CHAPTER IX.

UNDERGROUND WATERS OF THE EAST-CENTRAL DISTRICT.

INTRODUCTION.

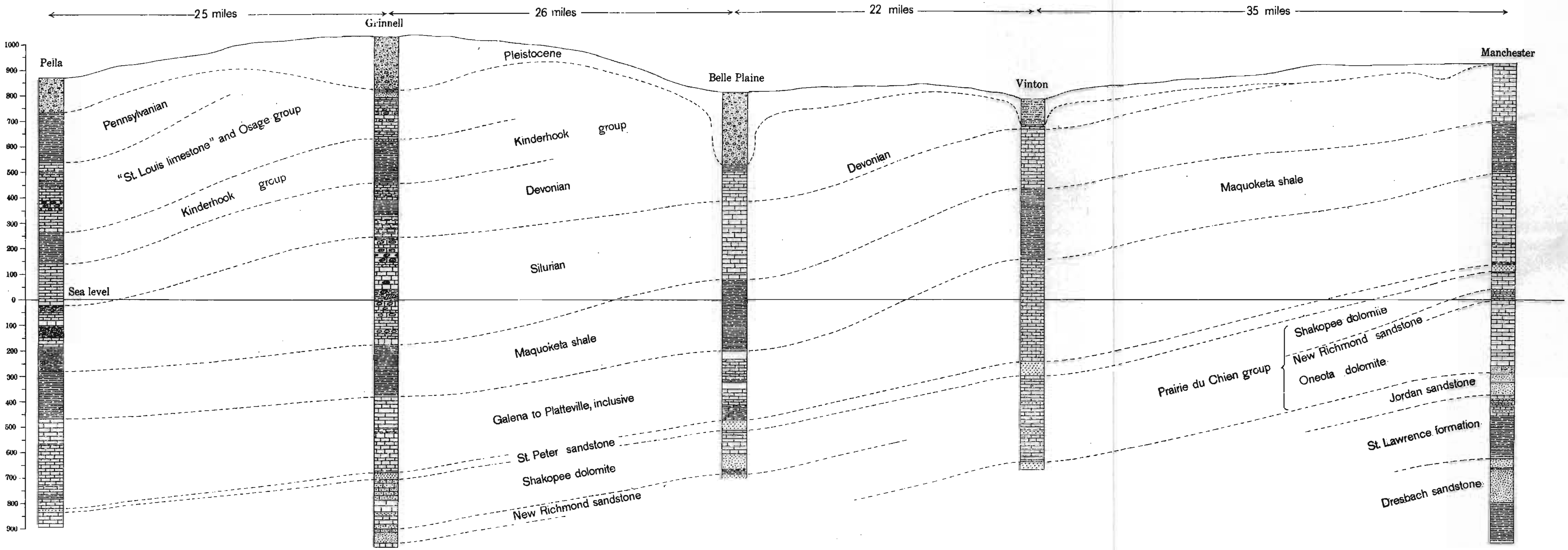
BY W. H. NORTON.

The east-central area fronts on the Mississippi; it comprises the twelve counties of Benton, Cedar, Clinton, Iowa, Jackson, Johnson, Jones, Linn, Muscatine, Poweshiek, Scott, and Tama. The great Cambrian and Ordovician aquifers lie within moderate distances of the surface and dip southwestward. Their waters show increasing mineralization with increasing depth and distance from the area of supply, but are by no means unpotable.

From Monticello to Homestead the dip averages 10 feet to the mile for the Saint Peter sandstone and 12 feet to the mile for the Jordan sandstone. In the western part of the area the southwestward dip of the Saint Peter is 9.4 feet to the mile from Vinton to Grinnell. (See Pl. VIII.) In the eastern part of the district the Saint Peter dips four feet to the mile, from Sabula to Vinton (Pl. IX), but the greatest dip is southward, as shown by the outcrops of the Devonian and Silurian rocks in the southeastern counties. Thus, though the dip of the Saint Peter from Maquoketa southwestward to Tipton is but 6.8 feet to the mile (Pl. X), the southward dip from Maquoketa to Davenport is 11.5 feet to the mile, and from Green Island to Davenport 12.6 feet to the mile. This southward dip is due in part to an upwarp in the eastern portion of the area whose axis seems to run through or near Stanwood. The base of the Maquoketa shale at Stanwood (Pl. XI) is 150 feet above the level at which it would be found if the dip of the strata were uniform from Clinton to Cedar Rapids. Both base and summit of this formation are lower at Clinton than at Stanwood, 50 miles west. From Cedar Rapids west to Belle Plaine the dip of the Maquoketa is 6.3 feet to the mile and of the Saint Peter 5.5 feet to the mile. (See Pl. XI.)

