and gravel overflow when the altitude of the land is less than the height to which the artesian water will rise. In places where the land surface is above the level to which the artesian water will rise the wells do not flow. The first are called flowing artesian wells and the second, nonflowing artesian wells.

The loss of pressure is most noticeable in wells along the western edge of the area of artesian flow, where the original pressure brought the water only a few feet above the ground. An example is well 2, owned by L. C. Egglington. According to a picture of this well taken about 1912 [7] the water at that time rose several feet above the ground and the flow amounted to 615 gallons a minute. Another picture of this well, shown in plate 13, A, was taken September 2, 1938, at which time the water level stood 3.3 feet below the surface.

In some localities there are apparently great differences in the artesian water pressure in the different water horizons. For instance, in well 17, owned by James Filbey, which was drilled to a depth of about 625 feet, the water will rise about 90 feet above the land surface; whereas in wells 14 and 15, with their present depths of 393 and 425 feet, respectively, the water will rise only about 9 feet above the land surface, even though the surface is lower than at well 17. Wells 33 and 34 are about a mile apart and at approximately the same altitude, but their depths are 386 and 690 feet, respectively. The water will rise about 47 feet higher in well 34 than in well 33. In well 12, owned by T. J. Thebo, the artesian water from the sands below a depth of 530 feet will rise 26 feet higher than the water from the sands between depths of 120 and 530 feet.

The overlying, confining beds of clay that hold the water in the lower sands may reach a higher altitude along the foot of the mountains than the confining beds of the higher sands, and thus, by maintaining a higher water level at the intake, they may have caused somewhat greater original pressure in the lower sands in localities down the dip. It seems likely, however, that the artesian water pressures in the sands at different depths did not originally differ nearly as much as they do at present and that the differences observed in 1938 are due largely to unequal drafts upon the water sands. Some of the wells in the Las Vegas area penetrate only the upper sands of the artesian system. Because of the lower cost of production from the upper sands, they have been drawn upon more heavily and for a longer time than the deeper sands, and consequently, the artesian pressure has decreased more in the upper sands than it has in the lower sands.

METHODS OF WELL CONSTRUCTION IN RELATION TO UNDERGROUND LEAKAGE

Most wells in the Las Vegas area have been drilled with cable tools. It has been the usual practice to drill until the well begins to cave and then to install casing of the largest size that can be used. After the hole is cased, drilling is continued with a bit small enough to pass through the casing. The smaller hole is carried down until more trouble is experienced with caving, and then another string of casing is placed. Sometimes the well is drilled to considerable depth by allowing the casing to follow the bit as the hole is deepened. In

[7] Carpenter, Everett, Ground water in southeastern Nevada: U. S. Geol. Survey Water-Supply Paper 365, pl. 3, A, 1915.

other wells casings of successively smaller sizes are used. As a result most of the wells in this area have several sizes of casings that overlap. In some wells the casing of smaller size is cut off near the bottom of that of the next larger size, and in other wells the smaller casings are brought all the way to the surface. As a rule lead seals or packers have not been used to make tight connections between casings of different sizes. When the first wells were drilled in the area they were provided with the minimum length of casing, and some of them have as little as 40 to 60 feet.

In recent years it has been the general practice to "cement" on the outside of the largest casing. This is done by pouring a mixture of sand and cement down the annular opening outside of the casing, clearing the way to some extent by probing with a long stick or rod. In nearly all wells the annular space on the outside of the casing was full of water when the well was cemented, and sometimes water was even flowing out at the surface. It should be pointed out that this is an unsatisfactory method of cementing a well. In the first place, the concrete does not get down to the lower end of the casing, where it belongs, and, in the second place, the sand and cement separate as they fall through the water. The sand drops down a short distance and bridges in the hole, while the cement floats for a time and then is either washed out by the flowing water or becomes waterlogged and does not set when it finally comes to rest.

It is good insurance against leakage to fill the annular space on the outside of the casing with cement or clay, but probably a better cementing could be accomplished by drilling the well down about 200 feet with a bit large enough to accommodate a 1-inch pipe on the outside of the casing, through which neat cement could be introduced in a continuous stream to the bottom of the casing. The 1-inch pipe should be withdrawn as necessary, care being taken that the lower end is always below the top of the cement in the hole. If there is an overlying water-bearing bed containing corrosive water it is desirable that the well be cemented the full length of the casing exposed to corrosion, in order to protect the casing and to give support to it if parts of it should be eaten away. If there is no corrosive water present to attack the casing it is satisfactory to fill the space with a good clay mud introduced through a pipe to the bottom of the casing in the same manner as when wells are cemented.

The life of a well depends to a very large extent upon the casing and upon sound and watertight connections. Accordingly only casing of the best grade should be used. Wells that are open to several of the artesian water-bearing sands allow water from the deeper sands, which are under higher pressure, to flow up through the well and out into sands in which the artesian pressure is lower. Other wells that are open to unsaturated sands allow artesian water to flow upward in the well and out into shallow beds of sand and gravel. In wells of the first kind there is not strictly a waste of artesian water, because the water so lost recharges other artesian sands and probably may be recovered by wells yielding from those sands, but this exchange of water results in a loss of artesian pressure from the lower sand.

An example of such exchange of water between sands was found in well 12, drilled during August and September 1938 for Mr. Thebo. This well was cased to a depth of 120 feet with 8-inch casing and was drilled deeper with a bit of smaller size. A 6-inch casing, extending from the surface to a depth of 530 feet, was set inside the 8-inch casing. On September 9, 1938, the water inside the 6-inch casing rose 26.7 feet above the surface, and the water between the 6-inch and 8-inch casings rose only 0.7 foot above the surface. If separate casings to these two water-bearing horizons had not been set there would be a substantial movement of water from the lower sand into the upper, and the water level indicated at the surface would be somewhere between 26.7 and 0.7 feet, the exact level depending upon the permeability of the two horizons.

The volume of artesian water wasted below the surface on account of the lack of casing or of poor well construction depends largely upon the permeability of the material that overlies the artesian water sands. The material in the valley, being outwash from the surrounding mountains, varies greatly in fineness from place to place and probably is finest toward the center of the valley. Wells near the center of the valley, therefore, should waste less water, other conditions being equal, than those near the mountain. The driller should be able, while he is drilling, to determine the permeability of the material from the surface down to the artesian horizon. If the material below the water table and above the artesian horizon is so dense that water has to be added in order to drill, little water will be wasted below the water table. If, on the other hand, the well passes through coarse sand and gravel, and if bailing seems to have little effect upon the water level, the well can be expected to leak considerably unless it is properly cased. In the Roswell artesian basin, New Mexico,[8] part of the overlying formations consists of permeable material, into which large quantities of artesian water can escape from the wells. In the Honolulu artesian basin part of the overlying formation consists of porous coral, into which artesian water easily escaped after holes in the casing had been formed by corrosion.[9] In the Las Vegas basin, in contrast, especially in its lower part, the overlying formation consists largely of fine material and the shallow sands probably are not continuous, being very irregular and lenticular,

[8] Fiedler, A. G., and Nye, S. S., Geology and ground-water resources of the Roswell artesian basin, N. Mex.: U. S. Geol. Survey Water-Supply Paper 639, pp. 231-236, 1933.

[9] McCombs, John, Methods of exploring and repairing leaky artesian wells on the island of Oahu, Hawaii: U. S. Geol. Survey Water-Supply Paper 596-A, pp. 4-24, 1927.

and do not provide outlets for underground leakage in large quantities from the artesian wells.

METHODS OF TESTING WELLS FOR UNDERGROUND LEAKAGE

For a number of years the Geological Survey has made investigations of wells where faulty construction has suggested that water from the artesian basin may be escaping through wells into higher formations and in this way may be wasted. For determining leakage in artesian wells a special current meter was designed about 1925.[10] This meter is placed in the well and lowered to the bottom by means of a conductor cable. If the water in the well is flowing it impinges upon the vanes of a rotor and turns it with a velocity that is proportional to the velocity of the water in the well. In the contact chamber at the upper end of the meter shaft an electrical circuit is completed and broken at each revolution of the rotor, and this is heard by means of earphones worn by the observer. The observer notes the frequency of the revolutions and thus determines the velocity at the point where the meter is held during the observation. The velocity of the water corresponding to different rates of rotation of the meter vanes has been determined by calibration tests made at the United States Bureau of Standards. The volume of the leakage is computed from the velocity of the water and the cross-sectional area of the pipe or hole.

