of the glacier. They are known as kames. Many of them are mounds that rise above the general land surface and others occur below the surface at the general plain level. Most gravel pits in the county are in these deposits.

The trend of kames and associated deposits throughout the county is in a northeast-southwest direction, similar to the present trend of Eel River. The relatively uniform trend suggests that the ice sheet moved southwest across the county, which accords with the direction of movement suggested by the deposits in nearby counties.

The relatively great permeability of the surficial materials in areas of Fox and Genessee soils, as shown on plate 1, allows water from precipitation and, in places, from stream flow to percolate freely into the underlying outwash deposits, from which the water is discharged into streams or by evaporation and transpiration (use by vegetation), or is transmitted by slow seepage to less permeable adjacent deposits. The kames and associated gravel deposits serve in a similar manner.

Recharge from precipitation doubtless occurs through the soil and glacial till in the area of ground moraine. Surface drainage is poor and large flat areas or depressions slow up surface runoff and promote ground-water recharge. However, owing to the low permeability of the till, the rate of recharge is much less than that in areas of glacial outwash.

GROUND WATER AND GROUND-WATER LEVELS

GENERAL DISCUSSION

Water falling as precipitation on the earth's surface follows a complex hydrologic cycle. Part of the precipitation returns to the air by evaporation and transpiration; part runs off into surface streams, ditches, and lakes; and part seeps into the ground. That part that is stored in the ground, generally temporarily, is called ground water.

The water that seeps into the ground tends to percolate downward through openings in the soil and rocks, including interstices between individual fragments of rock and cracks and fissures in hard rocks, to reach the zone of saturation, in which the rock openings are filled with water. The upper surface of the zone of saturation, except where formed by an impermeable body, is the water table, and its position is shown in a general way by the water levels in wells.

In areas where porous and permeable formations are present at the surface and water from precipitation can reach the zone of saturation by direct downward percolation, water is said to occur under water-table conditions. Where, however, the water-bearing formations are overlain by relatively impermeable formations and the water in the aquifers is confined under hydrostatic pressure, artesian conditions exist, and the water levels in wells will rise above the bottom of the confining layer. Under artesian conditions, the water levels in wells tapping the confined aquifers will show the position of the pressure-indicating or piezometric surface. In Boone County, ground water occurs under both artesian and water-table conditions in different places.

The water levels in many wells are recorded in the well tables as depth in feet below the land surface. Some of these levels are based on drillers' and owners' reports, but many were measured by personnel of the U. S. Geological Survey. The latter measurements are indicated where the water level is shown to the nearest tenth or hundredth of a foot. The elevations of water levels in feet above sea level in the individual wells are shown on plate 5 and figure 5, which also show contours on the piezometric surface or the water table. In some localities the surface shown is the water table but in others it is an artesian-pressure surface. No attempt has been made to distinguish between the two on the map. The contours in the extreme southern part of the county, from Fayette to Jamestown, are questionable because of the scarcity of reliable data.

The elevations of water levels in the shallow wells (that is, wells less than about 32 feet in depth), which include most of the dug wells, were used with caution as a guide in contouring. In general, the water levels in deep and shallow wells fairly close to each other are nearly the same, though in most localities the water levels in the shallow wells are slightly higher than those in the deep wells. The mean difference in water levels between the deep and shallow wells was observed to be approximately 8 feet in 47 localities where a shallow well and a deep well are close together. However, it is believed that the aquifers of Boone County are connected hydraulically even though they may be separated locally by relatively impermeable beds. The lower water levels in the deeper wells indicate that water is moving from the shallow into the deeper aquifers.

The estimated elevation of the water surface of streams near bench marks at various points in the county are shown on plate 5.

An examination of plate 5 shows that generally the piezometric surface and water table conform with the topography and that ground water discharges naturally to Sugar Creek and Eagle Creek. Discharge by evapo-transpiration

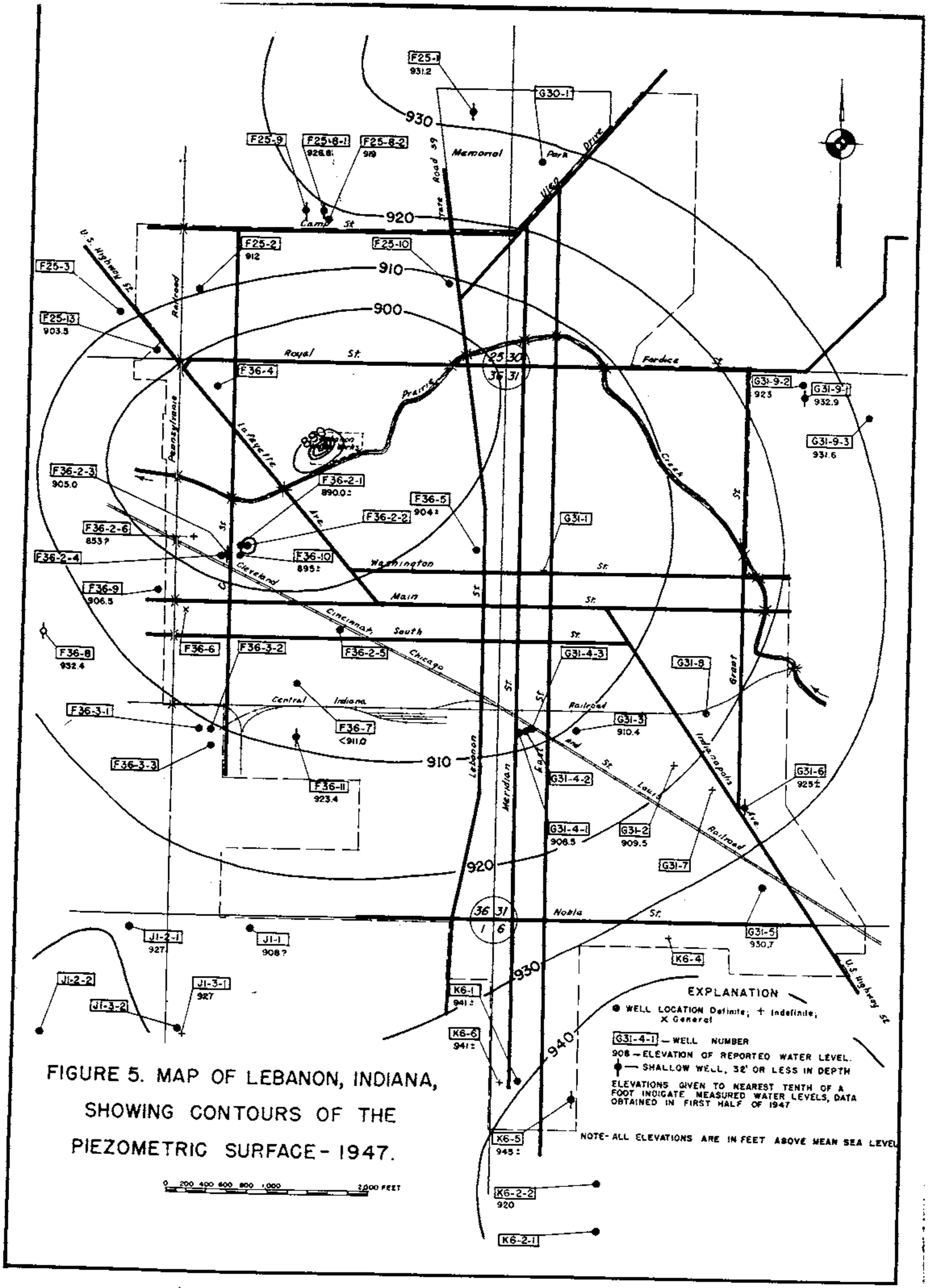

FIGURE 5. MAP OF LEBANON, INDIANA, SHOWING CONTOURS OF THE PIEZOMETRIC SURFACE - 1947.

is discussed later, in the section on observation wells. The effects of pumping at Lebanon and Jamestown are also indicated by cones of depression of the piezometric surface. (See fig. 5 for a more detailed picture of the Lebanon area.) The high points on the piezometric surface in the area surrounding Lebanon indicate possible areas of recharge from rainfall to the ground-water reservoir. The depression in this surface near the center of Tps. 18 and 19 N., R. 2 W., may be due to structural or textural features in the bedrock allowing a relatively high rate of movement of the ground water through it, inasmuch as the bedrock is close to the surface in this area.

There are a number of flowing wells in Boone County. They are located in areas in which the piezometric surface is higher than the ground surface, mainly in valleys. They are indicated in the well records and are shown on plate 5.

The strongest flows noted by the writer were from well BoB29-1-1, which was reported to yield 250 to 300 gallons per minute from a 3-inch casing, and well BoL14-3, which was observed to give about the same yield from a 4-inch casing. Harrell (8, p. 132) reports that three flowing municipal gravel wells at Thorntown (probably wells BoA35-1, 2, and 3), "produce an unlimited quantity of water, estimated as high as one and one-quarter million gallons per day." Capps (4, p. 72) reports that well G-Bo??-33 in 1887 spouted an 8-inch jet of water 7 feet above the well mouth, from gravel at a depth of about 90 feet, which he stated to indicate a flow of over 3,000 gallons per minute.

Comparison of present water levels with those given by Capps (4) in 1907 suggest some general decline in water level. It was not possible to locate many of the wells listed by Capps or to determine the season during which the water level was measured. Records of water levels in past years, except those given by Capps, are almost nonexistent. Of the 19 wells or areas for which general comparisons could be made, 13 showed net declines in water level ranging from a few feet to as much as 22 feet, 5 showed net rises ranging from a few feet to as much as 8 feet, and 1, near Royalton, showed no net change. The apparent net declines in water level have occurred in the vicinity of towns and cities, where pumpage of ground water is doubtless much greater at present than in 1907.

Capps (4) reported the water level in a well 97 feet deep in Lebanon municipal well field to be about 20 feet below the ground surface. The highest water level in well BoF36-1-6, about 104 feet deep, during 1945, 1946, and 1947, was 42 feet below the surface, in 1947, showing a decline of at least 22 feet in that well, one of the greatest declines reported in the county.

Declines of water levels were noted in other wells in Lebanon. The water level in well BoG31-4-1 was reported to be 17 feet below the ground surface when the well was drilled in 1910. The highest static level measured in recent years was about 40.5 feet. A nearby well (BoG31-2), tapping a different aquifer, had the same general water level (18 feet below the land surface in 1917 when the well was drilled). The hydrograph of this well shows that there was no apparent decline in the water level up to the spring of 1937.

An examination of plate 5, figures 6, 7, and 8, and the well records suggests that the decline of water levels is due primarily, if not almost totally, to pumping, and that cessation of pumping probably would result in a rise of water levels to stages comparable with those when wells were first drilled.

Four wells listed in the records were reported to have "completely drained" when nearby ditches were excavated or deepened; they are wells BoF11-1, BoF22-1-1, BoJ2-1-1, and BoJ26-3. However, nearby wells tapping the same aquifers as wells BoF22-1-1 and BoI2-1-1 were apparently unaffected. The original water level elevations of these wells agree with the contours of the water table drawn from other water-level elevations on plate 5. It is possible that the wells may have been drained, but it is more likely that the water levels may have declined to a point below the suction of the pumps or that the wells or pumps became plugged or otherwise faulty, suggesting the complete "draining."

OBSERVATION WELLS

Regular measurements of water level were started in wells BoJ23-1-1 and BoK4-1-1 in September and October 1935, respectively, as part of a State-wide observation-well program. These wells are also identified as observation wells O-Boone 1 and O-Boone 2, respectively. The regular measurements were discontinued in October 1941, but occasional measurements were made in 1942, 1943, 1944, and 1945. Regular measurements were resumed in 1945 and have been continued to date in well O-Boone 2. Well O-Boone 1 was replaced by well O-Boone 16 (BoJ23-1-2) in September 1946. These are abandoned shallow wells, less than 25 feet deep, located in areas where there is no apparent effect of pumping from other wells. Graphs of water levels in these wells are shown in figures 6 and 7.

The water levels in these wells usually rise during the winter and spring when losses from evaporation and transpiration are at a minimum and when conditions for recharge from precipitation are favorable. During the growing season, from about the last week in April to the second week in October, losses by evaporation and transpiration are high and ground-water recharge is small, so that the water levels, particularly in shallow wells, generally decline as the ground water moves to lower areas and is discharged into and along the streams. Precipitation during the summer months is seldom effective in raising ground-water levels.

Regular water-level measurements were made in an abandoned well, O-Boone 3 (BoG31-2), in the southeastern part of Lebanon, from October 1935 to April 1937, when the well was destroyed. This well was reported to be about 230 feet deep. The graph of water level in this well, which also appears on figure 6, shows a maximum seasonal range of 8.6 feet for the period of record.

The water-level records for wells O-Boone 4 (BoF36-1-6) and O-Boone 10A (BoF36-1-10A) were obtained by automatic water-stage recorders installed in May and October 1945, respectively. The first well is 104 feet deep and the second, about 216 feet deep; both are abandoned wells in the Lebanon municipal well field of Lebanon Utilities, Inc. (See fig. 9 and well records.) Water-level records for these wells reflect very clearly the effects of pumping from other nearby wells in the same aquifers. Graphs of the water levels at 2 a.m. for each day of record are shown in figure 8. The great decline of the water level of well O-Boone 10A (BoF36-1-10A) in the summer of 1946 is due to the fact that BoF36-1-10 was pumped frequently, starting early in June.