Plate 12 shows the equipment used in the Las Vegas investigation. Plate 12, *A*, shows the meter case, which is 3 inches in inside diameter and 36 inches long, and beside it the meter, which is 3 inches in outside diameter and about 6 inches long, and the winch with about 1,000 feet of 0.09-inch steel cable resting upon the box into which it folds for moving. On the end of the cable is hanging an assembly consisting of bushings ranging in size from 4 inches down to the ⅛-inch packing gland. Plate 12, *B*, shows the Sund well on the Lindsay estate while the pipe fittings were being removed. Plate 12, *C*, shows the same well under control and the test in progress.

In order to test the flowing wells that are under high pressure it was, of course, desirable to stop all flow from them at the surface. As some of the old fittings on the wells had not been disturbed for many years, considerable trouble was experienced in removing them so that the proper connections could be made. For the test on the Sund well the elbow was unscrewed and replaced by an 8-inch collar. Above the collar, in order, were the following fittings: 6-inch O. D. to 4-inch I. D. bushings, a short 4-inch nipple, a 4-inch tee, a 4-foot length of standard 4-inch pipe, a 4-inch collar, several bushings

[10] Fiedler, A. G., The Au deep-well current meter and its uses in the Roswell artesian basin, N. Mex.: U. S. Geol. Survey Water-Supply Paper 596, pp. 24–32, 1928.

ranging in size from 4 inches to ⅛ inch, an ⅛-inch packing gland, and a 4-inch guide pulley. The main valve on the well was first closed and the meter placed inside the 4-inch pipe, after which the bushings at the top of the pipe were screwed in. After all connections were tight and the meter had been tested, the valve was opened and the meter was lowered into the well. In this manner it was possible to test wells under high pressure without the trouble of raising the casing as high above the surface as the artesian water would flow.

The rotor in the meter turns as the meter is lowered into the well, and by carefully observing the velocity of the rotor in relation to the rate at which the meter is lowered, any increase in the velocity of the water can easily be noted. As an additional check, the meter was held steady for observations of velocity at several points in the well. In all the tests, the meter was lowered into the well as far as it would go.

RESULTS OF TESTS FOR UNDERGROUND LEAKAGE

The results of the tests made in 1938 with the deep-well meter in wells in the vicinity of Las Vegas, are as follows: The locations of the wells are shown in figure 5, and the well records are given in the table on page 170–172.

WELL 1

Well 1, owned by H. Taylor, is on ground that is higher than the level to which the artesian water will rise; hence the well does not flow. On August 15, when the well was inspected, the casing was obstructed with rocks about 10 feet below the land surface, so that the deep-well meter would not pass that depth.

WELL 2

Well 2 is owned by L. C. Egglington. The water level in the well is about 3 feet below the land surface. A view of this well taken about 1912 appears in a previous report.[11] It was reported to have had a flow of about 615 gallons a minute at that time. Plate 13, *A*, shows a view taken September 2, 1938. In an effort to keep the well flowing as long as possible, holes have been punched in the casing near ground level, and a trench has been dug from the well through the earthen embankment that used to form the tank. This well furnishes a good example of what will happen to other wells as the artesian pressure declines. The meter was lowered into this well on August 26 to a depth of 273 feet below the top of the casing, which is 2.5 feet above the ground, and no underground leakage was found. The reason that this well does not flow, therefore, is because the artesian pressure in the water-bearing formation has decreased and not because the well is defective.

[11] Carpenter, Everett, Ground water in southeastern Nevada: U. S. Geol. Survey Water-Supply Paper 365, pl. 3, *A*, 1915.

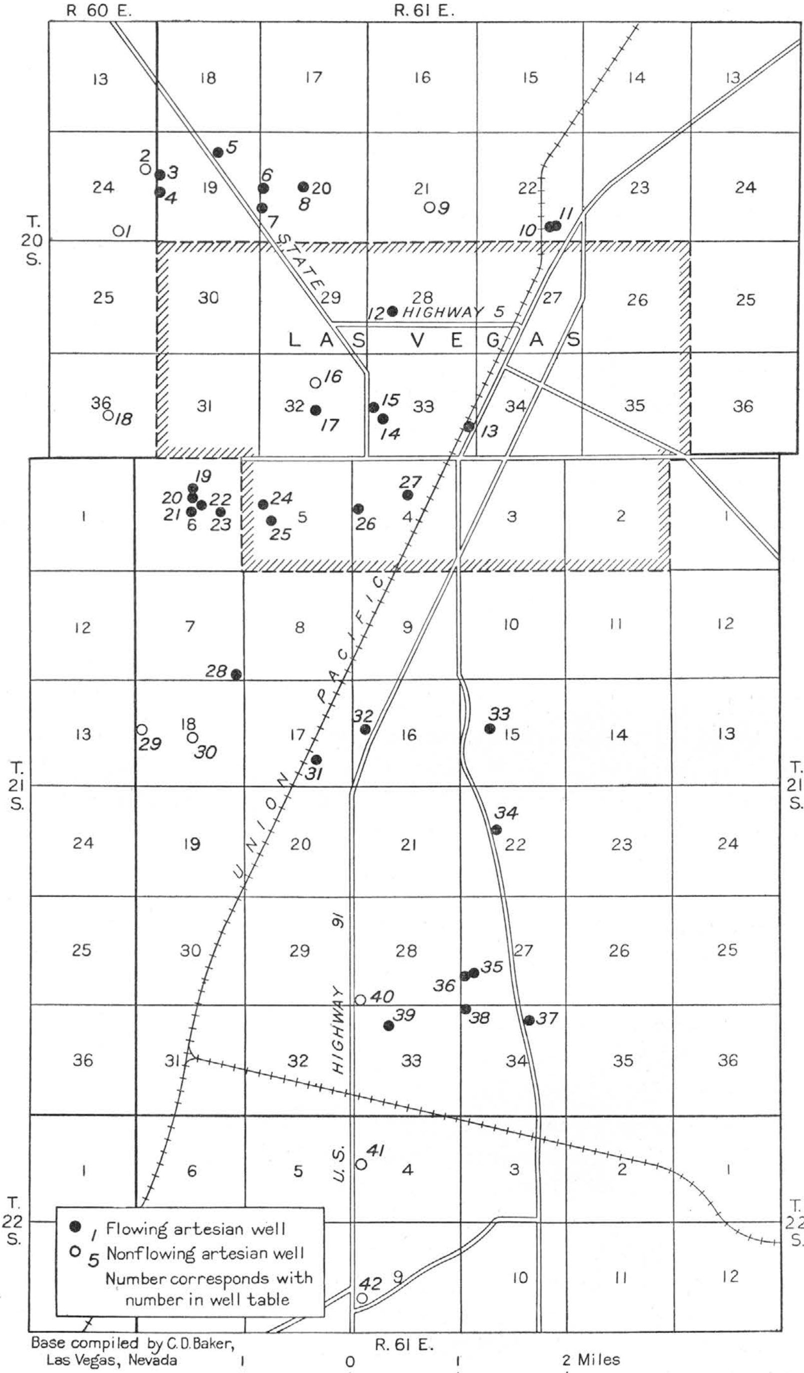


FIGURE 5.—Map of a part of the Las Vegas area showing location of wells examined.

WELL 3

Well 3 is known as Syndicate well No. 2. (See pl. 13, *B.*) It is provided with a valve to control the flow. The artesian pressure at this location is barely great enough to force the water above ground. The meter was lowered into the well August 26 to a depth of 236 feet below the top of the tee, which is about 2 feet above ground, and no underground leakage was found.