Regular weekly measurements of water levels in wells O-Boone 11 (BoF36-1-11), O-Boone 12 (BoF36-1-12), O-Boone 13 (BoF25-1), and O-Boone 14 (BoG31-2) were started in October 1945. These wells are 193, 142, 18, and 143 feet deep, respectively. The first two are abandoned wells in the Lebanon municipal well field (fig. 9). Their water levels are affected by pumping, that in the latter well to a lesser degree than that in the former, inasmuch as no pumped well of similar depth exists in this field. Well O-Boone 11 also shows the great decline of water level during the summer of 1946, as mentioned above. Well O-Boone 13 is an abandoned well in Grant Memorial Park, on the north side of Lebanon, and well O-Boone 14 is near the water tower in the central part of Lebanon (figs. 2 and 3). Graphs of the water levels of these wells are shown in figure 7; that of well O-Boone 13

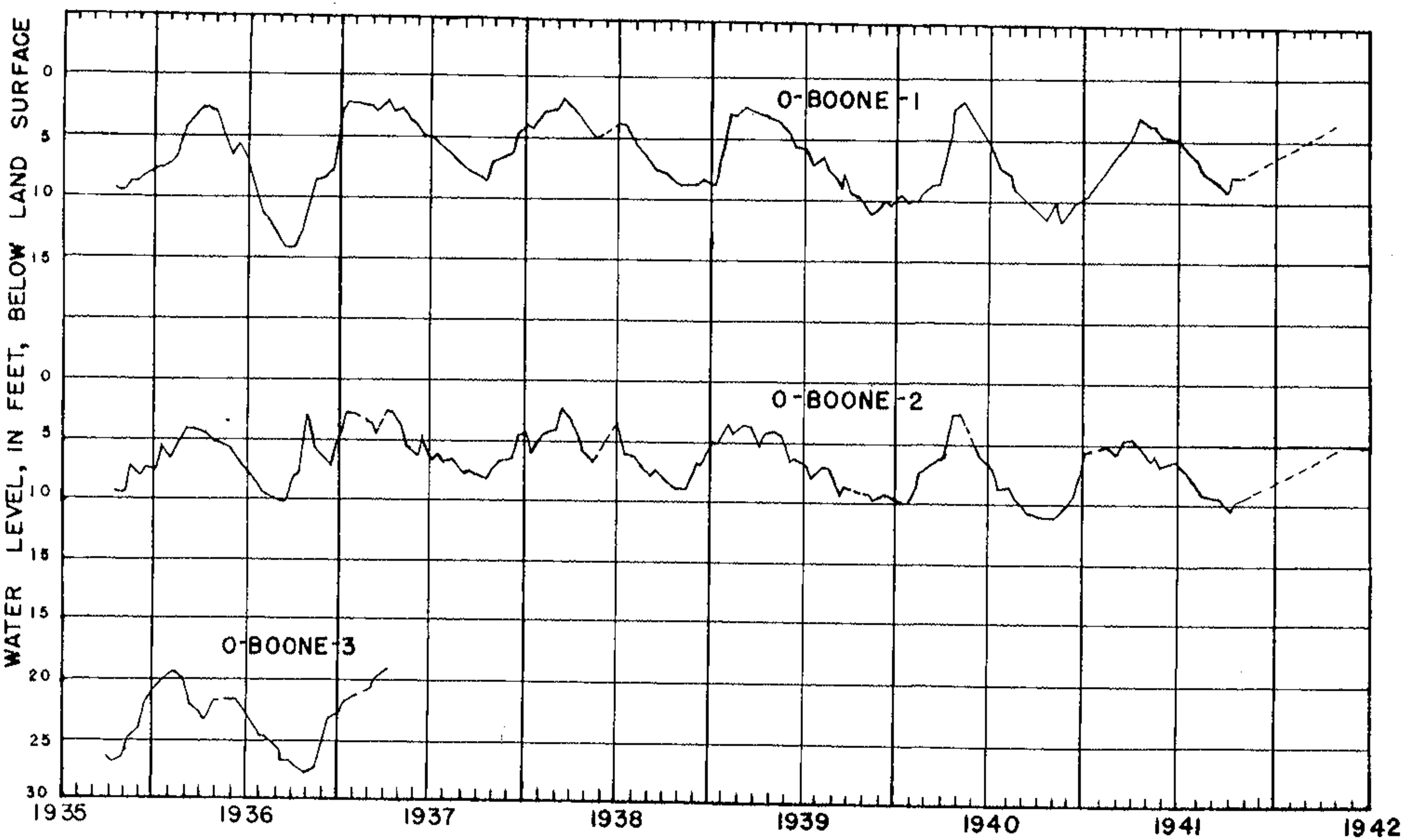

FIGURE 6. GRAPHS OF WATER LEVELS IN OBSERVATION WELLS O-BOONE-1, O-BOONE-2, O-BOONE-3, 1935-42, BOONE COUNTY, INDIANA

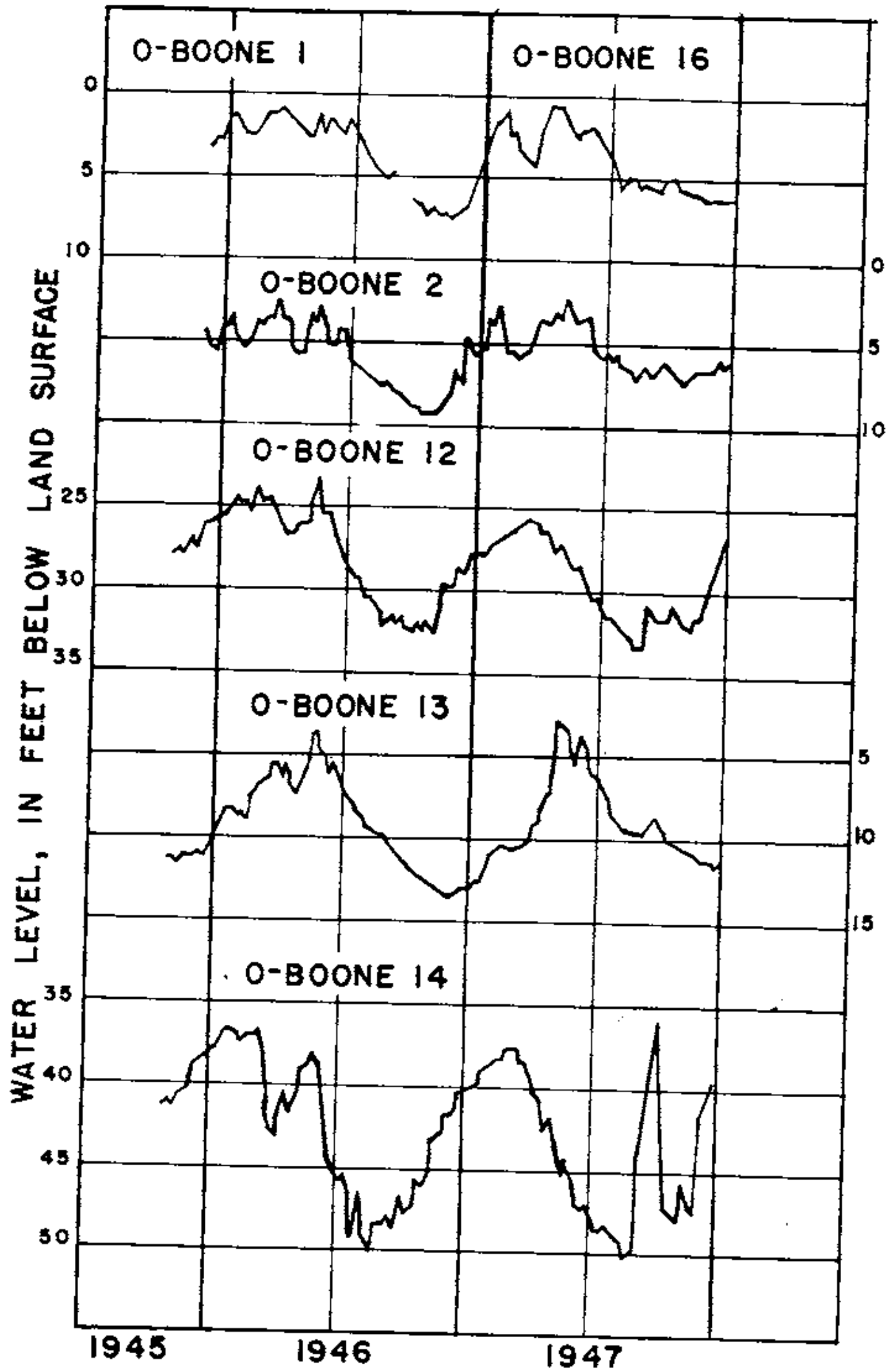

FIGURE 7. GRAPHS OF WATER LEVELS IN OBSERVATION WELLS O-BOONE 1, O-BOONE 2, O-BOONE 12, O-BOONE 13, O-BOONE 14, O-BOONE 16, 1945-47.

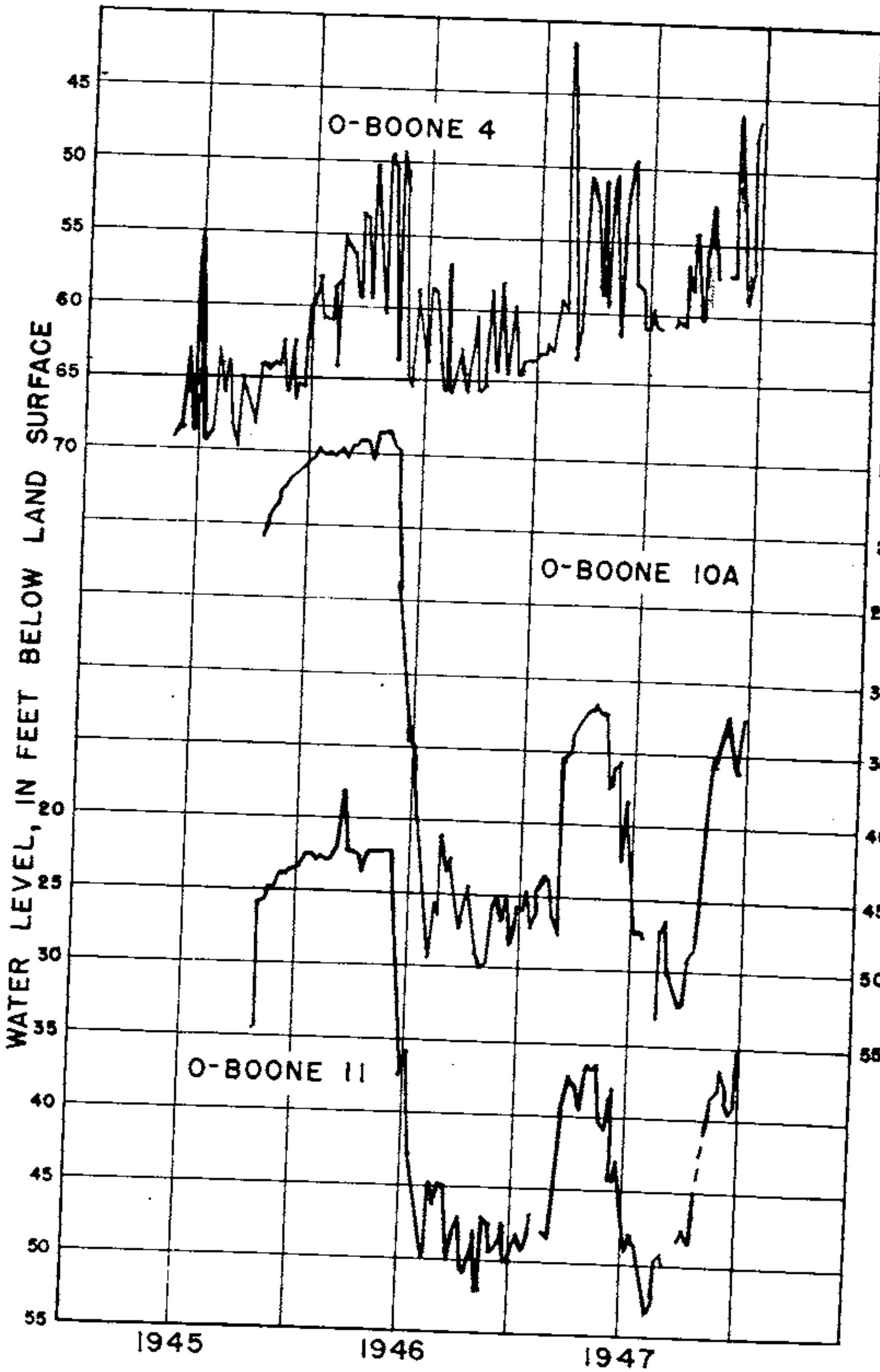

FIGURE 8. GRAPHS OF WATER LEVELS IN OBSERVATION WELLS O-BOONE 4, O-BOONE 10A, AND O-BOONE 11, 1945-47.

is similar to those of wells O-Boone 1, 2, and 16. The pumping of well BoF25-1-2 during the warmer months may possibly affect the water level in well O-Boone 13 to a small extent. The graph of the water level in well O-Boone 14 shows the effect of pumping well BoG31-4-1, a 154-foot well located about 575 feet west of it. Regular weekly measurements of the water level in the latter well, which is pumped during spring, summer, and autumn by an ice company for cooling purposes, were begun in February 1946.

The highest and lowest water levels measured in these observation wells during 1946 and 1947 are listed below as depths in feet below the land surface.

Table 5. Range in water level in observation wells, Boone County, Indiana, in feet below land-surface datum, 1946-47.

Observation well	1946				1947			
	Highest water level	Date	Lowest water level	Date	Highest water level	Date	Lowest water level	Date
O-Bo-1	0.97	3/18	----	--	----	--	----	--
O-Bo-16	----	--	7.29	11/25	0.56	4/21	6.10	11/28
O-Bo-2	2.52	3/15	9.18	10/11	2.15	5/1	7.25	10/18
O-Bo-4	45.50	4/8	67.60	2/16	41.55	2/22	63.35	1/24
O-Bo-10A	13.59	5/10	51.17	10/13	30.14	4/14	54.25	8/14
O-Bo-11	18.18	3/15	52.40	11/1	36.54	4/24	53.42	8/8
O-Bo-12	26.55	5/17	35.98	11/1	25.66	3/14	33.36	8/21
O-Bo-13	3.49	5/24	13.47	12/6	2.83	5/1	12.73	1/10
O-Bo-14	36.70	1/25	50.14	8/23	35.78	10/4	50.02	8/21
O-Bo-15	39.45	3/15	93.67	8/16	40.15	2/14	99.60+	7/18-8/18[a]

a/ Measurements discontinued Aug. 18.