WELL 4

Well 4 is known as Syndicate well No. 1. (See pl. 13, *C.*) It is provided with a valve to control the flow. The artesian pressure at this location is also barely great enough to force the water above ground. The meter was lowered into this well on August 27 to a depth of 247 feet below the top of the tee, which is 2.7 feet above ground, and no underground leakage was found.

WELL 5

Well 5 is known as Syndicate well No. 5. (See pl. 14, *A.*) It is provided with a valve to control the flow. It is just east of the highway leading to Tonopah, and the waste of water from it has been discussed by many people who pass it. The meter was lowered into this well on August 27 to a depth of 264 feet below the top of the plug, which is 4.5 feet above ground, and no underground leakage was found.

WELL 6

Well 6 is owned by R. J. Lewis. (See pl. 14, *B.*) The well is provided with a valve to control the flow. There is a continuous flow from a spring beside it estimated at about 15 gallons a minute when the valve is closed but a little less when the well is allowed to flow freely. The meter was lowered into this well on August 29 to a depth of 270 feet below the top of the tee, which is about 2 feet above ground. When the valve was closed there was a flow of water in this well amounting to about 13 gallons a minute. The water came from a depth of 220 to 270 feet and flowed up the well through the 6-inch casing to within about 6 feet of the surface of the ground, at which level it flowed over the top of the 6-inch casing. Thence it flowed down between the 6-inch and 8-inch casings and passed through or under the 8-inch casing, probably coming to the surface on the outside, as shown by the spring.

WELL 7

Well 7 is owned by H. Oppdyke. (See p. 14, *C.*) It flows without control. The meter was lowered into this well on August 23 to a depth of 101 feet below the ground. When the well was closed at the top there was a flow of about 35 gallons a minute. The water came from the bottom of the well, passed upward, and escaped at a level of 41 to 43 feet below the surface.

WELL 8

Well 8 is owned by John Frewalt, well driller. It has not been completed and probably will be drilled deeper. It was tested to determine possible leakage through the casing. The meter was lowered into this well on August 27 to a depth of 302 feet below the top of the casing, which is about 2 feet above ground, and no leakage was found.

WELL 9

Well 9 is owned by the Las Vegas Building & Land Co. It does not overflow. When inspected on August 29 it was obstructed with rocks at ground level, and therefore the meter could not be used.

WELL 10

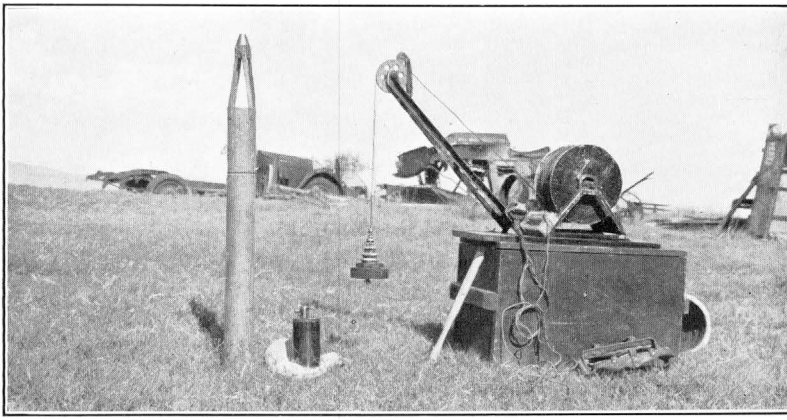
Well 10 belongs to the town of North Las Vegas and is used for a public water supply. It is on the southwest side of the water tank and overflows into the tank. The meter was lowered into the well on September 10 to a depth of 524 feet below the top of the tee, which is about 2 feet above ground. A slight movement of water seemed to occur from a depth of more than 250 feet to a depth of less than 50 feet below the surface.

WELL 11

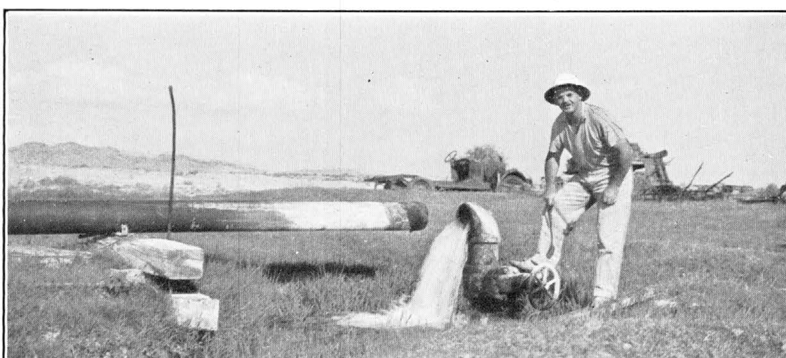
The town of North Las Vegas also owns well 11, which is on the east side of the water tank. The meter was lowered into this well on September 10 to a depth of 146 feet below the top of the tee, which is about a foot above ground. Down to this depth, below which the meter could not be lowered, no underground leakage was found. It is believed that the casing had been perforated at about 146 feet and that the meter was prevented from going farther down by pieces of metal left projecting into the well by the perforator.

WELL 12

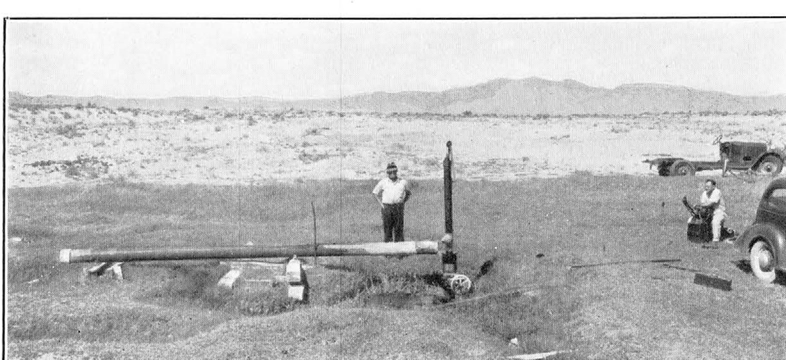
Well 12 is owned by T. J. Thebo, and drilling had just been completed when the well was inspected. The meter was lowered on September 9 to a depth of 639 feet below the top of the 8-inch collar, which is 1.7 feet above ground. There was a flow in this well of about 5 gallons a minute. The water came from the bottom of the well, moved upward, and escaped into another sand before it reached the bottom of the 6-inch casing at a depth of 530 feet below the surface. This movement was probably due to a slightly lower artesian pressure in the upper sand. There was no indication of any leakage around the bottom of the 6-inch casing.



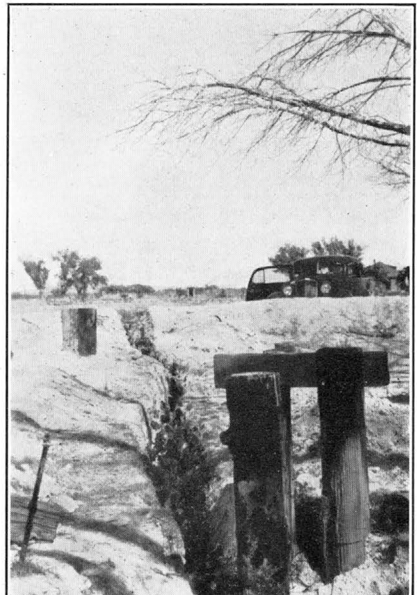
A. DEEP-WELL METER AND ACCESSORIES USED FOR EXPLORING ARTESIAN WELLS AT LAS VEGAS, NEV.



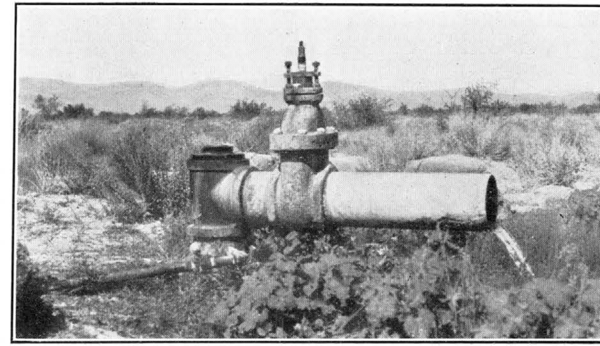
B. REMOVING FITTINGS FROM WELL 25 (SUND WELL) IN PREPARATION FOR TEST



C. WELL 25, UNDER CONTROL AND TEST IN PROGRESS.

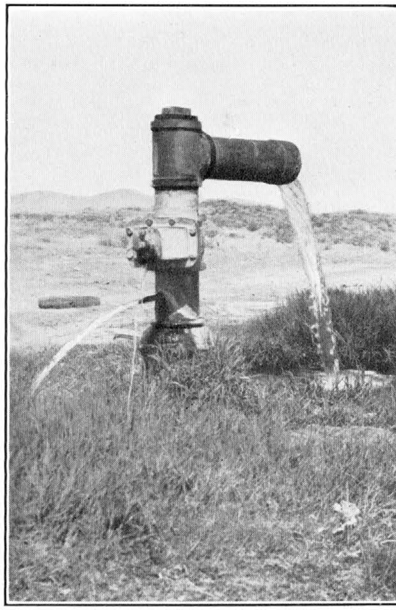


A. WELL 2, OWNED BY L. C. EGGLINGTON.

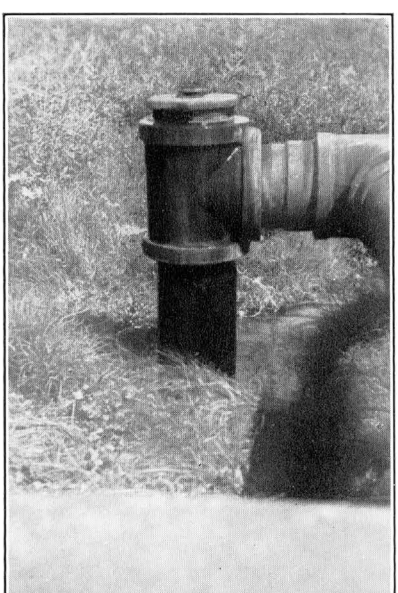


B. WELL 3, KNOWN AS SYNDICATE NO. 2.

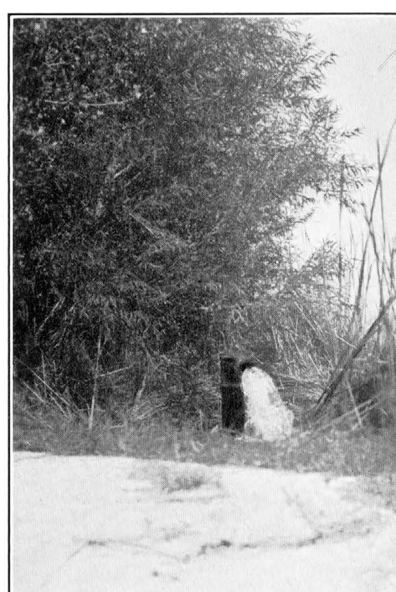
C. WELL 4, KNOWN AS SYNDICATE NO. 1.



A. WELL 5, KNOWN AS SYNDICATE NO. 5.



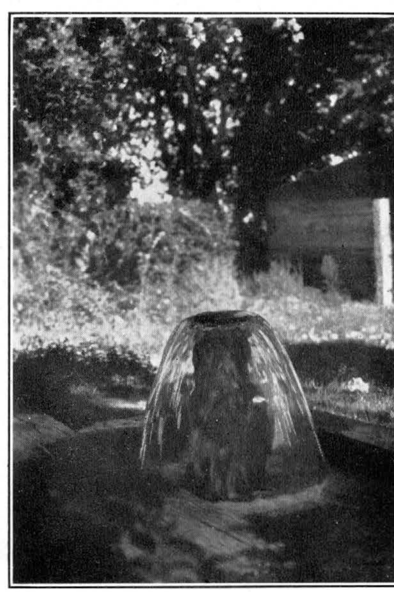
B. WELL 6, OWNED BY R. J. LEWIS.
Note artesian spring around well casing.



C. WELL 7, OWNED BY H. OPPDYKE.

A. WELL 21, OWNED BY J. H. UMBAUGH.

B. WELL 24, OWNED BY THE LINDSAY ESTATE.



C. WELL 33, OWNED BY L. H. ROCKWELL.

WELL 13

Well 13 is owned by Pat Cline and is in the rear of the bottling works. The flow is under control. The well was drilled during August 1938 and is reported to have 595 feet of 6-inch casing. The meter was lowered on August 23 to a depth of 600 feet, and a flow of about 15 gallons a minute was found escaping around the lower end of the casing.

WELL 14

Well 14 is owned by A. W. Blackman. The flow is under control. The meter was lowered into the well on August 25 to a depth of 395 feet below the top of the tee, which is about 2.4 feet above ground, and no underground leakage was found.

WELL 15

Well 15 is owned by Mrs. Myrtle Tate. The flow can be controlled. The meter was lowered on August 24 to a depth of 425 feet below the surface, and no underground leakage was found. The test showed that a small flow of water that was escaping through fittings at the surface during the test came from a depth of 370 to 390 feet. There seems to be a reduction in the size of the casing from 8-inch to 6-inch about 10 feet below the surface.

WELL 16

Well 16 is owned by Helen Nagel. It is on ground that is higher than the level to which the water will rise by artesian pressure. There are indications, however, that the well has flowed in recent years. It was explored with the meter on August 26 to a depth of 368 feet below the top of the casing, which is 5 feet above ground. A very slight movement seemed to take place between depths of 150 and 200 feet.

WELL 17

Well 17 is owned by James Filbey, well driller, who intends to make repairs as soon as possible. The flow from the well is under control with the exception of a flow of about 30 gallons a minute that issues between the 6-inch and 8-inch casings. The meter was lowered on August 24 to a depth of 618 feet below the top of the valve, which is about 2 feet above ground.

Record of velocity in well 17

Depth (feet)	Velocity (feet per second)	Depth (feet)	Velocity (feet per second)	Depth (feet)	Velocity (feet per second)	Depth (feet)	Velocity (feet per second)
7	0.04	132.5	0.21	350	0.33	470	0.49
15	.04	135	.33	400	.34	490	.48
30	.04	140	.35	450	.33	500	.50
50	.04	150	.35	460	.34	550	.50
70	.04	170	.35	462	.34	600	.48
100	.04	200	.34	464	.34	615	.47
125	.04	250	.34	465	.42	617	.42
130	.07	300	.33	466	.46	618	.26

The owner reports that the well has 120 feet of 8-inch casing, 450 feet of 6-inch casing, and 620 feet of 4-inch casing. On the basis of a 4-inch casing extending to the bottom of the well the flow from depths of 125 feet to 7 feet amounts to a little over a gallon a minute, which about equals the amount of leakage in the pipe fittings above the surface during the test. The flow from 615 to 466 feet amounted to about 15 gallons a minute, and the flow from 464 to 135 feet amounted to about 11 gallons a minute. Evidently the water flowing in the well during the test came from the bottom of the well. The leakage was of necessity measured inside the 4-inch casing and, of course, does not indicate the possible leakage under or through the 8-inch casing or the leakage from lower sands into upper sands having lower artesian pressure. The static artesian water pressure, amounting to about 90 feet with reference to the surface, is the highest pressure measured during the investigation. The volume of water flowing up between the 6-inch and 8-inch casings seems to be increasing, and it probably represents an excess from the lower sands that is not being taken in by the upper sands. As the pressure builds up in the upper sands less water is taken in and more water comes to the surface.

WELL 18

Well 18, owned by M. D. Kidder, is on ground above the level to which the artesian water will rise. The meter was lowered on August 18 to a depth of 210 feet below the top of the casing, which is about a foot above ground, and no underground leakage was found. According to the driller's log the well has 262 feet of 8-inch casing; 132 feet of 6-inch casing, from 213 to 345 feet; and 86 feet of 4-inch casing, from 295 to 381 feet. The meter doubtless struck the top of the 6-inch casing at a depth of 210 feet. As water would be most likely to come up through the 6-inch casing, because of greater pressure in the deeper sands, special care was taken to determine any movement at the top of that casing, but none was found.