It should be noted that in all the wells except wells O-Bo-10A, -11, and -15, which are greatly affected by pumping, both the highest and lowest water levels reached during 1947 were from a tenth of a foot to several feet higher than similar levels reached during 1946, although precipitation at Whitestown during 1946 was greater than during 1947.

The period of record of water levels in Boone County is too short for the determination of general trends. The records do show, however, that water levels in Boone County in wells unaffected or only slightly affected by pumping have a seasonal fluctuation of about 7 to 15 feet. For this reason, it is necessary to continue regular measurements of water level in wells over a period of years to determine general long-term trends. The seasonal fluctuation in wells 0-Bo-10A, -11, and -15 has been considerably greater, ranging from about 18 to more than 60 feet, owing in large part to the effect of pumping.

Early in November 1947 the water levels were measured in wells widely distributed throughout the county. These levels were compared with those measured when the well inventory was made in the first half of 1947. Three wells of the 72 measured showed a rise in water level. These three are deep wells in the Lebanon area, where the fluctuation in the amount pumped would account for the rise. Of these, the greatest rise (18.68 feet), was in well BoF35-1-3. The remaining 69 wells showed a net decline in water level. Twenty-five of these are shallow (approximately 32 feet or less in depth) and showed an average decline of about 4 feet, the greatest decline in a well unaffected by pumping being 5.44 feet, in well BoL23-3-1. Forty-four wells are deep and showed an average decline of 1½ feet, the greatest decline being 4.08 feet, in well BoF34-9, which is affected by little or no pumping. The declines appear to be seasonal, and do not indicate a general downward trend.

UTILIZATION OF GROUND WATER

INTRODUCTION

Because of the relative ease in obtaining small supplies of ground water at low cost, ground water is used more extensively than surface water in Boone County. All the municipal water-supply systems and nearly all the industrial plants that use substantial amounts of water depend on ground water for their source of supply, as do also the rural users. Surface water is used for watering stock and washing gravel. The water used for cooling purposes by the Indiana Condensed Milk Co., in Lebanon is taken from water-filled gravel pits, which constitute, in effect, large dug wells, in the southeast part of town. The Ohio Oil Co. plant in Hendricks County, just southeast of Jamestown, is reported to use a continual supply of water taken from Eel River.

WELL CONSTRUCTION AND OPERATION

There are several common types of water wells in Boone County. A dug well is generally a shallow well consisting of a hole dug in the ground. Most of these wells are lined with some material, such as brick, stone, tile, or wood slats, to prevent caving of the sides. Generally they are several feet in diameter, and tap water-table or shallow artesian aquifers. An unusual dug well is BoF36-1-4, which is 47 feet deep and 30 feet in diameter, and is lined with concrete.

Driven wells are constructed by driving into the ground a small-diameter pipe, usually fitted with a well point and screen on the bottom section, until an aquifer is penetrated or the screen is below the water table. They are usually not deep.

The most common type of well in the county is the drilled well. In recent years most new wells have been drilled because of the speed with which they can be completed and the greater depths to which they can be constructed. The depths and diameters of these wells vary greatly. Generally in Boone County the well casings are from 2 to 12 inches in diameter, the municipal and industrial wells ranging between 6 and 12 inches, and the more recently drilled domestic wells, 2 to 4 inches. This type of well, in Boone County, is made by drilling a hole with a standard cable-tool rig by the percussion method, through a metal casing driven into the hole, keeping the drilling bit several feet ahead of the bottom of the casing. The rock cuttings are bailed out frequently. When a suitable aquifer is penetrated, the hole is drilled to a desired depth and the bit is withdrawn. In sand and gravel wells a screen may be set in the bottom of the hole and the well is bailed clean. Not all drillers use a screen, nor do all seal the screen to the bottom of the casing. Some drillers pump and surge the well to remove the fine materials from the aquifer surrounding the screen. No screen is used in rock wells, and the casing generally is driven just to or into the rock.

Various types of pumps and power are used on these wells. The driven wells are equipped with pitcher pumps and other types of hand pumps. Domestic and stock wells are equipped with all types of suction and lift pumps, pitcher pumps, and jet pumps, operated manually or by windmill or electric power. Municipal and industrial wells are generally equipped with deep-well turbine pumps or suction pumps, powered by electricity.

WELL-WATER USE

Most of the rural or farm wells are widely scattered throughout the county. Many farms have two or more wells, one for domestic use and one or more for watering stock, cooling milk, and general washing purposes. These wells generally are capable of producing about 10 gallons per minute.

Most of the water from industrial wells is used for cooling purposes, making steam, washing, and domestic uses. These wells are generally in or near towns. Their production varies, ranging from a few gallons up to several hundred gallons per minute. Active industrial wells in the Lebanon area are BoF35-1-7, BoF36-2-2, BoF36-3-2 and -3, BoF36-4, and BoG31-4-1 and -3.

The water from municipal wells is used in a variety of public services, such as domestic, industrial, stock watering, miscellaneous cooling, fire fighting, some irrigating, etc. Towns having municipal water-supply systems, all of which utilize ground water, are Lebanon, Zionsville, Thorntown, Jamestown, and Advance. The wells of these systems are described in the well records and in the following section.

PUBLIC WATER-SUPPLY SYSTEMS

Lebanon

According to Capps (4, p. 73) and the records of the Public Service Commission of Indiana, the municipal waterworks at Lebanon was built and started operations in 1894 at the location on Chicago Street between Klotz and Kersey Streets, just north of Prairie Creek (fig. 9). The water supply was obtained from three wells, 43, 97, and 230 feet in depth. By 1907 four more wells, 97 feet in depth and 8 inches in diameter, were drilled, and one hole was drilled to a depth of 816 feet (BoF36-1-11). This latter hole was reported to have been dynamited at 230 feet in an unsuccessful attempt to make it a productive water well. Capps (4) states that the water was distributed from a standpipe (189,000-gallon capacity) and that a new underground cement reservoir (500,000-gallon capacity) was completed by the end of 1907.

In 1947 the water supply was obtained from wells 1, 2, 3, 4, 7, 8, and 10. The locations of these and other wells at the waterworks field are shown on figure 9. The water from the active wells in the field is pumped

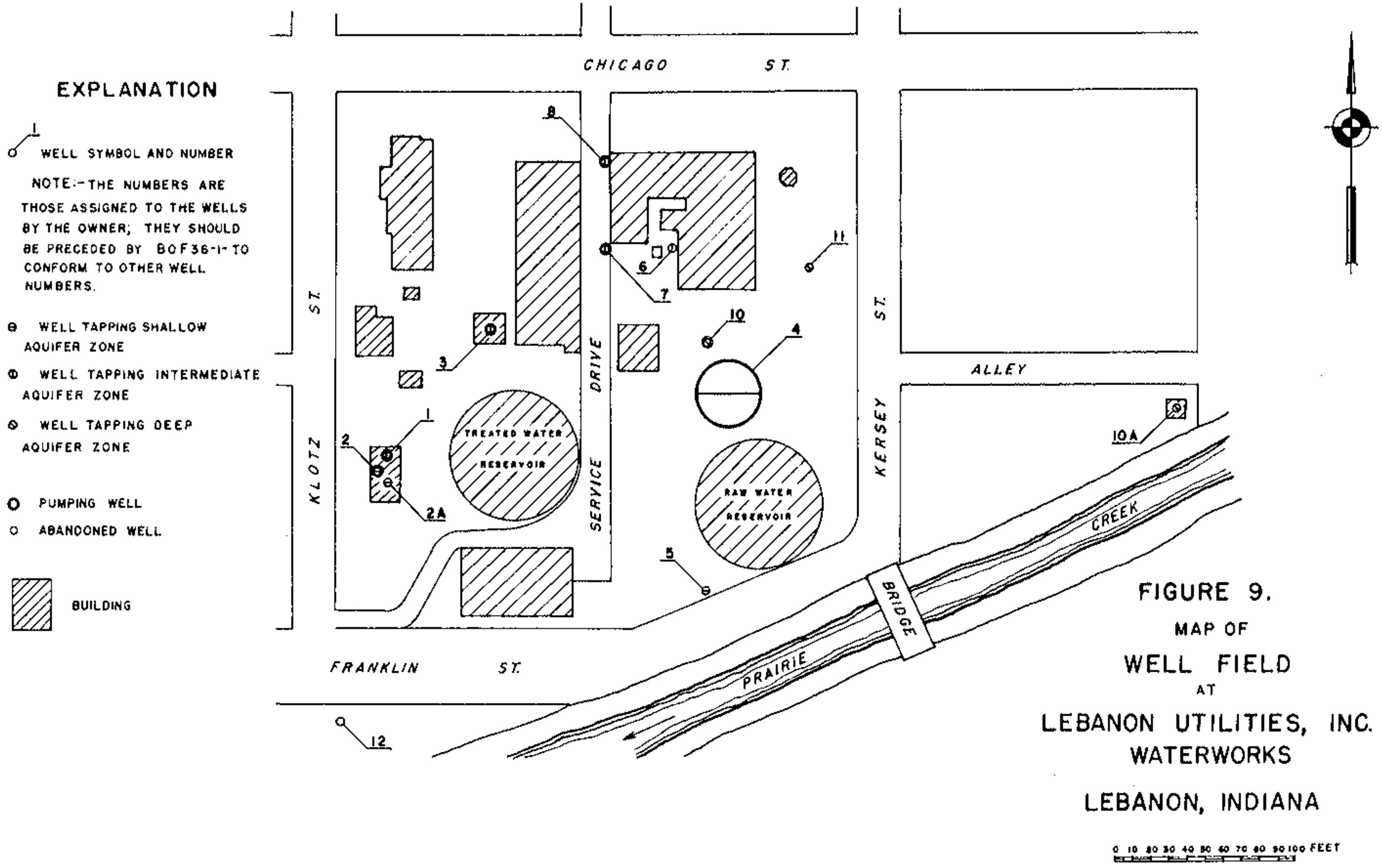

FIGURE 9.
MAP OF
WELL FIELD
AT
LEBANON UTILITIES, INC.
WATERWORKS
LEBANON, INDIANA

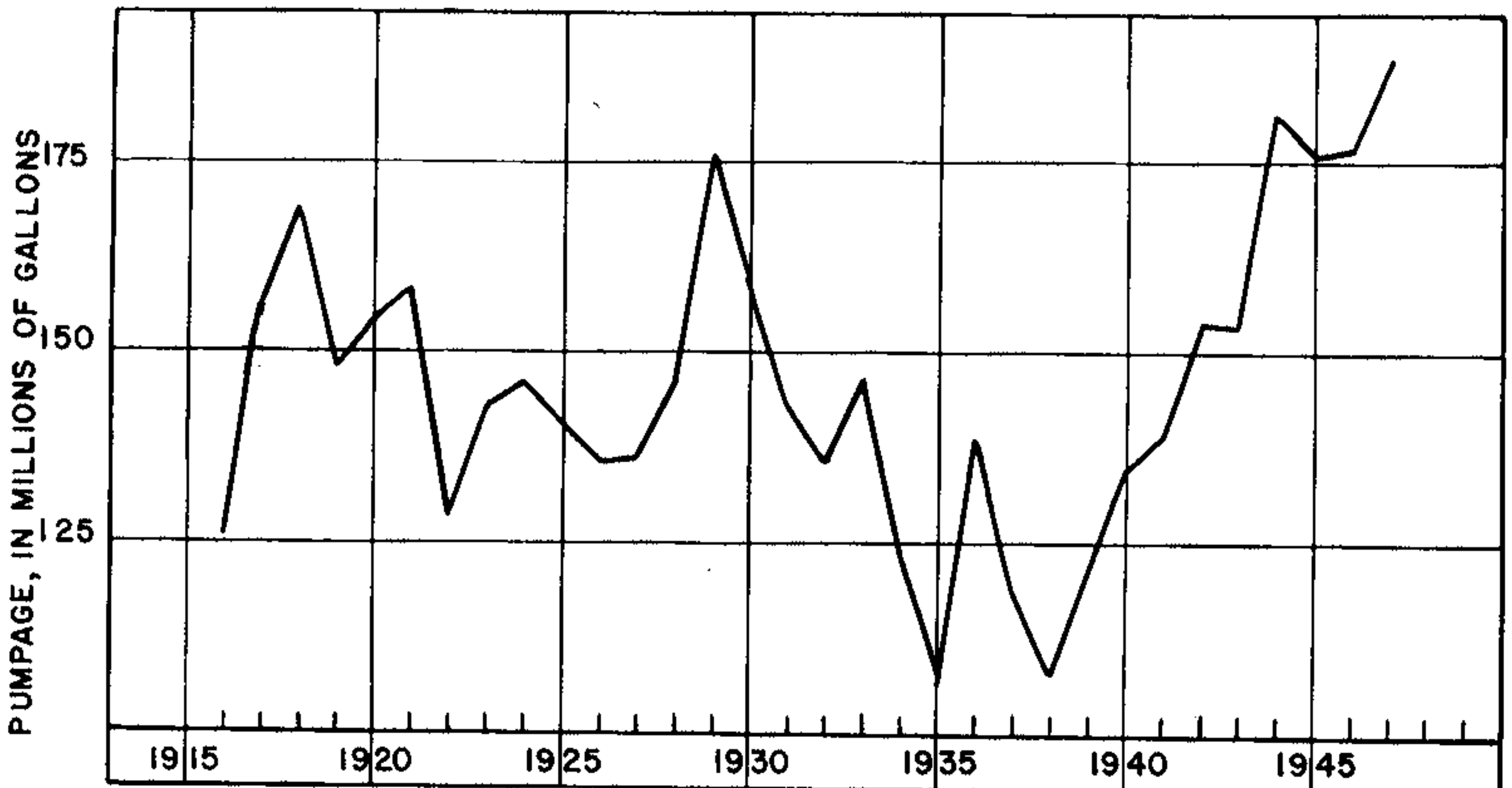

FIGURE 10. ANNUAL PUMPAGE FROM WELLS OF LEBANON UTILITIES, INC. WATER-WORKS, LEBANON, INDIANA.

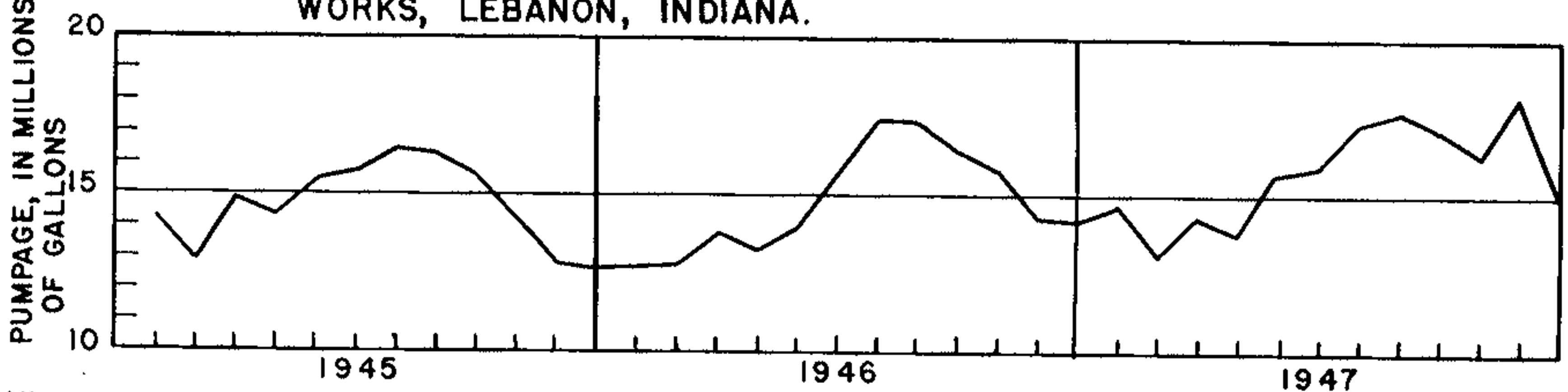

FIGURE 11. MONTHLY PUMPAGE FROM WELLS OF LEBANON UTILITIES, INC. WATERWORKS, LEBANON, INDIANA.

into a raw-water reservoir with a capacity of about 450,000 gallons. Well 4 is pumped only when pumping from the other wells fails to maintain a certain minimum level in the reservoir. The water is then treated and pumped into a soft-water reservoir of about 400,000-gallon capacity, from which it is pumped into the distribution system by high-service pumps. A standpipe, 120 feet high and of a reported 300,000-gallon capacity, in the southeastern part of town, 30 feet west of well BoG13-3, about two-thirds of a mile from the plant, maintains pressure in the system. The treatment consists of iron removal and softening, accomplished by aeration followed by addition of chemicals, coagulation, and sedimentation. Finally the water is chlorinated and pumped into the distribution system.

Within the last several years there have been periods when continual pumping from all the active wells barely produced enough water to satisfy peak demands. Water levels in well 6 (O-Bo-4) indicate that, during 1947, there was almost continuous pumping from its aquifer. Water levels in well 10A (O-Bo-10A) indicate that well 10 was pumped somewhat less than half the time during 1947. This condition is due to increased pumping to meet increasing demands and to declines in yields of the wells. Total yearly pumpage from the entire field for the period of record is shown in table 6 and figure 10. Monthly pumpage for the last 3 years appears in table 7 and figure 11. Declines in yield of the wells are indicated by comparison of reported capacities of the wells at the time they were drilled and those determined by pumping tests during the present investigations. The declines in yield are due, at least in part, to incrustation of the well screens and aquifers near the screens by deposition of minerals and sediment caused by the decrease of hydrostatic pressure, the release of dissolved carbon dioxide, and contact with air. The decrease in hydrostatic pressure is due to the lowering of water levels, which in turn is increased by interference

Table 6. Total annual pumpage, in thousands of gallons, of Boone County municipal waterworks systems

Year	Lebanon	Zionsville	Thorntown	Jamestown
1915	a/ 58,557	b/ 1,029 est.	---	---
1916	126,469	c/ 16,000 est.	---	---
1917	156.419	11,000 est.	---	---
1918	168,081	4,910 est.	---	---
1919	147,773	6,000 est.	---	---
1920	154,610	---	---	---
1921	158,627	---	42,602	---
1922	128,823	---	37,306	---
1923	142,593	---	25,633	---
1924	145,651	4,730 est.	20,097	---
1925	141,539	6,463 est.	17,362	---
1926	135,460	---	16,200	---
1927	136,256	---	19,414	---
1928	146,020	15,580	18,250 est.	---
1929	176,726	9,693	18,250 est.	---
1930	157,958	10,078	25,000 est.	---
1931	143,735	12,900	17,863 est.	---
1932	135,265	---	18,064	---
1933	146,567	---	15,105	---
1934	122,746	---	11,420	---
1935	105,390	---	10,714	---
1936	138,037	---	13,548	---
1937	118,306	---	---	---
1938	107,566	14,637	---	---
1939	120,690	16,598	---	---
1940	134,761	19,912	---	---
1941	139,261	20,193	---	---
1942	153,757	22,578	---	---
1943	153,561	24,109	---	---
1944	181,374	23,385	---	---
1945	175,474	22,418	---	5,475
1946	176,900	27,004	---	5,475 est.
1947	188,519	---	---	5,475 est.

a/ Pumpage from end of June to end of year.
b/ Pumpage from June 30, 1914, to June 30, 1915.
c/ Pumpage from June 30, 1915, to June 30, 1916.
est. Estimated pumpage.

Table 7. Monthly pumpage, in thousands of gallons, of Lebanon Utilities, Inc. waterworks

	YEAR		
MONTH	1945	1946	1947
January	14,287	12,651	14,536
February	12,908	12,772	13,084
March	14,790	13,740	14,219
April	14,335	13,200	13,896
May	15,419	13,943	15,664
June	15,640	15,606	15,909
July	16,490	17,343	17,143
August	16,458	17,298	17,546
September	15,612	16,352	17,157
October	14,218	15,573	16,230
November	12,750	14,219	18,185
December	12,567	14,201	14,949

between closely spaced wells. The maximum distance between wells pumping from the same formation is only about 200 feet (wells 1 and 8).

In 1943 an attempt was made to increase the yield of the well field by acidizing wells 1, 2A, 7, and 8. Before acid treatment, well 7 was reported to yield about 75 gallons per minute with a 33-foot drawdown, giving a specific capacity of 2.3 gpm per foot of drawdown. After acidizing, the well yielded 200 gpm with a 14-foot drawdown and had a specific capacity of 2.3 gpm per foot of drawdown. After acidizing, the well yielded 200 gpm with a 14-foot drawdown and had a specific capacity of 14.3 gpm per foot of drawdown, an increase in well efficiency of more than 600 percent. The yield of well 2A was not materially improved and the well was abandoned.

The information on the aquifer is gained mainly from information on the depths of wells and on screen settings. There appear to be three main zones of aquifers in the area of the municipal waterworks, as indicated by the common 50-, 104-, and 220-foot (approximate) depths of wells. Apparently these water-bearing zones are separated by glacial drift composed mainly of bluish-gray boulder clay. The shallow zone is tapped by wells 2A, 2, 4, and 5, as indicated on figure 9. Of these, only wells 2 and 4 are active. The elevation of the top of this zone is about 885 feet above sea level except in well 5, in which there is evidently either 9 or 21 feet of gravel, the top of which is at an elevation of 877± feet.

The intermediate zone is tapped by wells 1, 3, 6, 7, and 8, of which all but well 6 are active. Most of the production of the field comes from this zone. The elevation of the top of this zone and its thickness in these wells vary greatly, according to the records, ranging from an elevation of about 833 feet to 863 feet above sea level.

The deep zone is tapped by wells 10A, 10, and 11, of which only well 10 is active. The elevation of the top of this zone, which is about 8 feet thick, is approximately 710 feet. The only record of the aquifer of well 12 is that the well was reported to have been drilled to a depth of 185 or 145 feet. It was measured and found to be 142 feet deep. The hydraulic characteristics of these wells and of the aquifers they tap, and relations between aquifers, are discussed in the section on quantitative hydraulic characteristics.

Zionsville

It is reported that the municipal waterworks of Zionsville began pumping water from a well 27 feet deep on January 1, 1914. No storage or treatment of the water was maintained. About 1922 a new well was drilled to a depth of 110 feet and it subsequently flowed. In 1931 the waterworks was operating two wells (one 20 feet deep and 10 feet in diameter. and one 140 feet deep and 6 inches in diameter) yielding about 50,000 gallons per day. In 1937 a well (BoP2-1-3), about 70 feet deep, was drilled at the city building on the southwest corner of Cedar and Elm Streets. Owing to a decrease in yield from 75 to 25 gallons per minute, probably due to incrustation, another well (BoP2-1-4), 74 feet deep, was drilled in 1939 at the present pumping station on the west side of Elm Street between Pine and Hawthorne Streets. The yield of this well has decreased from an original 200 gallons per minute with a 5-foot drawdown to 125 gallons per minute with a 4-foot drawdown in July 1947. The latter well is used for the town supply and well BoP2-1-3 is used only in emergencies. The water is chlorinated and pumped into the distribution system. A 100,000-gallon elevated steel tank, located on the uplands on the west side of town, maintains pressure in the distribution system.

Thorntown

In December 1909 the municipal waterworks began pumping water from a well (BoA35-1-1), 96 feet deep, located at the original pumping plant on the west side of Pearl Street midway between Main and Bow Streets. The water was pumped into the distribution system, including an 18,000-gallon reservoir 3 feet below the station level and a 40,000-gallon elevated tank, 85 feet high, at the plant. In 1916 a new well (BoA35-1-2) was drilled to a depth of either 103 or 113 feet, close to the original well. Both these wells were supplying the town in 1920. In 1923 another well (BoA35-1-3), 110 feet deep, was drilled in this same locality. According to records of the Sanborn Map Company of New York, on file at the Thorntown city building, all three of these flowing wells were pumped by two Dean duplex double-acting steam suction pumps in September 1926, the water being pumped to the system described above. Drillers and natives of Thorntown claim that a deep (almost 1,000 feet) test well (BoA35-1-4) drilled between 1920 and 1930 was unsuccessful. In 1928 two new flowing wells (BoA35-1-5 and -6), about 70 feet deep, were drilled in the valley of Prairie Creek at the base of the upland slope east of Front Street, in line with Church Street extended. The new station was electrified and equpped with three centrifugal pumps. A 50,000-gallon elevated steel storage tank at the old plant location maintains pressure in the distribution system. The flow of well BoA35-4, 150 feet south of the present municipal wells, is intermittent because of the pumping of those wells.

Jamestown

In 1939 and 1940 the waterworks at Jamestown was built and a 56-foot well (BoM10-6-1) was drilled in the eastern part of town in a lot between the railroad and State Highway 34. A 75,000-gallon elevated steel tank, 100 feet high, was built 2,300 feet west-northwest of this well, on higher ground. In 1941 a second well (BoM10-6-2) of similar depth was drilled about 70 feet north-northwest of the first. Water from these wells was pumped by electric deep-well turbine pumps into the distribution system. The two wells supplied sufficient water to meet the needs of the town until about the middle of 1947. About 1941 two unsuccessful wells had been drilled in an attempt to augment the supply. They are well BoM10-6-3, 100 feet deep, near the storage tank, and well BoM10-6-4, 185 feet deep, in the southwestern part of town. In 1946 another attempt to obtain more water was made by drilling well BoM10-6-5 midway between the two original wells, to a depth of 512 feet. It also was a failure. In July 1947 well BoM10-6-6 was drilled about 800 feet east of the two pumped wells. It was originally drilled to 105 feet, but it was finally made into a supply well at a depth of 31 feet. It was reported to yield 50 gallons per minute with a 9-foot drawdown after approximately 8 hours of pumping. Plans were made to put this well in operation in the last half of 1947, as a replacement for well BoM10-6-2. The water from well BoM10-6-2 and from the original waterworks wells was being chlorinated in July 1947, although State records show no treatment in earlier years. It is noteworthy that this well is located in a small area of Fox silt loam (which is usually underlain by sand and gravel) in the southeastern part of Jamestown (see pl. 1). It should also be noted that this hole, as well as others in Boone County, such as BoF35-1-7 and BoL19-4-2, was successful at a shallow depth after deeper unsuccessful holes had been drilled. This indicates the importance of attempts to develop wells in water-bearing formations that do not appear at first to be satisfactory aquifers.

Advance

The town of Advance had one or more public wells as early as 1907. Capps (4, p. 76-77) reports a 2-inch limestone well (BoI23-1), 90 feet deep, half a square south of the railroad station. Two other public wells in the center of town, equipped with hand suction pumps, apparently were drilled early in the century. One of these is well BoI22-2.

In the latter part of 1946 construction of a municipal waterworks was begun. A 6-inch test well, BoI23-3-1, was drilled to a depth of 38 feet in the southeastern part of town. Upon recommendation of the Indiana State Board of Health, a well (BoI23-3-2) for the municipal supply was drilled at a location 50 feet south of the test well, to a depth of 45 feet, but did not produce a satisfactory yield; the original well was reamed to a diameter of 10 inches and plans to use it as a source of supply were made. It was reported to have a 23-foot drawdown after 24 hours of pumping 74 gallons per minute.

Available pumpage records for the municipal water-supply systems in Boone County are shown in table 6.

QUALITY OF WATER

In general, ground water in Boone County is of good quality from a bacteriological standpoint and only moderately high in mineral content. Most wells yield calcium bicarbonate water, which is hard and usually quite high in iron content. Of the drilled wells for which records were obtained, the water from only two (BoF25-3 and BoL10-1-2) was reported to have been rejected for human use by the Indiana State Board of Health on the basis of bacteriological analyses. The former yields water containing rust- to flesh-colored soft material resembling skin and mucous discharge. Well BoL10-1-2 was a flowing well that yielded water that was clear but had a "sulfur odor." Both wells probably tap gravel aquifers; they are 85 and 109 feet deep, respectively.