WELL 19

Well 19 is owned by W. N. Hinson. The flow is under control. The meter was lowered on September 7 to a depth of 276 feet below the top of the 8-inch collar, which is 0.5 foot above ground. When the valve was closed there was a flow in this well amounting to about 8 gallons a minute. The water came up from a depth of about 275 feet, passed over the top of the 6-inch casing at a depth of 10 to 15 feet, and thence probably escaped through or under the 8-inch casing.

WELL 20

Well 20 is owned by I. M. Pinjuv. The flow is under control. The meter was lowered on August 18 to a depth of 270 feet below the ground and no velocity was recorded. This well was reported to be cased with 292 feet of 6-inch standard pipe, and therefore the meter was in the cased portion of the hole during the test. The meter did not reach the bottom of the casing, where any leakage would be likely to occur. The casing was perforated after it had been placed in the well, and it is believed that the meter was caught on projecting pieces of metal left by the perforator.

WELL 21

Well 21 is owned by J. H. Umbaugh. It is provided with a valve to control the flow. A view of this well is shown in plate 15, *A*. After removing the 10-inch tee and valve, it was discovered that the 8-inch casing inside the 11-inch casing projects above the 10-inch collar. Pipe fittings were not available to bring the well under control for testing.

WELL 22

Well 22 also is owned by J. H. Umbaugh. The flow can be controlled. The well was explored with the meter on September 7 to a depth of 224 feet below the top of the 6-inch casing, which is 1.7 feet above ground, and no underground leakage was found. There was evidence of a reduction from 6-inch to 4-inch casing at a depth of 167 feet.

WELL 23

Well 23 is owned by Fred Gobeli. It is not provided with a control valve. The meter was lowered on September 8 to a depth of 229 feet below the top of the 6-inch casing, which is about 3 feet above ground, and no underground leakage was found.

WELL 24

Well 24 is owned by the Lindsay estate. It is provided with a valve to control the flow. A view of it is shown in plate 15, *B*. The meter was lowered on September 6 to a depth of 555 feet below the top of the 8-inch valve, which is about 2 feet above ground. As soon as the control valve was closed, a spring with a flow estimated at 30 gallons a minute appeared near the well. On the basis of an 8-inch well casing, about 50 gallons a minute entered the well while it was shut in and moved upward. About 10 gallons a minute was lost from the well at a depth of 470 to 495 feet, about 11 gallons a minute was lost at a depth of 402 feet, and the remaining flow of 26 to 28 gallons a minute continued upward and left the well at a depth of 64 feet. It is believed that about all the water escaping from the well comes to the surface through the spring beside the well.

Record of velocity in well 24

Depth (feet)	Velocity (feet per second)	Depth (feet)	Velocity (feet per second)	Depth (feet)	Velocity (feet per second)	Depth (feet)	Velocity (feet per second)
20	0	95	0.18	395	0.21	495	0.37
45	0	120	.18	400	.20	498	.33
60	0	145	.18	402	.20	500	.34
62	.04	170	.20	403	.27	505	.34
63	.11	195	.19	405	.27	515	.36
64	.14	220	.19	410	.27	525	.37
65	.23	245	.19	420	.27	535	.37
70	.18	270	.19	445	.27	545	.37
75	.18	295	.20	470	.28	555 [1]	.35
85	.18	345	.20				

[1] Obstruction at 555.5 feet.

WELL 25

Well 25 is owned by the Lindsay estate and is known as the Sund well. It is provided with a valve to control the flow, but when the valve is closed a large number of small springs appear near the well. Views of this well are shown in plate 12, *B*, *C*. On September 7 the valve was closed and the flow from the springs as measured was 230 gallons a minute. On the following day, after the well had been flowing with the valve open for about 24 hours, the total flow from the springs and the well amounted to 360 gallons a minute. The meter was lowered on September 7 to a depth of 230 feet below the valve, which is about at ground level. According to the driller's log, the well has 136 feet of 8-inch casing and 341 feet of 6-inch casing (from 62 to 402 feet). On the basis of a 6-inch casing, there was a flow of about 15 gallons a minute. The water moved up inside the 6-inch casing from a depth of about 230 feet and gradually left the well between depths of 194 and 94 feet below the surface. The meter would not go below a depth of 230 feet, but the comparatively high velocity recorded at 230 feet, together with the obstruction, indicate that there may be a large leakage at that depth.

Record of velocity in well 25

Depth (feet)	Velocity (feet per second)	Depth (feet)	Velocity (feet per second)	Depth (feet)	Velocity (feet per second)	Depth (feet)	Velocity (feet per second)
19	0.01	169	0.07	189	0.18	220	0.19
44	.00	172	.07	194	.19	222	.19
69	.01	177	.08	199	.19	224	.19
94	.02	179	.11	209	.19	227	.19
119	.04	184	.13	214	.19	228	.19
144	.07	186	.14	217	.19	229	.19
152	.07	187	.15	219	.19	230	.35
167	.07	188	.18				

WELL 26

Well 26 is known as Syndicate well No. 6. It is provided with a valve to control the flow. The top of the valve is about at the height to which the artesian water will rise, and, as the pressure varies from day to day, the flow is intermittent. The meter would not pass an obstruction about 4 feet below the surface.

WELL 27

Well 27 is owned by J. O. Blevins. The flow is under control. The meter was lowered into this well on August 25 to a depth of 345 feet below the top of the valve, which is about 4 feet above ground, and no underground leakage was found.

WELL 28

Well 28 is owned by W. M. Sweet. It is provided with a valve to control the flow. The meter was lowered on September 1 to a depth of 363 feet below the top of the valve, which is about 2.5 feet above ground. When the valve was closed there was a small flow in the well of about 2 gallons a minute. The water came up from a depth between 345 and 363 feet, flowed over the top of the 6-inch casing at a depth of 9 feet, and thence went down between the 6-inch and 8-inch casings. It probably escaped from the well by passing through or under the 8-inch casing.

WELL 29

Well 29 is owned by Henry Deadrich. It is on ground above the level to which the artesian water will rise. The meter was lowered on August 31 to a depth of 222 feet below the top of the casing, which is about a foot above ground, and no underground leakage was found.

WELL 30

Well 30 is close to the house of C. A. Bryant, and the land surface at the well site is above the level to which artesian water will rise. The well was explored on September 1 to a depth of 226 feet below the top of the casing, which is about a foot above ground. There was a very small flow in this well. The water came up past a depth of 226 feet and escaped from the well at a depth of about 148 feet.

WELL 31

Well 31, owned by the city of Las Vegas, is known as the Woodard well. The flow is under control. The meter was lowered on August 31 to a depth of 294 feet below the top of the tee, which is about 2 feet above ground, and no underground leakage was found.

WELL 32

Well 32 is owned by the Nevada State Highway Department. The flow is under control. The meter was lowered on September 8 to a depth of 647 feet below the top of the 10-inch casing, which is about 1.7 feet above ground, and no underground leakage was found.

WELL 33

Well 33 is owned by L. H. Rockwell. No provision has been made to control the flow. A view of the well is shown on plate 15, *C*. The meter was lowered into the well on September 6 to a depth of 387 feet below the top of the casing, which is 1.3 feet above ground. There was a small flow of about 2 gallons a minute. The water entered the well between depths of 327 and 347 feet, moved upward, and escaped between depths of 317 and 299 feet. A few very small springs appear around the well when it is shut in.