The water from the majority of the wells is relatively hard and high in iron content. Records of chemical analyses of ground water are limited largely to waters of wells furnishing municipal supplies. These records are found in Capps' report (4) and in the files of the Indiana State Board of Health.

Most of the analyses of the Lebanon supply were of water from the raw-water supply. Those in recent years (1931 to 1947) show an iron content ranging from about 0.5 to 3.0 parts per million (average, 1.2 parts), an alkalinity ranging from 344 to 396 parts as calcium carbonate, and a total hardness ranging from 280 to 494 parts, also expressed as calcium carbonate. Dissolved solids were 352 and 622 parts per million, according to analyses made in 1907, and 512 and 791 parts, according to analyses made in 1934. From two sets of analyses (made in 1935) of waters from different wells, the order of wells, arranged from low to high in iron, alkalinity, and hardness, is BoF36-1-1, -6, -8, -3, -10, -4, -9, -5, and -2. It is noteworthy that the wells tapping the intermediate aquifer are first in this order (the water is best) and those tapping the shallow zone are last; and that, of those tapping the intermediate zone, the ones on the periphery of this group of wells are first, and those toward the center, last.

Analyses of the Zionsville water supply made from 1930 to 1946 show the following ranges: iron, 0 to 11 parts per million; alkalinity, 148 to 430 parts; total hardness, 73 (?) to 521 parts. The chloride content decreased at the end of 1939 and remained low through 1946.

Analyses of the Thorntown water supply, made from 1931 to 1946, show the following ranges: iron, 0 to 9.6 (?) parts per million; alkalinity, 322 to 420 parts; total hardness, 364 to 488 parts. The chloride content decreased here also in 1940 and remained low through 1946.

Analyses of the Jamestown water supply, made in 1942 and 1946, show the following ranges; iron, 1.2 to 2.0 parts per million; alkalinity, 328 to 356 parts; total hardness, 258 to 269 parts.

Analyses of water from municipal wells in Advance, made in 1946 and 1947, show the following results: iron, 5 and 10 parts per million; alkalinity, 370 and 400 parts; total hardness, 338 and 354 parts, respectively.

The above records show that the average iron content of ground water in Boone County is about 1.2 parts per million or higher, and that the hardness in most places is over 300 parts. The Jamestown analyses show the lowest hardness.

The high iron content of practically all well water is evidenced by the rust-colored deposits on equipment that it contacts. The runoff streams from flowing wells have deposited much rust-colored material along their channels.

Wells yielding water that is obviously sulfurous are BoA35-1-4 and -5, BoF36-1-7 and -8, BoJ2-1-1, BoL10-1-2, and BoM6-1. The water from the last well has a very peculiar taste. It is reported to be purgative, and to deposit a black film on metals it contacts. It is obtained from bedrock, as is the water from wells BoF31-1 and BoL14-2. The water from well BoL14-2 becomes milky with precipitated iron on standing. The water in well BoF34-10, which taps bedrock, was reported to be very highly mineralized and especially high in iron when the well was drilled, but it improved considerably in quality after it was used for several months.

On the basis of measurements made by the author during 1947, the mean ground-water temperature in 21 wells and 3 springs rather well distributed in the county was found to be about 52.50° F. This is 1.2° F. higher than the mean annual air temperature as determined at the U. S. Weather Bureau station at Whitestown. These measurements were made at various times during the year. The difference in temperature between summer and winter measurements was found to be 1° F. in well BoL14-3 and 1½° in spring BoL25-2. The water in well BoE31-1, which flows, was measured at 52° in the summer of 1947.

This is probably the same well which Capps (4, p. 76) reports yielded water with a temperature of 51° in 1907. The temperature of 50° F. reported by Capps in well BoB?-40 in (1907) is the lowest ground-water temperature reported in the county. The lowest temperatures found in 1947 were in wells BoG12-1, BoH21-1-2, and BoE23-1-2 and were 51¼° F., 51¼° F., and 51-3/4° F., respectively. The highest temperatures were found in wells BoH16-1, BoH14-1, and BoG27-1 and were 57° F., 54° F., and 53½° F., respectively. It is noteworthy that the two coldest waters and the two warmest waters measured are in the same general area, the former occurring in gravel wells 20 and 40 feet deep, and the latter in limestone wells 216 feet deep.

QUANTITATIVE HYDRAULIC CHARACTERISTICS OF WATER-BEARING MATERIALS

INTRODUCTION

Pumping a well in a water-bearing formation causes water levels to decline in the vicinity of the pumped well. The amount of water-level decline caused by pumping a well at a given rate depends upon the hydraulic characteristics of the formation, including the coefficients of storage, permeability, and transmissibility, the areal extent of the formation, and the rate and distribution of recharge to and natural discharge from the formation. The coefficients of storage, permeability, and transmissibility are determined by field or laboratory tests. The other significant factors involved must be determined from analysis of geologic, hydrologic, and climatic data.

DEFINITIONS

The coefficients of storage, permeability, and transmissibility of the formation are hydraulic characteristics and define the ability of the formation to store and transmit water.

In the zone of saturation, all connected spaces between the rock particles are filled with water. When the water table is lowered, the voids in the zone of lowering are partially drained under the influence of gravity, but the rest of the water is held to the surfaces of the rock particles by molecular forces. The ratio of (1) the volume of water released from storage by gravity flow to (2) the total volume of the drained rock (including the voids) is called the specific yield of the formation. The specific yield is a measure of the stored water available for withdrawal from the formation under water-table conditions. The ratio of the water retained by molecular forces to the total volume is the specific retention.

The ability of an artesian formation to store water is indicated by its coefficient of storage. When the hydrostatic pressure in the artesian formation is reduced, a resultant compression of the beds occurs, accompanied by the release of a relatively small quantity of water. The coefficient of storage is the amount of water, in cubic feet, released from a vertical column of the formation with a base 1 square foot in area, when the hydrostatic pressure is reduced 1 foot.

The ability of a material to transmit water is indicated by its coefficient of permeability, which may be expressed quantitatively as the volume of water, in gallons a day, that will pass through a cross-sectional area of 1 square foot of material under a hydraulic gradient of 1 foot per foot at a temperature of 60° F. The coefficient of permeability of a formation is dependent mainly on the uniformity of size, shape, sorting, and packing of the individual particles. The field coefficient of permeability is that corrected to the local ground-water temperature.

The coefficient of transmissibility of a given formation is the product of the field coefficient of permeability a d the saturated thickness of the formation and is expressed as the quantity of water, in gallons a day, at the prevailing temperature, that will pass through a vertical section of the formation 1 foot wide under a hydraulic gradient of 1 foot per foot, or through a section of the formation a mile wide under a gradient of 1 foot per mile. The coefficients of transmissibility and storage define, in part, the ability of a formation to serve as an aquifer.

A term that is useful for comparing well efficiency and performance is the specific capacity of a well, the yield per unit of drawdown, generally expressed as gallons per minute per foot of drawdown. A well yielding 200 gallons of water per minute with a drawdown, or lowering of water level due to pumping, of 20 feet would have a specific capacity of 10 g.p.m. per foot of drawdown. Inasmuch as the specific capacity of a well changes with time until "equilibrium" or steady-flow conditions are reached, values of specific capacity should be determined at the end of a specified period of pumping in the group of wells to be studied.

PUMPING TESTS

The drawdown in the vicinity of a pumped well is the amount the water level is lowered as a result of pumping the well. The drawdown in the formation is less with increasing distance from the pumped well, and increases at a diminishing rate as the period of pumping is extended. The drawdown in the vicinity of the pumped well, the distance from the pumped well to the observation point, and the rate and duration of pumping are mathematically related to the coefficients of transmissibility and storage of the formation.

The coefficients of transmissibility and storage are determined in the field by pumping one or more wells at a constant rate and observing the changes in water levels in nearby idle wells. The data collected in the field are analyzed by several available methods. The most valuable formula available at the present time for use in the analysis of pumping-test data is the Theis nonequilibrium formula, for it can be used to determine the hydraulic characteristics of the formation from comparatively short pumping tests. The interested reader is referred to Wenzel (19) for a detailed discussion and explanation of pumping-test methods.

The equations generally used for obtaining the hydraulic characteristics of aquifers from pumping-test data are all based on similar assumptions and should yield the same results if the limitations of each equation are kept in mind. In applying the Theis nonequilibrium formula, it is tacitly assumed that the hydraulic properties of the formation are constant over an infinite area, and that there is no recharge to or natural discharge from the formation throughout the test. These assumed conditions rarely exist in the field, and use of the pumping-test results should be applied within limits according to the facts known about the formation tested. The aquifers in

Boone County, as indicated in this report, are believed to be very heterogeneous and poorly connected at many points, and many are perhaps of small areal extent. The use of the pumping-test results in this county is therefore generally limited to comparison studies of the formations tested. Although the use of test data is limited, pumping tests combined with other hydrologic and geologic data serve as a valuable guide in selecting the formation that will yield the maximum quantity of water with the least drawdown.

Pumping tests were made at the Lebanon municipal well field in February 1947 to determine the hydraulic properties of the aquifers tapped by the municipal wells. Well 10 (see fig. 9) in the deep zone was pumped at an estimated rate of 95 gallons per minute, and then allowed to recover for about 5 days. Water-level changes were observed in wells 10A and 11. The coefficients of transmissibility and storage of the deep zone were determined by means of the Theis nonequilibrium method to be approximately 7,000 gallons per day per foot and 2.0×10^{-4}, respectively.

In the intermediate zone, wells 1, 3, and 7 were pumped for about 6 hours each. Each pumping period was begun after water levels had become relatively stable. Water-level measurements were made in wells 1, 3, 6, and 7. From the interference and drawdown data collected during the tests, the coefficients of transmissibility and storage were computed to be about 10,000 gallons per day per foot (g.p.d./ft.) and 5.7×10^{-4}, respectively.

The yields, observed and computed drawdowns, and specific capacities of wells in the intermediate zone observed at the end of a 6-hour pumping period are given in table 8.

The computed drawdowns given in table 8 were determined by means of the Theis nonequilibrium formula, using the hydraulic characteristics calculated from the interference data, and the screen diameters. The computed

Table 8

Pumping-test data on wells in the intermediate zone, Lebanon Utilities, Inc., well field, Lebanon, Ind.

Well No.	Yield (g.p.m.)	Observed drawdown (feet)	Computed drawdown (feet)	Specific capacity 6-hour pumping period (g.p.m./ft.)
1	125	11.9	22.2	11.0
3	108	13.6	19.1	9.5
7	97	33.8	17.2	2.9

drawdown here accounts only for the drawdown in the formation at the well-screen face, assuming all flow in the formation to be laminar. However, an additional head loss, often called well loss, occurs in the pumped well by turbulent flow through the screen and up the casing to the pump intake, and by turbulent flow near the screen where the induced ground-water velocities are high. Incrustation of the screen and of the formation surrounding the screen may also cause observed drawdowns to be greater than the computed drawdown given. Generally the drawdown computed from the Theis formula and interference data is less than the drawdown observed in the pumping well, because well loss is not included in the computed drawdowns. The figures shown for well 7 show this clearly.

The data given for wells 1 and 3 show an observed drawdown much less than that computed, and the specific capacities of these two wells are almost twice as high as the theoretical value based on the interference data. This apparent anomaly may be due to heterogeneity of the water-bearing material, perhaps to a lens or stringer of highly permeable materials at the locations of wells 1 and 3; or to an increase in permeability near the wells due to removal of fine particles during the well construction, so that the effective diameter is larger than the nominal diameter.

Well 2 in the shallow zone was pumped at a rate of about 30 gallons per minute, and depths to water were measured in well 5. However, the slight effects on water levels noted at well 5 were not sufficient to permit computing definite values of the hydraulic characteristics, and the results of the tests were inconclusive.

SUMMARY OF RESULTS

As no quantitative data could be obtained from the existing wells in the shallow zone, its potentialities are known only from past experiences. The intermediate zone is better than the deep zone, considering individual well performance and interference. Test drilling near well 1, and a detailed analysis of the materials removed from the test holes, may substantiate or disprove the assumption made regarding the existence of the highly permeable lens in the intermediate zone.

The tests at the municipal well field indicate that the three water-bearing zones in the areas are not connected within some distance from the wells; that is, that the clays separating the zones are continuous over a rather broad area. Maintenance difficulties experienced in the past with the operation of wells in the shallow zone indicate that the shallow zone is of little value as a source of water supply from the standpoint of both quantity and quality.

The tests made at the municipal well field may not be used as a basis for extended predictions of water-level trends or of the perennial yields of the zones now in use. However, they do serve to demonstrate the relative abilities of the formations to transmit water, and to indicate features of the formations that might be explored and exploited. Reference is made to the assumed lens of highly permeable material in the intermediate zone. Wells screened in this material produce from 300 to 500 per cent more water than wells in the deep zone, or wells in the intermediate zone which apparently do not tap the assumed lens. The value of these tests cannot be emphasized too strongly in any future exploratory work. Detailed pumping tests in conjunction with the geologic logging of formations provide an excellent means of obtaining quantitative data for precise comparisons of the abilities of formations to transmit water to wells.

THE GROUND-WATER RESERVOIR IN BOONE COUNTY

The generally thick mantle of glacial drift that contains many deposits of sand and gravel at different levels within the drift of Boone County constitutes a large underground reservoir in which many millions of gallons of ground water are stored. Although the individual beds of sand and gravel appear to be discontinuous, horizontally and vertically, they are apparently connected hydraulically from place to place, so that water may pass slowly from one permeable bed to another. Although clay and glacial till are usually considered "impermeable," permeability is a relative term and water apparently may pass through clays and glacial tills at very slow rates of movement. It is believed that the glacial deposits of Boone County may be considered as a unit from the standpoint of ground-water storage. Water is added to the reservoir by recharge from precipitation and is withdrawn from ground-water storage by natural discharge into streams, by evaporation and transpiration, and by discharge from wells. The water levels in wells indicate in a general way the extent to which the underground reservoir is full.

The amount and seasonal distribution of precipitation and the comparatively flat topography present favorable conditions for recharge. The flat surface has the effect of retarding surface runoff. However, the surface of most of the county is underlain by clayey and silty soils and by glacial till, which are relatively impermeable, and the average recharge per unit area is therefore relatively small.

In an effort to evaluate the average annual recharge of water to the ground-water reservoir in Boone County, computations of the base flow of Sugar Creek at Crawfordsville and of Eagle Creek at Indianapolis were made by L. W. Furness, Surface Water Division, U. S. Geological Survey, at the request of the writer. The base flow or ground-water runoff of a stream is the quantity of water contributed to the stream by natural discharge of ground water and is approximately equal to the average annual recharge in the area drained by the stream. The ground-water runoff represents water that cannot be stored and therefore overflows into the surface stream, because the ground-water reservoir is already full in the vicinity of the stream.

The hydrologic analysis by Mr. Furness showed that the ground-water runoff of Sugar Creek at Crawfordsville was about 3.8 inches per year and of Eagle Creek near Indianapolis, about 2.9 inches per year. This is equivalent to an average annual recharge of about 180,000 and 138,000 gallons per day per square mile, respectively. It is estimated that the average annual recharge in Boone County is about 3.0 inches or about 143,000 gallons per day per square mile. According to this estimate and to the amount of direct surface runoff shown by the stream-gaging records, the total precipitation of nearly 39 inches in Boone County is dissipated in the following proportions: Surface runoff about 19 per cent, ground-water runoff or base flow about 8 per cent, and losses by evaporation and transpiration about 73 per cent. The percentage of ground-water runoff is relatively low, as compared to that for many other areas of Indiana, as might be expected from the clayey nature of the soils, and the losses by evaporation and transpiration are relatively high because of the shallow water table and slow surface drainage in many parts of the county.

The total annual pumpage of ground water through wells in Boone County during 1947 was estimated to be about 500 million gallons, or about 1,370,000 gallons per day. Of this amount about 250 million gallons, or about 50 per cent, was used for municipal supply, about 25 million, or about 5 per cent, was used for industrial supply, and the remaining 225 million gallons, or 45 per cent, was pumped from private wells for domestic and agricultural purposes. About 200 million gallons was pumped from wells in the Lebanon area, 190,000 of which was pumped for municipal supply.

In addition to the pumpage of ground water, a large quantity of ground water is wasted through flowing artesian wells. One well, reported to flow about 1,000 gallons per hour, would discharge 8,760,000 gallons of water in a year if the flow remained constant. It is estimated that about 200,000,000 gallons of water was wasted in Boone County during 1947 from uncontrolled flowing wells.

The available records of ground-water levels indicate no large decline of water levels in wells in Boone County except in the vicinities of the larger cities, towns, and industrial plants, where the declines have been due to heavy pumping from closely spaced wells. Such declines are necessary in order to draw water to the wells. Throughout most of the county, the ground-water level is not far below the land surface at present and, although long-term records are scarce, the decline in ground-water levels appear to have been comparatively small. Some decline may have been caused by artificial drainage and by the uncontrolled discharge of flowing wells.

The average annual recharge to the ground-water reservoir is many times greater than the annual withdrawal of ground water through wells. Ground-water levels are not far below the land surface and, in general, the ground-water reservoir is relatively full. It is believed that much of the natural discharge into streams could be salvaged and put to beneficial use by the development of properly located well fields near the stream valleys.

FUTURE DEVELOPMENT OF GROUND-WATER SUPPLIES

It has been shown that the ground-water supplies of Boone County have not been fully developed and that additional supplies may be developed in the county without exceeding the safe yield of the water-bearing formations. This general conclusion is based on a study of the county as a whole and may not be true in certain localized areas.

Although some rock wells, such as wells BoF31-1 and BoF34-9, are reported to yield large quantities of water, the bedrock formations of Boone County probably would not yield sufficient water for municipal or industrial use. The deeper bedrock formations, such as the Silurian and Ordovician limestones, probably would yield water of unsatisfactory chemical quality. These formations are used extensively in other parts of Indiana as a source of ground-water supply, but in Boone County the water from deep bedrock wells is highly mineralized.

The sand and gravel deposits of the glacial drift are the best aquifers within the county. The outwash deposits in the valleys of Sugar Creek and Eagle Creek are especially important, as they are relatively thick, course-grained deposits located close to a potential source of continuous recharge from the streams. They are fairly extensive along the valleys, and rather large supplies of water probably could be obtained from properly located wells. Other sand and gravel aquifers within the glacial drift have been discussed in this report and their locations are shown in plate 4. The most important of these at present are those that furnish relatively large supplies to municipal and industrial wells. It must be remembered, however, that good potential aquifers, not yet tapped by wells, may occur within the drift, particularly in areas where the conditions are not well known because most of the wells are relatively shallow or few wells have been drilled.

The records indicate that the sand and gravel deposits are generally more common and are thicker in areas underlain by bedrock valleys. Because of this and because the thickness of drift that might contain sand and gravel is greater, holes drilled over the bedrock valleys, shown on plate 3, have a better chance of obtaining a water supply than those drilled in areas of thin drift.

In the vicinity of Lebanon, areas that might prove suitable for the development of new wells for municipal and industrial use include an area within about 1,500 feet south and east of Noble and East Streets, where aquifers would probably be encountered at elevations of about 905-920, 880-890,[1/] 870-875, 825-830, 767, and 743 feet above sea level, and an area west of Lebanon in the central part of sec. 2, 3, 10, and 11, T. 18 N., R. 1 W., where sand and gravel would be encountered at elevations of about 905, 880, 860, 846, and 810 feet above sea level. In the Memorial Park area in Lebanon, the best aquifer probably would be at an elevation of about 890 feet above sea level. Other areas suitable for the development of large supplies of water may be revealed as additional wells in the Lebanon area are drilled and a more detailed knowledge of the local geology is thus obtained.

DEVELOPMENT OF NEW SUPPLIES AND CONSERVATION OF GROUND WATER

The information and maps of this report will serve as a guide to the location and development of new sources of ground-water supplies in Boone County. It should be remembered, however, that, because of the complexity of glacial deposition, the correlation of a particular aquifer over a broad area is often impossible.

In order to obtain additional information on the details of geology

1/ The elevations underlined indicate the best possibilities.

and ground-water conditions in Boone County, it is suggested that, in future drilling within the county, records should be made of the location of the drilling, a detailed description of the materials penetrated, and information on water levels, yields, drawdowns, and the quality of the water. Well drillers are requested to cooperate with the Division of Water Resources, Indiana Department of Conservation, Indianapolis, by submitting to that Division copies of well records of any new drilling, on the forms that will be provided by the State. These forms include spaces for information similar to that given in the well tables and will be provided free upon request. The purpose of the State in requesting that such information be filed is to provide a permanent record of detailed information on the occurrence of ground-water supplies throughout Indiana for the mutual benefit of well drillers, well owners, and the general public.

When the development of large supplies of ground water is planned, test drilling should be accompanied by pumping tests to determine the hydraulic characteristics of the water-bearing formations. From these data, the expected yields, interference effects, and spacing of wells can be estimated. Mechanical sieve analyses of the aquifer materials will assist greatly in the selection of a proper screen. Chemical and bacteriological analyses of the water obtained will be of value in the proper utilization of ground-water supplies.

One phase of well drilling that is often overlooked is the development of a new water well to remove the fine materials adjacent to the screen. Such development is usually done by intermittent pumping or by the use of a surge block which is moved up and down the well to force the water back and forth through the screen openings. In many wells the initial yield is materially increased by development. Most wells of moderate to large yield should be developed at a higher rate than that at which the well ordinarily will be pumped, in order to minimize the continued pumping of fine sand and silt in the water. The use of screens and the proper development of small-diameter wells will postpone or eliminate difficulties due to "sanding up" or "riling up" of wells.

Permanent records of the drilling, construction, and yield of the well, including well logs and water-level and drawdown data, are extremely valuable for later comparison when supply problems occur, such as declining yield and changes in the quality of the water. New wells should be spaced as far apart as possible to minimize interference effects.

The increased use and importance of the ground-water supplies of Boone County require that this valuable resource be developed wisely. Large quantities of ground water are wasted by the uncontrolled discharge of flowing wells. The continued waste will result in a lowering of the ground-water level. However, caution should be used in changing the discharge from a flowing well. Several wells are reported to have been plugged by sand by changing the rate of flow too suddenly.

APPENDIX A

RECORDS OF WELLS IN BOONE COUNTY, INDIANA

Explanation of symbols used

Uses:

D - domestic, S - Stock, Irr - irrigation, Ind - industrial, PS - public supply, RR - railroad, AC - air conditioning, Aban - abandoned, ( ) - indicates former use.

Depth:

All depth figures other than those followed by m (indicating measured depths) are reported depths.
Depth figures enclosed in parentheses indicate former greater depth to which well was drilled.

Aquifers:

Aquifer data in parentheses are those of minor aquifers or deposits of sand and gravel that may be suitable as aquifers.
Aquifer data not in parentheses are those of the formation utilized by the well.

Water level:

Figure preceded by + indicates measurement of artesian head above the land surface.
Figure followed by + indicates the water level of a flowing well at or slightly above top of casing, so that the true piezometric surface is at a higher but unknown level.
Figure followed by ± indicates approximate depth below land surface.
Figures shown in tenths and hundredths of feet indicate measured water levels.
D indicates that the well was reported to have been drained by nearby ditching operations.

Drawdown:

In the rate and time column, the rate appears in left hand column and the time figure is listed in the right hand column.

Quality of water:

An A indicates that an analysis of water from the well appears in Appendix C.
B indicates that the water from the well was condemned for human use without treatment by the Indiana State Board of Health.

1 - Water is very hard.
2 - Water has high iron content.
3 - Water is sulfurous.
4 - Water is comparatively "soft".
5 - Water has oily scum on it.
6 - Salt water.

The note number or letter refers to the quality of the water of the formation tapped by the well in cases in which no parentheses occur.
The figure in parentheses following the note number is the depth, in feet, of the aquifer that contains the water to which the note number refers.

Temperature:

An asterisk (*) indicates that this is the temperature of water from a nearby spring.

Notes:

1. Log of this well appears in appendix B.
2. Vegetal matter in good state of preservation was penetrated.
3. Swamplike muck deposit containing vegetal matter was penetrated.
4. Gas issued from this well.
5. Quicksand or fine- to medium-grained sand common.
6. Yellow clay penetrated.
7. Boulder layer or zone reported.
8. Dry sands and/or gravels penetrated.
9. Bedrock is limestone (probably Devonian)
10. Bedrock is black shale (Devonian, New Albany Shale).
11. Bedrock is soapstone or "blue shale" (Mississippian).
12. Bedrock is sandstone (Mississippian).
13. Bedrock is limestone (Mississippian).
14. Bedrock is porous rock (Mississippian).
15. Bedrock is yellow limestone or yellow rock (Mississippian).
16. Bedrock is green shale (Mississippian).
17. Inadequate water supply when drilled.

An asterisk (*) preceding a number indicates the number reference in the bibliography from which this well datum was obtained.

Number in parentheses following note number is depth, in feet, of material indicated, unless this number in parentheses is followed by a T, in which case it indicates the thickness, in feet, of the material referred to.

Well No.	Location	Owner	Driller	Date completed	Altitude of land surface, in feet above mean sea level	Use	Depth (feet)	Diameter (inches)	Aquifers: Depth to top of bed (feet)	Aquifers: Thickness (feet)	Aquifers: Materials	Depth to bedrock (feet)	Water level: Above (+) or below land surface (feet)	Water level: Date	Yield: Yield (g.p.m.)	Yield: Date	Drawdown: Amount (feet)	Drawdown: Rate (g.p.m.) and Time (hr.)	Quality of water	Water temperature (°F.)	Notes
G-Bo[illegible]-1	"At Lebanon"	-	-	-	935±	Gas test	1,600	-	-	-	-	210	-	-	-	-	-	-	-	-	1,*12 No gas
G-Bo[illegible]-2	"Lebanon, Ind. gas well"	-	-	-	940±	Gas well	450±	-	(26) (105)	(2) (8)	-	342	-	-	-	-	-	-	-	-	1,*10 *11
G-Bo[illegible]-3	"4½ miles NE. from Lebanon"	-	-	-	950±	do.	285	-	(26) (105)	(2) (8)	(Sand) (Gravel)	285	-	-	-	-	-	-	-	-	1,*10 *11
G-Bo[illegible]-4	"At Thorntown"	-	-	-	850	do.	1,287	-	-	-	-	65	-	-	-	-	-	-	-	-	1,*4
G-Bo[illegible]-5	"In Prairie Cr. Valley in Thorntown"	-	-	-	820±	do.	40+	-	40 ft of drift is mainly sand, gravel			40	-	-	-	-	-	-	-	-	*11
G-Bo[illegible]-6	"On the uplands in south Thorntown"	-	-	-	850±	do.	75+	-	75 ft of drift is mainly sand, gravel			75	-	-	-	-	-	-	-	-	*11
G-Bo[illegible]-7	"At Zionsville"	-	-	-	860±	do.	1,113	-	-	-	-	160	-	-	-	-	-	-	-	-	1,*12
G-Bo[illegible]-8	"In valley of Eagle Cr. at Zionsville"	-	-	-	825±	do.	165	-	(30)	(8)	(Gravel)	-	-	-	-	-	-	-	-	-	1,*11
Bo[illegible]-9	"In neighborhood of Big Springs"	-	-	-	935±	-	8 to 100	-	8 to 100	-	Gravel	-	10	About 1907	-	-	-	-	-	-	*7
Bo[illegible]-10	"In Dover"	-	-	-	900±	-	8 to 120	-	8 to 100	-	Sand, gravel, limestone	100	8	do.	-	-	-	-	-	-	13,*4
Bo[illegible]-11	"Short distance north of Dover"	Thomas McDaniel	-	-	895	-	22½	-	22	½	Gravel	-	-	-	-	-	-	-	-	-	1,*7
Bo[illegible]-12	"3 miles SE. of Elizaville, on Michigan Road"	-	James A. Ball	-	956	-	84	-	(18) (41)	(3) (11)	Quicksand Finesand	-	-	-	-	-	-	-	-	-	1,*7
Bo[illegible]-13	"Hazelrigg"	-	-	-	916	-	11 to 96	-	11 to 96	-	Gravel	-	8	About 1907	-	-	-	-	-	-	*4
Bo[illegible]-14	"2 miles E. of Hazelrigg"	Otis Crane	-	-	925±	-	175	3	175	-	Probably gravel	-	6	do.	-	-	-	-	-	-	*4
Bo[illegible]-15	"2½ miles E. of Hazelrigg"	do.	-	-	922±	-	47	1½	47	-	Gravel	-	+2	-	-	-	-	-	-	-	*4
Bo[illegible]-16	"2½ miles N. of Jamestown"	Isaac Emerts	James A. Hall	-	955	-	236	-	(30)	(2)	(Quicksand)	76	-	-	-	-	-	-	-	-	1,*7
Bo[illegible]-17	"4 miles N. of Jamestown in Jackson Township"	John M. Shelly	-	-	940±	-	88	-	(12) (22) 62	(6) (6) 26	Sand, gravel White sand Sand, gravel	-	-	-	-	-	-	-	-	-	1,*7
Bo[illegible]-18	"In Lebanon"	-	-	-	930 to 950	-	40 to 60 E 100 to 300 W	-	-	-	Gravel	-	-	-	-	-	-	-	-	-	*4
Bo[illegible]-19	"Washington St. well in Lebanon"	-	-	-	935±	-	108	-	(12) (19) 82	(4) (4) 1	(Sand) (Sand, gravel) Gravel	-	-	-	-	-	-	-	-	-	1,*7
Bo[illegible]-20	"5 miles W. of Lebanon"	Clairborne Cain	-	-	920±	-	243	-	(17) (73)	(5) (5)	(Quicksand) (Dry gravel)	-	-	-	-	-	-	-	-	-	1,17,*7