Record of velocity in well 33

Depth (feet)	Velocity (feet per second)	Depth (feet)	Velocity (feet per second)	Depth (feet)	Velocity (feet per second)	Depth (feet)	Velocity (feet per second)
0–297	0	303	0.02	308	0.02	357	0.01
297	0	304	.02	317	.03	367	0
299	.01	305	.02	327	.03	387	0
301	.01	306	.02	337	.02	385	0
302	.01	307	.02	347	.01		

WELL 34

Well 34 is owned by E. M. Cornish. A valve is provided to control the flow at the surface. A view is shown on plate 16, *A*. Explorations were made with the meter on September 6 to a depth of 691 feet below the top of the casing, which is about 2 feet above ground. The pipe fittings at the surface were leaking about 2 gallons a minute during the test, which accounts for all movement recorded down to a depth of 377 feet. In the absence of the casing record it is impossible to determine accurately what is taking place below that depth. If the well is cased with 6-inch casing, as seen at the surface, down to 380 feet, and if there is no casing below that depth, there may be a leak around the end of the casing amounting to about 5 gallons a minute. In any event the leakage is small and need not be considered serious.

Record of velocity in well 34

Depth (feet)	Velocity (feet per second)	Depth (feet)	Velocity (feet per second)	Depth (feet)	Velocity (feet per second)	Depth (feet)	Velocity (feet per second)
15	0.02	245	0.02	380	0.09	520	0.04
45	.02	270	.02	381	.12	545	.04
70	.02	320	.02	382	.06	570	.04
95	.02	345	.02	385	.07	595	.04
120	.02	370	.02	395	.04	620	.04
145	.01	375	.01	420	.04	645	.04
170	.02	377	.02	445	.03	670	.02
195	.02	378	.05	470	.04	689	0
220	.02	379	.09	495	.03	691	0

WELL 35

Well 35, owned by F. E. Armstrong, is near the ranch house. No provision has been made to control the flow. A view of the well taken September 2, 1938, is shown in plate 16, *B*, and a view taken more than 20 years ago, when it was known as "Barnsley's flowing well," appears in a previous report.[12] The meter was lowered on September 1 to a depth of 110 feet below the top of the casing, which is about a foot above ground, and no underground leakage was found. This test was not satisfactory, because the meter probably did not reach the bottom of the casing. The well was partly obstructed at a depth of 37 feet and totally obstructed at 110 feet.

WELL 36

Well 36 is also owned by F. E. Armstrong. It is in the southwest corner of the property. No provision has been made to control the flow. Explorations were made with the meter on September 1 to a depth of 346 feet below the top of the 8-inch collar, at ground level, and no underground leakage was found. A view of this well is shown in plate 16, *C*.

WELL 37

Well 37 is owned by G. T. Tallackson. The flow is under control. The meter was lowered into the well on August 30 to a depth of 247 feet below the top of the 4-inch tee, 1.5 feet above ground, and no underground leakage was found.

WELL 38

Information as to the ownership of well 38 was not obtained. The well is not provided with a control valve. The meter was lowered on August 30 to a depth of 265 feet below the top of the 6-inch collar, which is about 1.5 feet above ground, and no underground leakage was found. The pipe fittings leaked about 2 gallons a minute during the test, and this leakage was found to be coming from a depth of 236 to 241 feet.

WELL 39

Well 39 is owned by F. R. Mildren. It is provided with a valve to control the flow. The meter was lowered on August 30 to a depth of 222 feet below the top of the tee, which is at ground level, and no underground leakage was found.

WELL 40

Well 40, owned by W. E. Ferron, is situated on ground above the level to which the artesian water will rise. The meter was lowered

[12] Carpenter, Everett, Ground water in southeastern Nevada: U. S. Geological Survey Water-Supply Paper 365, pl. 3, B, 1915.

on August 31 to a depth of 103 feet below the top of the casing, 0.5 foot above ground, and no underground leakage was found.

WELL 41

Well 41, owned by Maude Fitzpatrick, is situated on ground above the level to which the artesian water will rise. The meter was lowered on August 31 to a depth of 359 feet below the top of the casing, which is 4 feet above ground, and no underground leakage was found.

WELL 42

Well 42, owned by Daisy Bell, is on ground above the level to which the artesian water will rise. The meter was lowered on August 31 to a depth of 128 feet below the top of the casing, which is about a foot above ground, and no underground leakage was found.

SUMMARY OF LEAKAGE TESTS AND SUGGESTIONS FOR REPAIRING LEAKY WELLS

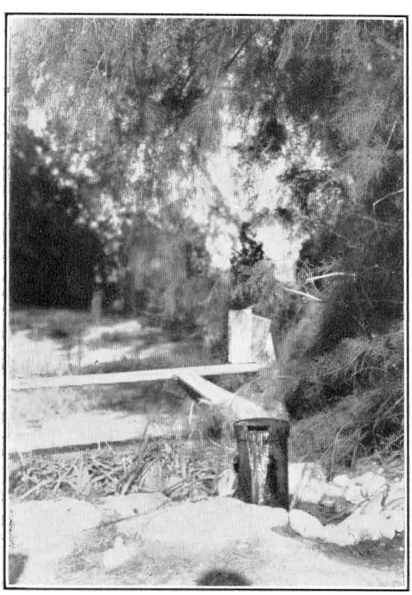
Of the 42 wells listed in this report 34 were tested to a satisfactory depth. The 8 wells not tested were caved or obstructed or for some other reason could not be tested to a depth at which leakage might be expected. The estimated total amount of underground leakage in the 34 wells tested was about 375 gallons a minute, of which about 300 gallons a minute came to the surface as springs in the vicinity of the wells. Most of the flow of 375 gallons a minute was lost from wells 7, 24, and 25. The leaks from the other wells tested are small and need not be considered further.

Well 7 leaks about 35 gallons a minute at a depth of about 41 to 43 feet, and the water thus lost evidently does not come to the surface near the well. The leak could be repaired by first pumping the well hole full of clay through a small pipe extending to the bottom, then removing the casing and setting a new string of casing to a much greater depth, and finally cementing on the outside of the casing by pumping cement through a small pipe extending to the bottom of the casing.

Well 24 leaks about 10 gallons a minute at a depth of 470 to 495 feet, 11 gallons a minute at 402 feet, and 26 to 28 gallons a minute at 64 feet. The movement below 400 feet is probably that of water flowing into upper sands that are under lower artesian pressure. In view of the fact that about 30 gallons a minute comes to the surface in the form of a spring close to the well, it appears probable that most of the underground leakage goes to supply this spring. It seems inadvisable to attempt to repair this well until a rigid conservation program covering the whole artesian basin is in force.

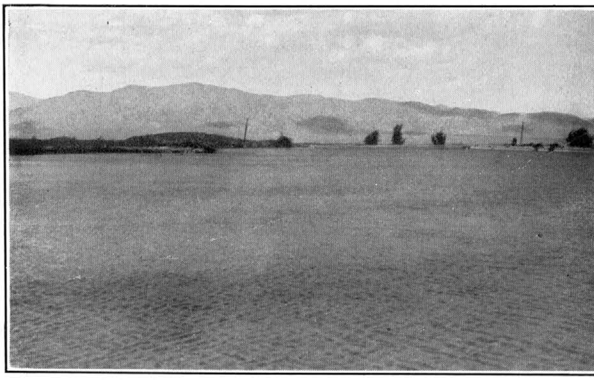
The springs surrounding well 25 flow about 230 gallons a minute. As this represents a large percentage of the total flow from the well,