Records of wells in Boone County, Indiana-Continued

Well No.	Location	Owner	Driller	Date completed	Altitude of land surface, in feet above mean sea level	Use	Depth (feet)	Diameter (inches)	Aquifers: Depth to top of bed (feet)	Aquifers: Thickness (feet)	Aquifers: Materials	Depth to bedrock (feet)	Water level: Above (+) or below land surface (feet)	Water level: Date	Yield: Yield (g.p.m.)	Yield: Date	Drawdown: Amount (feet)	Drawdown: Rate (g.p.m.) and Time (hr.)	Quality of water	Water temperature (°F)	Notes
Bo??-21	"6 miles W. of Lebanon"	Seth W. Porter	-	-	910±	-	18	-	13	5	Sand	-	-	-	-	-	-	-	-	-	1,*7
Bo??-22	"6 miles S. of Lebanon"	Gar Vandeveer	James A. Ball	-	956	-	109	-	-	-	-	100	-	-	-	-	-	-	-	-	1,12,*7
Bo??-23	"Max"	-	-	-	930	-	10 to 125	-	-	10 to 70	Gravel and limestone	70	4 to 15	About 1907	-	-	-	-	-	-	13,*4
BoN?-24	"New Brunswick"	-	-	-	950±	-	11 to 150	-	6 to 150	-	Gravel	-	-	-	-	-	-	-	-	-	1,*4
Bo??-25	"Pike"	-	-	-	915	-	18 to 150	-	18 to 150	-	do.	-	16	About 1907	-	-	-	-	-	-	*4
BoG?-26	"Ratsburg"	J. M. Chambers	-	-	956±	-	18	-	17½	½+	Sand	-	-	-	-	-	-	-	-	-	*7
BoP?-27	"Royalton"	-	-	-	880 to 930	-	10 to 116	-	10 to 116	-	Gravel	-	7 to 15	About 1907	-	-	-	-	-	-	*4
BoP?-28	do.	Messrs. Foster and Leap	-	-	880 to 930	-	10 to 96	-	20½	5	do.	-	-	-	-	-	-	-	-	-	1,*7
BoP?-29	"In Fishback Valley in Royalton"	-	-	-	976	-	100±	-	25±	5	do.	-	-	-	-	-	-	-	-	-	1,*11
BoM?-30	"Slabtown"	George Dischman	-	-	960±	-	46½	-	32	½	do.	-	-	-	-	-	-	-	-	-	1,*7
Bo??-31	"At Thorntown"	Messrs. Walt and Klizer	James A. Ball	-	850±	-	333 or 343	-	(21) or (15)	(4) or (3)	(Quicksand) (Gravel)	150 or 137	-	-	-	-	-	-	-	-	1,*7
Bo??-32	"In Thorntown"	-	-	-	820 to 850	-	14 to 28	-	-	-	Sand and gravel	-	-	-	-	-	-	-	-	-	*10
G-Bo??-33	"East edge of Thorntown"	Samuel Jatt	-	1887	818±	Gas test	1,700	8	90	-	Gravel	-	+12	About 1907	-	-	-	-	A	-	*4
Bo??-34	"1 mile W. of Thorntown"	William Mill	-	-	830±	-	108	-	(25)	(3)	(Quicksand)	-	-	-	-	-	-	-	-	-	1,*7
Bo??-35	"About 1½ miles W. of Thorntown"	Charles Moffitt	-	-	835±	-	44	-	(4)	(40)	(Dry gravel)	-	-	-	-	-	-	-	-	-	17,*7
Bo??-36	"3½ miles W. of Thorntown"	Robert Woody	-	-	820±	-	147	-	(18)	(55)	(Fine sand)	144	-	-	-	-	-	-	-	-	1,*7
BoF?-37	"1 mile S. of Thorntown"	Frank Harris	-	-	865±	-	132	-	(4) (126)	(23) (6+)	(Quicksand) (Cemented gravel)	-	-	-	-	-	-	-	-	-	1,*7
BoA?-38	"3 miles N. of Thorntown"	S. Dukes	James A. Ball	-	830±	-	185	-	(18)	(12)	(Quicksand)	183½	-	-	-	-	-	-	-	-	1,*7
BoA?-39	do.	Al Weatherald	do.	-	830±	-	187	2	(18) 120	(12) ?	do. Clay	183½	10	About 1907	-	-	-	-	-	-	1,*7
BoB?-40	"3 miles NE of Thorntown"	John Leatherman	-	About 1905	845±	-	140	4	140	?	Sand	-	+4	About 1907	-	-	-	-	-	50 1907	*4

Records of wells in Boone County, Indiana-Continued

Well No.	Location	Owner	Driller	Date com-pleted	Altitude of land surface, in feet above mean sea level	Use	Depth (feet)	Diameter (inches)	Aquifers: Depth to top of bed (feet)	Aquifers: Thickness (feet)	Aquifers: Materials	Depth to bedrock (feet)	Water level: Above (+) or below land surface (feet)	Water level: Date	Yield: Yield (g.p.m.)	Yield: Date	Drawdown: Amount (feet)	Drawdown: Rate (g.p.m.) and Time (hr.)	Quality of water	Water temperature (°F)	Notes
BoB?-41	"3½ miles NE. of Thorntown"	J. E. Leatherman	-	-	845±	-	140	4	140	?	Gravel	-	+7	-	-	-	-	-	-	-	*4
BoB?-42	"3 miles E. of Thorntown near Union Church"	-	-	-	880±	-	111	-	(27)	(9)	(Quicksand)	-	-	-	-	-	-	-	-	-	1,*7
BoO?-43	"1 mile N. of Whitelick"	Willis Johnston	-	-	960±	-	60	2	60	-	-	-	+5	-	30	About 1907	-	-	-	-	*4
BoL?-44	"Whitestown"	Isaac Isenhour	-	-	935±	-	105	4	105	-	Gravel	-	9	About 1907	-	-	-	-	A	-	*4
Bo??-45	"At Zionsville"	-	-	-	830 to 890	-	37+ to 65	-	16 to 22	1 to 3	do	-	-	-	-	-	-	-	-	-	1,*7
Bo??-46	"Zionsville"	Jas. W. Brendel	-	-	830 to 890	-	108	3	108	-	do	-	3	About 1907	-	-	-	-	A	-	*4
BoL?-47	"2½ miles NW. of Zionsville"	A. Perry Moore	-	-	940±	-	81	2½	78	-	Gravel and sand	-	+6	do	1	About 1907	-	-	-	54 1907	*4
BoA?-48	"In vicinity of Sugar Creek, near west boundary of county"	-	-	-	815±	-	-	-	-	-	-	20 to 40	-	-	-	-	-	-	-	-	13,*10
BoG?-49	"E. of Lebanon"	-	Flem D. Boyd	-	940 to 960	-	120 to 160	-	110+ to 150±	10±	Gravel	-	-	-	-	-	-	-	-	-	4
BoA14-1	SW¼SE¼	Lester Skeen	Noble Higer	Fall of 1946	834	D,S	52	2	50±	2+	Sand	-	7±	Fall 1946	-	-	-	-	-	-	-
BoA15-1	SE¼SE¼	Lawrence White	John Armstrong	About 1902	844	D,S	107 or 111	4	-	-	-	-	11 or 7	About 1945	-	-	-	-	-	-	-
BoA17-1	N½SW¼	Frank Powers	Abe Winks and Noble Higer	1936 or 1937	840	D,S	630	6	196 (70) (190)	434	Blue shale and limestone (Gravel and sand) (Sand and gravel)	196	100	1936 or 1937	150 to 200	1936 or 1937	-	-	-	-	11
BoA19-1	NW¼NE¼	Marvin Larsh	Cory	1926	825	D,S	90	-	-	-	-	-	2±	About 1945	-	-	-	-	-	-	-
BoA21-1	NE¼NW¼	Kirt Holloway	do	-	849	D,S	64±	4	-	-	-	-	11	About 1945	-	-	-	-	-	-	-
BoA22-1	SW¼SE¼	Big Four Railroad	Noble Higer	About 1927	817	RR	56	2	53	3	Gravel	-	+	About 1927	17	-	-	-	-	-	-
BoA22-2	NE¼NE¼	Lawrence White	-	Long before 1947	838	S	65m	4	-	-	Probably gravel	-	+1.13	June 19 1947	60 to 70	June 19 1947	4.9	6± ¼	-	52½ June 1947	-
BoA26-1	SE¼SW¼	Big Four Railroad	Noble Higer	About 1927	820±	RR	140	2	-	-	Gravel	-	16	About 1927	-	-	-	-	-	-	-

Records of wells in Boone County, Indiana—Continued

Well No.	Location	Owner	Driller	Date completed	Altitude of land surface, in feet above mean sea level	Use	Depth (feet)	Diameter (inches)	Aquifers			Depth to bedrock (feet)	Water level		Yield		Drawdown		Quality of water	Water temperature (°F.)	Notes
									Depth to top of bed (feet)	Thickness (feet)	Materials		Above (+) or below land surface (feet)	Date	Yield (g.p.m.)	Date	Amount (feet)	Rate (g.p.m.) and Time (hr.)			
BoA30-1	E½SW¼	Noble Higer	Noble Higer	1946	794	D	56	2	21	35±	"Limestone"	21	+2 3	1946 January 1947	-	-	-	-	-	-	11,13
BoA30-2	SW¼NE¼	Nathan Coyle	do.	1946	812	D	101	2	100	1+	do.	100	1.34	June 20, 1947	-	-	-	-	-	52½ Jan. 1947	-
BoA31-1	SE¼NW¼	Harley Etter	Claude Kersey	About 1937	815	D,S	81	3	10±	71+	"Very hard limestone"	10±	6	About 1937	-	-	-	-	-	*53 1/47	-
BoA31-2-1	SE¼NE¼	Charles Boyer	John Armstrong	-	824	D,S	60±	4	-	-	"Limestone"	-	9±	About 1946	-	-	-	-	-	-	-
BoA31-2-2	SE¼NE¼	do.	Higer	-	820	S	40	2	20	-	do.	-	-	-	Good well	Up to present	-	-	-	-	-
BoA31-2-3	SE¼NE¼	do.	do.	-	820	S	40	2	20	-	do.	-	-	-	Well not good	Up to present	-	-	-	-	-
BoA31-2-4	NW¼SE¼	do.	John Armstrong	-	825	S	60±	4	-	-	-	-	13±	About 1946	-	-	-	-	-	-	-
BoA31-3-1	NE¼SE¼	Ed Grau	-	-	824	S	15m	24	-	-	-	-	12.00	Nov. 7, 1947	-	-	-	-	-	-	-
BoA31-3-2	NE¼SE¼	do.	John Armstrong	-	824	D,S	37½m	4	-	-	Limestone or gravel	-	7.59	June 19, 1947	-	-	1±	- 2½	-	-	-
BoA34-1	SW¼SW¼	Sugar Plain Church	Noble Higer (?)	About 1937	826	D	120	-	95	25	Gravel	-	30	About 1937	-	-	-	-	-	-	-
BoA34-2	SW¼SW¼	Herb Sussing	Claude Kersey	About 1945	831	D,S	165	-	-	-	do.	-	-	-	-	-	-	-	-	-	-
BoA35-1-1	110± N. Pearl St., Thorntown	Thorntown Municipal Water Plant	James Kersey	About 1910	851	(PS) Aban	97	8	90±	-	Probably gravel	-	-	-	200	About 1910	-	-	1	-	-
BoA35-1-2	do.	do.	do.	do.	851	(PS) Aban	103 or 113	8	90±	-	do.	-	-	-	200	About 1910	-	-	1	-	-
BoA35-1-3	do.	do.	do.	do.	851	(PS) Aban	110	8	90±	-	do.	-	-	-	200	About 1910	-	-	1	-	-
BoA35-1-4	do.	do.	do.	do.	851	PS test	765 or 960	12 to 6	500	200	Limestone	200	-	-	-	-	-	-	6	-	1,17
BoA35-1-5	NE¼SE¼, 650± ft. E. of Front and Church St., Thorntown	do.	-	1928	818	PS	70	8	-	-	Gravel	-	+	1928 and 1947	-	-	-	-	4	-	-
BoA35-1-6	do.	do.	-	do.	818	PS	70	8	-	-	do.	-	+	do.	-	-	-	-	4	-	-
BoA35-2	NW corner Pearl and Plum Sts., Thorntown	Thorntown Dairy Products	Holt Bros.	Jan. 1947	853	D,Ind	88	8	78	10	Gravel and sand	-	40	Jan. 1947	100	Jan. 1947	40	100 1	-	-	1
BoA35-3	120 W. Church St., Thorntown	Robert Coolman	Henderson	1898	853	Aban	110	2½	-	-	Probably gravel	-	+ 50	1898 1940	- -	-	-	-	-	-	-

Records of wells in Boone County, Indiana-Continued

Well No.	Location	Owner	Driller	Date completed	Altitude of land surface, in feet above mean sea level	Use	Depth (feet)	Diameter (inches)	Aquifers: Depth to top of bed (feet)	Aquifers: Thickness (feet)	Aquifers: Materials	Depth to bedrock (feet)	Water level: Above (+) or below land surface (feet)	Water level: Date	Yield: Yield (g.p.m.)	Yield: Date	Drawdown: Amount (feet)	Drawdown: Rate (g.p.m.) and Time (hr.)	Quality of water	Water temperature (°F.)	Notes
BoA35-4	222± N. Front St., Thorntown	Brockmeyer	Edward Applegate	-	818	-	65?	6	-	-	Probably gravel	-	8.3+	June 20 1947	50 est	June 20, 1947	-	-	-	-	-
BoA36-1	SE¼NW¼	John McKinsey	Clyde Kersey	1946	840	D,S	82	3	74	8	Gravel	-	7	1946	-	-	-	-	-	-	-
BoB13-1-1	SW¼SW¼	Gustin Bluebaugh	A. R Kelly	About 1945	883	D,S	190	4	185	5+	do.	-	15	About 1945	10	About 1945	5	10 -	-	-	-
BoB13-1-2	NW¼SW¼	do.	do.	About 1940	883	D,S	52	4	-	-	do.	-	11	About 1943	-	-	-	-	-	-	-
BoB19-1	SW¼NW¼	W. and A. McKern	Noble Higer	About 1927	843	D,S	144	2	(70) 140	(10) 4	(Gravel) Gravel	-	+9	About 1927	16.7	About 1927	-	-	5(70)		4(70, 100)
BoB19-2	SE¼SE¼	Clarence Reagan	do.	About 1930	855	D,S	153±	2	-	-	-	-	0	About 1930	-	-	-	-	-	-	2(151)
BoB20-1	SW¼SW¼	Lloyd Bennington	James and Clyde Kersey	Sept. 1936	855	D,S	145	3 or 4	125	20	Gravel	-	+	1947	-	-	-	-	-	-	-
BoB20-2	NE¼SW¼	Glenn Bratton	-	-	875	S	139	4	-	-	Probably gravel	-	20.74	June 16 1947	Not a good well	Up to present	-	-	-	-	-
BoB23-1	NW¼NE¼	S. C. Allen	-	About 1907	887	D,S	56	1¼	41	15	do.	-	15 31±	1907 1947	-	-	-	-	-	-	-
BoB24-1	SW¼NW¼	H. E. Whiffing	A. R. Kelly	1944	888	D	235	4	230	5	Yellow gravel	-	20	1944	6	1944	5	- 6	-	-	-
BoB24-2	SW¼SW¼	Ralph Higgins	Willard English	About 1945	885	D	27	3 or 4	-	-	Gravel	-	18	About 1945	-	-	-	-	-	-	-
BoB24-3	SW¼NW¼	State of Indiana	do.	do.	877	D	158	4	155	3	do.	-	28	do.	-	-	-	-	-	-	2(188)
BoB24-4-1	NW¼NW¼	Gustin Bluebaugh	A R. Kelly	do.	882	D,S	48	4	-	-	Probably gravel	-	11	do.	-	-	-	-	-	-	-
BoB24-4-2	NW¼NW¼	do.	Noble Higer	About 1935	881	S	50	2	-	-	Sand and gravel	-	9.85	About 1935	-	-	-	-	-	-	-
BoB25-1	NW¼NW¼	Ralph Higgins	Willard English	About 1945	891	D,S	74	4	72	2	Gravel	-	30	About 1945	-	-	-	-	-	-	-
BoB28-1	S½SW¼	H. E. Whiffing	A. R. Kelly	About 1943	880	D,S	184±	4±	-	-	do.	-	20	About 1943	-	-	-	-	-	-	5
BoB29-1-1	SW¼NW¼	Lloyd Bennington	James Kersey	Dec. 1936	826	D,S	124	3	-	15?	do.	-	+15+	July 31, 1947	275± est.	July 31, 1947	-	-	-	52½ June 1947	-
BoB29-1-2	NW¼SW¼	do.	do.	July 1940	840	-	136	3	121?	15?	do.	-	+	do.	-	-	-	-	-	-	-
BoB30-1	NE¼SE¼	Alfred Warren	Ray Lister	1947	834	D,S	110	4	-	-	do.	-	+0.25+	Apr.11, 1947	-	-	-	-	-	-	-
BoB30-2	NE¼NW¼	Charles Graham	Noble Higer	About 1935	851	D,S	149	2	145	4±	do.	-	+	-	3.3 est	About 1935	-	-	-	-	4(80)
BoB30-3	NE¼NE¼	William Endres	Cory	-	841	D,S	140	2	-	-	Probably gravel	-	+1.8+	June 16, 1947	1.5	June 16, 1947	-	-	-	-	-

Records of wells in Boone County, Indiana—Continued

Well No.	Location	Owner	Driller	Date completed	Altitude of land surface, in feet above mean sea level	Use	Depth (feet)	Diameter (inches)	Aquifers: Depth to top of bed (feet)	Aquifers: Thickness (feet)	Aquifers: Materials	Depth to bedrock (feet)	Water level: Above (+) or below land surface (feet)	Water level: Date	Yield: Yield (g.p.m.)	Yield: Date	Drawdown: Amount (feet)	Drawdown: Rate (g.p.m.) and Time (hr.)	Quality of water	Water temperature (°F.)	Notes
BoB32-1	NW¼SE¼	Mrs. Ward Moore	Ray Lister	April 1947	879	D,S	215	4	205	10+	Gravel	-	19	April 1947	-	-	-	-	-	-	-
BoB35-1	SE¼SW¼	H. E. Whiffing	A. R. Kelly	About 1944	910	D,S	230	4	218	12	Fine gravel and sand	320	45	About 1944	-	-	-	-	5-320	-	4(218)
									(318) (320)	(2) -	(Gravel) Bedrock										
BoC20-1	SE¼NE¼	Cecil Rogers	Blaine Rader	About 1943	907	D,S	96±	-	-	-	Gravel	-	16½	About 1943	-	-	-	-	-	-	5
BoC22-1	SE¼NE¼	Willis DeFord	do.	About 1945	914	D,S	40m	3	-	-	Probably gravel	-	-	-	-	-	-	-	-	-	-
BoC23-1	SW¼SW¼	Orval Wood	-	-	913	D,S	96	-	-	-	do.	-	-	-	-	-	-	-	-	-	-
BoC30-1	NW¼SE¼	Kenneth Nance	-	"Long ago"	902	D,S	39 27m	1½	-	-	do.	-	7.26	June 25, 1947	-	-	-	-	-	-	-
BoC32-1	SE¼NE¼	Wendall Morton	A. R. Kelly	About 1943	919	D,S	35	4?	-	-	Gravel	-	8±	About 1943	-	-	-	-	-	-	-
BoC33-1-1	SW¼SE¼	Morton Bros.	do.	do.	930	D,S	80	4	60	20	Sand and gravel	-	5	do.	-	-	3	6 ?	-	-	1
BoC33-1-2	NW¼SW¼	do.	do.	do.	927	D,S	140	4	138	2	Gravel	-	40	do.	-	-	-	-	-	-	6 7(130 to 140)
BoC35-1	SW¼SE¼	Herman Warner	-	-	941	D,S	188	4	-	-	Probably gravel	-	-	-	-	-	-	-	-	-	-
BoC36-1	NW¼NE¼	Emma Sample	A R Kelly	About 1945	934	D,S	256	4	250	6	Gray gravel	-	-	-	-	-	5	6 ?	-	-	-
BoD18-1	NW¼SW¼	Merris Green	Blaine Rader	1946	924	D,S	55	-	-	-	Gravel	-	6	1946	-	-	-	-	-	-	-
BoD20-1-1	SE¼NW¼	Bertha Bowers	do.	Before 1925	940	D	96	2	-	-	do.	-	19	About 1945	-	-	-	-	-	-	-
BoD20-1-2	SE¼NW¼	do.	do.	do.	938	S	140	-	-	-	-	-	40 to 60	do.	-	-	-	-	-	-	-
BoD23-1	NW¼SW¼	V. R. Goodman	Jess Goodnight	Spring 1946	942	D	85	2	-	-	-	-	3½	Spring 1946	-	-	-	-	-	-	-
BoD23-2	NW¼SW¼	R. K. Childers	Jess and H(?) Agard	"Long ago"	938	D	35±	-	33±	2±	Sand and gravel	-	7±	1947	-	-	-	-	-	-	-
BoD23-3	NW¼SW¼	H(?) Agard	H(?) Agard	do	938	D	14	185?	9	5	Gravel	-	-	-	-	-	-	-	-	-	-
BoE1-1-1	SE¼SW¼	The Swine Breeder Pure Serum Co.	-	About 1910	848	D,S Ind	165±	6	-	-	Gravel and sand	-	+1 or+2	1910±	-	-	-	-	2	-	5
BoE1-1-2	SE¼SW¼	do.	Noble Higer	About 1930	848	D,S Ind	167	6	(40) 159	(10) 8	Sand, gravel Gravel	-	+1 or+2	About 1930	500	About 1930	-	-	2	-	-
BoE4-1-1	NE¼SW¼	Earl Rahm	Claude Kersey	About 1944	833	D,S	52	4	49	2	Gray gravel	-	7± or 13	About 1944	-	-	-	-	-	-	-

Records of wells in Boone County, Indiana-Continued

Well No.	Location	Owner	Driller	Date completed	Altitude of land surface, in feet above mean sea level	Use	Depth (feet)	Diameter (inches)	Aquifers: Depth to top of bed (feet)	Aquifers: Thickness (feet)	Aquifers: Materials	Depth to bedrock (feet)	Water level: Above (+) or below land surface (feet)	Water level: Date	Yield: Yield (g.p.m.)	Yield: Date	Drawdown: Amount (feet)	Drawdown: Rate (g.p.m.) and Time (hr.)	Quality of water	Water temperature (°F)	Notes
BoE4-1-2	NW¼SE¼	Earl Rahm	Claude Kersey	1947	841	Not yet in use (D,S)	122m	4	(30)	(3)	Gravel	-	32.89	June 18 1947	-	-	-	-	-	-	-
BoE8-1	NW¼SW¼	Dwight B. Kendall	Sutton	-	853	D,S	60±	4	-	-	Gravel ?	-	-	-	-	-	-	-	1	-	-
BoE11-1-1	W½W½	Lloyd Bennington	Clyde Kersey	April 1947	877	None	185	4	-	-	None	180	Dry	-	-		-	-	-	-	22,10
BoE11-1-2	W½W½	do.	do.	May 1947	876	Not yet in use (D,S)	140 107m	4	-	-	-	-	20.59	June 18 1947	-	-	19	-	-	-	-
BoE12-1-1	NW¼NE¼	Robert Simms	-	-	860	(S) Aban	22m	24	-	-	-	-	4.07	June 20 1947	-	-	-	-	-	-	-
BoE12-1-2	NW¼NE¼	do.	-	About 1920	856	S	180m	2	-	-	Probably gravel	-	+ 5.69	About 1920 June 20 1947	-	-	-	-	-	-	2(180)
BoE16-1-1	NE¼SE¼	W. E. Swisher	Ed Kirk	About 1923	893	D,S	110	4	-	-	"Limestone"	-	18±	About 1945	-	-	-	-	-	-	-
BoE16-1-2	NE¼SE¼	do.	†	-	893	(D) Aban	65	2	-	-	Probably sand and gravel	-	-	- -	-	-	-	-	-	-	-
BoE19-1-1	NE¼NE¼	Harold Cox	Armstrong and Sutton	About 1907	876	D	52	4	-	-	Gravel	-	18±	About 1945	-	-	-	-	-	-	-
BoE19-1-2	NE¼NE¼	do.	do.	do.	876	S	60	4	-	-	do.	-	18±	do.	-	-	-	-	-	-	-
BoE19-1-3	NE¼NE¼	do.	-	Before 1907	872	(D) Aban	47m	4	-	-	Probably gravel	-	19.20	June 20 1947	-	-	-	-	-	-	-
BoE23-1-1	SW¼SW¼	William Gillan	-	About 1910	898	D	38	2	-	-	Sand and gravel	-	10	1947	-	-	-	-	-	-	-
BoE23-1-2	SW¼NW¼	do.	-	do.	896	S	38	2	-	-	do.	-	8	do.	-	-	-	-	-	51-3/4 June 1947	
BoE23-1-3	NE¼NW¼	do.	Noble Higer	About 1945	895±	S	26	2	-	-	Gray gravel	-	3 to 4	1945	-	-	-	-	-	-	-
BoE25-1	SE¼SE¼	Orville Taylor	Newt Kersey	About 1907	918	D,S	75 or 80	2 or 3	-	-	Sand and gravel	-	18±?	About 1945	-	-	-	-	-	-	-
BoE29-1	SE¼SE¼	A. T. Galloway	-	1936	890	D,S	125	4	-	55	"Blue limestone"	-	16	1947	-	-	-	-	-	-	13
BoE31-1	SW¼SW¼	Mrs. LaFollette	-	Before 1907	858	S	60 57m	4	30	30±	do.	30	+7 +0.7	1907 June 20 1947	16.7	About 1945	-	-	-	51-1907 52-June 1947	*4
BoE32-1	NW¼NE¼	-	-	-	873	Aban	21	4	-	-	Probably gravel	-	9.57	July 23 1947	-	-	-	-	-	-	-