A. WELL 34, OWNED BY E. M. CORNISH.

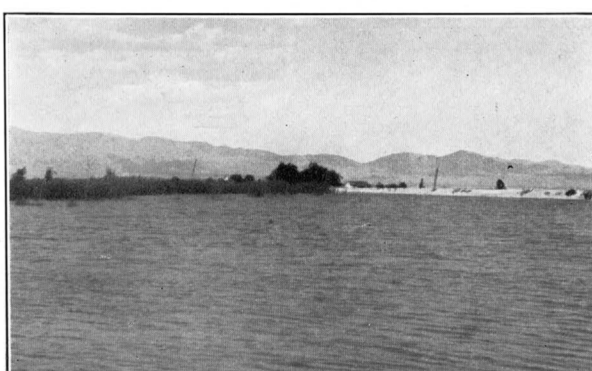


B. WELL 35, OWNED BY F. E. ARMSTRONG.

C. WELL 36, OWNED BY F. E. ARMSTRONG.



A. UPPER LAKE AT THE UNITED STATES FISH HATCHERY, MADE BY IMPOUNDING WATER FROM FLOWING ARTESIAN WELLS.



B. LOWER LAKE AT THE UNITED STATES FISH HATCHERY, MADE BY IMPOUNDING OVERFLOW FROM THE UPPER LAKE.

it shows either that the passageway on the outside of the casing is open and offers little friction to the movement of water or that the casing is obstructed and offers a nearly equal amount of friction. It is unfortunate that the well is so obstructed at 230 feet that the meter could not be lowered below that depth. It is believed, however, that most of the underground leakage comes to the surface and that there is no necessity for repairing this well until a serious effort is made to reduce the waste due to flowing wells from the whole artesian basin. When it becomes necessary to repair this well it could be brought under control by pumping it full of clay through a pipe, 1½ or 2 inches in diameter, leading to the bottom of the well. It might then be possible to pull out all the casing, ream the hole larger to a depth of about 200 feet, set a new casing, and cement on the outside of it. If difficulty were experienced in getting a tight seal at the bottom of the casing for cementing, the mud from the bottom of the well up to a depth of about 200 feet could be replaced with sand through a pipe leading to the bottom. Later the mud or sand could be removed from the well by circulating water in it or by means of an air-lift pump. Probably it would be cheaper, however, to seal this well with clay and a cement plug and to drill a new well than to attempt repairs.

It is believed that the waterlogging of the ground east of the group of wells comprising Nos. 19 to 23 is caused by irrigation from these wells and is not due to underground leakage from them. The surface flow from this group amounts to at least 450 gallons a minute continuously.

Only a small percentage of the total number of artesian wells in the valley were tested with the current meter. It is believed, however, that the underground leakage from wells is very small, except from a few that are poorly constructed or improperly cased.

WASTE OF ARTESIAN WATER

It has been reported by Floyd Francis, well driller, that the first flowing artesian well in the Las Vegas basin was drilled in the NW¼NE¼ sec. 21, T. 20 S., R. 61 E., in the year 1907. Since then wells have been drilled from time to time until in 1938 there were probably between 200 and 300 artesian wells in the basin. For the most part, if water from a well has not caused any local inconvenience the well has been allowed to flow in full force year after year. Many wells have flowed unchecked ever since the day they were drilled.

As the artesian pressure has been lowered, the flow from some wells has decreased considerably and other wells have ceased to flow. As the pressure in the upper artesian sands has declined, new wells have been drilled to the deeper sands, and these, too, are allowed to flow uncontrolled. The flow from some of the wells irrigates only a few cottonwood trees surrounding abandoned homes. The flow from wells 24 and 25, amounting to a measured total of over 1,100 gallons a minute during September 1938, waters a few head of stock, and the surplus goes to form a wild-duck pond. Plate 17, *A* and *B*, shows views of two fish ponds belonging to the United States fish hatchery that are supplied from flowing artesian wells. The seepage from these earth-banked ponds has spread out down the slope and can be seen nearly as far as the Las Vegas-Tonopah highway, a mile away. Attempts are being made in some localities to combine the flow of water from several wells and to carry it in open earthen ditches for several miles to places where it is used for irrigation. The soil absorbs water readily and only a small part of the flow at the wells reaches the land to be irrigated. In these localities the water from the artesian wells is generally allowed to flow in the ditches all winter in order that the soil along the ditches will be wet when spring comes. It is believed that if this soil were allowed to dry out during the winter the water from the wells would probably not reach the fields during the summer. There are no water meters in the waterworks that supply the city of Las Vegas. The Las Vegas Land and Water Co., which owns and operates the waterworks, reports that with the advent of air-conditioning, water consumption has increased, until in 1938 the city, with a population of about 8,000, is consuming about 5,000,000 gallons a day. This water is obtained by the company from the original spring and from two flowing wells that discharge into the main reservoir. The wells are allowed to flow without control, and any excess water that the city does not use overflows into the creek and so reaches a ranch northeast of the city.

CONCLUSIONS

The results of the tests with the deep-well current meter in 34 artesian wells in the Las Vegas area show that the underground leakage from these wells is small. A few wells that are poorly constructed or improperly cased leak an appreciable amount of water, but the aggregate leakage is small.

It is believed that the wells tested are fairly representative of the wells in the area and that the loss of artesian water by underground leakage is not great. The material of the valley fill varies widely from place to place, but it is generally coarser near the mountains and finer toward the valley, and therefore wells are less likely to leak through the fine overlying material in the valley than through the coarser material toward the mountains. The material varies so widely from place to place that it is only by knowing the permeability of the overlying material at each well that it is possible to judge the amount of water that may waste from the well below the ground and the care that is necessary in placing and cementing the casing. New wells should be tightly cased and the casing cemented to a depth of at least 200 feet.

Much artesian water that is discharged by wells is wasted or put to low use. The area a short distance east of wells 19 to 23 is probably waterlogged by artesian water used in surface irrigation rather than by underground leakage from the artesian wells. The ground near the United States fish hatchery is being waterlogged chiefly by seepage from the lakes that are maintained by the flow from artesian wells and not from underground leakage. The people in the Las Vegas area should understand that the artesian water supply is not unlimited and that conservation of the supply is necessary. It is believed that if the draft upon the artesian basin were reduced and strict measures of conservation applied, the pressure, in the shallower sands, especially, would increase noticeably.

The water that flows from the wells is clear and does not carry much sediment, and therefore there is little danger of affecting the potential capacity of the wells by closing the valves when the water is not needed. However, the flowing wells should be opened or closed slowly in order to avoid shock from water hammer that may dislodge any loose material from the walls of the hole.

WELL RECORDS

Records of wells in the Las Vegas area, Nev., inspected during August and September 1938

Well No.	Owner	Location			Depth below surface to which meter could be lowered (feet)	Size of casing (inches)	Apparent use of water [1]	Temperature (°F.)	Flow at surface				Water level			Remarks
		Section	T. (S.)	R. (E.)					Gallons per minute	Miner's inches, Nevada	Point of discharge above surface (feet)	Date	Measuring point above surface (feet)	Above or below (−) measuring point (feet)	Date	
1	H. Taylor	SW¼SE¼ sec. 24	20	60		8	N		None	None		Aug. 15	Top of casing, 0.6.	−14.7	Aug. 15	Obstructed 10 feet below surface. Depth to water 10.5 feet in 1936.
2	L. C. Eggling-ton.	SW¼SE¼ sec. 24	20	60	270	8	N		None	None		Aug. 15	Top of casing, 2.5.	−5.80	Aug. 15	Water level at surface in 1936. See also W. S. P. 365, p. 30, well 1.
3	Syndicate No. 2	SW¼NW¼ sec. 19	20	61	234	8	N	72	27	3.0	1	Sept. 12	Top of tee, 2.0	0.93	Aug. 26	
4	Syndicate No. 1	NW¼SW¼ sec. 19	20	61	244	12	N	72	20	2.2	2	Sept. 12	Top of tee, 2.7	0.84	Aug. 27	
5	Syndicate No. 5	NW¼NE¼ sec. 19	20	61	260	12	N	72	67	7.5	4	Sept. 12	Top of plug, 4.5	18.5	Aug. 15	
6	R. J. Lewis	NW¼SW¼ sec. 20	20	61	268	8 6	D, S, Irr	72	67	7.5	3	Sept. 12	Top of tee, 2.0	10.4	Aug. 29	
7	H. Oppdyke	NW¼SW¼ sec. 20	20	61	101	6	Irr	72	245	27.3	2.5	Sept. 12	Top of casing at bottom of tee, 2.0.	31.2	Aug. 23	
8	John Frewalt	NE¼SW¼ sec. 20	20	61	300	10	Irr	72	9	1.0	1	Aug. 27				
9	Las Vegas Building & Land Co.	NW¼SE¼ sec. 21	20	61		10	N		None	None		Aug. 29	Top of casing, 1.2.	−3.58	Aug. 29	Obstructed at ground level.
10	Town of North Las Vegas	SW¼SE¼ sec. 22	20	61	524	8 6	P		100	11.1	2	Sept. 10	Top of 4-inch tee, 2.0.	13.6	Sept. 10	
11	Town of North Las Vegas.	SW¼SE¼ sec. 22	20	61	146	4	P		120	13.4	2	Sept. 10	Top of 4-inch tee, at ground.	17.3	Sept. 10	
12	T. J. Thebo	SW¼ sec. 28	20	61	637	8 6	D	76	75 10	8.4 1.1	6 1.7	Sept. 9	Top of 8-inch collar, 1.7.	28.4 2.4	Sept. 9	Pressures taken inside and outside of 6-inch casing.
13	Pat Cline	NE¼SE¼ sec. 33	20	61	600	8 6	Ind						Top of 8-inch casing, 1.0.	41.4	Aug. 23	Drilled in 1938.
14	A. W. Blackman	NW¼SW¼ sec. 33	20	61	393	6	N						Top of 6-inch tee, 2.4.	11.5	Aug. 25	Flow 225 gallons per minute in 1936.

15	Mrs. Myrtle Tate.	NW¼SW¼ sec. 33	20	61	425	8, 6	D, S, Irr		63	7.0	4	Sept. 12	Top of 4-inch valve, 4.0.	5.1	Aug. 24	
16	Helen Nagel	SW¼NE¼ sec. 32	20	61	363	8, 6	N		None	None		do	Lower lip of elbow, 4.4.	−6.45	Sept. 12	
17	James Filbey	NW¼SE¼ sec. 32	20	61	616	8, 6, 4	N	79	265 30	29.5 3.3	2 0.5	do	Top of 8-inch casing, 0.0	89.8	Aug. 24	Flow between 5 and 8-inch casings and from 6-inch casing.
18	M. D. Kidder	NW¼SE¼ sec. 36	20	60	209	8, 6, 4	N		None	None		Aug. 18	Top of casing, 1.0.	−29.62	Aug. 15	4 feet to water in 1925; 24 feet to water in 1936.
19	W. N. Hinson	SW¼NE¼ sec. 6	21	61	275	8, 6	D, S, Irr	74	33	3.7	2	Sept. 12	Top of 8-inch casing, 0.5.	17.1	Sept. 7	56 feet of 8-inch casing; 270 feet of 6-inch casing.
20	I. M. Pinjuv	SW¼NE¼ sec. 6	21	61	270	6	D, S, Irr	74	120	13.4	2	do	Top of 4-inch valve, 0.5.	18.0	Aug. 16	292 feet of 6-inch pipe.
21	J. H. Umbaugh	SW¼NE¼ sec. 6	21	61		11, 8	S, Irr	75	300	33.4	1	do				32 feet of 11-inch casing; 362 feet of 8-inch casing.
22	J. H. Umbaugh	SW¼NE¼ sec. 6	21	61	222	6	S, Irr	74	100	11.1	3	do	Top of 6-inch casing, 1.7.	17.8	Sept. 7	Flow 13.5 inches in 1935.
23	Fred Gobeli	SE¼NE¼ sec. 6	21	61	226	6	D, S, Irr		36	4.0	7	Sept. 8	Top of 6-inch collar, 3.0.	18.5	Sept. 8	Reported to have 130 feet of 6-inch casing.
24	Lindsay estate	SW¼NW¼ sec. 5	21	61	553	8	N	77	760	84.6	2.5	Sept. 12	Top of valve, 2.0.	73.7	Sept. 6	
25	Lindsay estate	SW¼ sec. 5	21	61	230	6	D, S		360	40.1	0	Sept. 8	Top of valve, at ground.	35.8	Sept. 7	Drilled in 1914.
26	Syndicate No. 6	SW¼NW¼ sec. 4	21	61	8	8	N		2	.2	4	Aug. 25				Reported to have 135 feet of 8-inch casing to depth of 373 feet.
27	J. O. Blevins	SW¼NE¼ sec. 4	21	61	341	8	D, S, Irr						Top of valve, 4.0.	6.9	Aug. 25	
28	W. M. Sweet	SE¼SE¼ sec. 7	21	61	360	8, 6	D, S, Irr	74	35	3.9	3	Sept. 12	Top of 4-inch valve, 2.5.	20.6	Sept. 1	
29	Henry Deadrich	SW¼NW¼ sec. 18	21	61	221	8	N		None	None		Aug. 31	Top of 8-inch collar, 1.0.	−28.15	Aug. 31	
30	C. A. Bryant	NW¼SE¼ sec. 18	21	61	225	6, 4	N		None	None		Sept. 1	Top of casing, 1.0.	−6.16	Sept. 1	80 feet of 6-inch casing; 275 feet of 4-inch casing.
31	City of Las Vegas.	NW¼SE¼ sec. 17	21	61	292	6	N						Top of 6-inch tee, 2.0.	12.2	Aug. 31	Known as the Woodard well.
32	State Highway Department.	SW¼NW¼ sec. 16	21	61	646	10, 8, 6	Irr.	77					Top of 10-inch cap, 1.7.	35.3	Sept. 8	
33	L. H. Rockwell	SE¼NW¼ sec. 15	21	61	386	6	S	75	120	13.4	3	Sept. 12	Top of casing, 1.3.	7.6	Sept. 6	
34	E. M. Cornish	SE¼NW¼ sec. 22	21	61	690	8, 6	N						Top of 8-inch casing, 2.0.	54.8	Sept. 6	

Records of wells in the Las Vegas area, Nev., inspected during August and September 1938—Continued

Well No.	Owner	Location: Section	Location: T. (S.)	Location: R. (E.)	Depth below surface to which meter could be lowered (feet)	Size of casing (inches)	Apparent use of water [1]	Temperature (°F.)	Flow at surface: Gallons per minute	Flow at surface: Miner's inches, Nevada	Flow at surface: Point of discharge above surface (feet)	Flow at surface: Date	Water level: Measuring point above surface (feet)	Water level: Above or below (−) measuring point (feet)	Water level: Date	Remarks
35	F. E. Armstrong	NW¼SW¼ sec. 27	21	61	109	8	N	78	11	1.2	2	Sept. 12				See also W. S. P. 365, p. 30, well 6.
36	F. E. Armstrong	NW¼SW¼ sec. 27	21	61	346	8	N	78	16	1.8	0	Sept. 12				
37	G. T. Tallackson.	NW¼NE¼ sec. 34	21	61	246	4	D, S, Irr						Top of 4-inch tee, 1.5.	6.9	Aug. 30	
38	Unknown	NW¼NW¼ sec. 34	21	61	263	6	N	77	19	2.1	2	Sept. 12	Top of 6-inch collar, 1.5.	24.3	Aug. 30	
39	F. R. Mildren	NE¼NW¼ sec. 33	21	61	222	6	N	83	100	11.1	0	Sept. 12	Top of 6-inch tee, at ground.	0.60	Aug. 30	
40	W. E. Ferron	SW¼SW¼ sec. 28	21	61	103	8	N		None	None		Aug. 14	Top of 8-inch casing, 0.5.	−20.03	Aug. 14	
41	Maude Fitzpatrick.	SW¼NW¼ sec. 4	22	61	355	8	N		None	None		Aug. 14	Bullet hole in casing, 3.0.	−78.79	Aug. 14	
42	Daisy Bell	NW¼SW¼ sec. 9	22	61	127	12	N		None	None		Aug. 31	Top of casing, 1.0.	−90.8	Aug. 31	

[1] D, Domestic; Ind, industrial; Irr, irrigation; N, not used; P, public supply; S, stock.

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Harold L. Ickes, Secretary

GEOLOGICAL SURVEY
W. C. Mendenhall, Director

Water-Supply Paper 849

CONTRIBUTIONS TO THE HYDROLOGY OF THE UNITED STATES

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