IOWA GEOLOGICAL SURVEY

PLATE VIII



GEOLOGIC SECTION BETWEEN MANCHESTER AND PELLA, IOWA
By W. H. Norton

THE NORRIS PETERS CO., WASHINGTON, D. C.

In the eastern part of the district the country rock—that is, the rock at the surface or immediately underlying the drift—is of Silurian age; in a wide belt passing through the central part the country rock is Devonian; in the western and southwestern parts, including Tama, Poweshiek and parts of Iowa and Johnson counties, the country rock is Mississippian. In the areas where the country rock is Silurian and Devonian the water of these formations may be allowed to mingle with that of the deep aquifers without impairing the quality of the latter, but the Mississippian waters are usually charged heavily with sulphates, and their effect on the deeper waters is plainly indicated by the analyses of the waters of deep wells in the western counties. The Silurian rocks also appear to become gypseous in the western counties, and here their waters may increase the sulphate content of the water from deep wells.

Toward the south and west the aquifers lie deeper and their waters are more highly mineralized, but in all parts of this district the Cambrian and Ordovician rocks furnish potable water.

The chief water beds are the Saint Peter, Shakopee, New Richmond, Oneota, Jordan, and Dresbach and subjacent Cambrian sandstones. (See Pl. I, in pocket.) Artesian water may also be found in the Galena and Platteville, as at Davenport, Wilton, and Grinnell; in the Niagaran, as at Homestead; and in the Devonian, as at Cedar Rapids, Vinton, and Belle Plaine. But none of the aquifers above the Saint Peter is dependable, and all contracts for artesian wells should provide for drilling to the base of the Jordan sandstone.

The lowest water beds—the Dresbach sandstone and the subjacent sandstones of the Cambrian—lie within the limits of profitable drilling along Mississippi river and yield copious supplies of excellent water at Clinton and Davenport. At Anamosa and at Tipton drilling was carried far into these terranes, but no information as to their water beds is available. At Cedar Rapids the first well drilled by the city water company found, either in these terranes or possibly in a higher water bed below the Oneota, a strongly corrosive water, on account of which the well was plugged just above the vein. Wells drilled later were stopped above this zone.

As a rule, throughout the east-central district abundant water may be found without drilling as deep as the Dresbach, and it is recommended that the drill be stopped at the top of the Saint Lawrence formation, or at least at the top of the glauconiferous shales of that terrane. In towns of the Mississippi valley, however, where the higher formations are overdrawn, wells should be carried to the Dresbach and the first sandstone underneath it.

In the extreme southwestern part of the district deep artesian wells are not recommended for the smaller upland towns on account of the expense of drilling and the difficulty in casing out the poorer upper waters. Thus, in southwestern Poweshiek county the Saint Peter lies about 750 feet below sea level; in towns situated 1,100 or 1,200 feet above sea level, therefore, drilling would have to be carried to a depth of 1,850 or 1,950 feet in order to reach that formation.

BENTON COUNTY.

BY H. E. SIMPSON AND W. H. NORTON.

TOPOGRAPHY.

Benton county comprises a portion of the undulating prairie plain characteristic of north-central Iowa. Topographically, however, it is divisible into two strikingly contrasted areas coinciding with the surface areas of two drift sheets of different age—the Kansan and the Iowan. The Kansan drift area, embracing about 40 square miles in the southwest corner of the county, shows a mature drift plain, thoroughly drained by streams flowing in deep valleys on the broad flood plains. The Iowan drift area, comprising the rest of the county, is a very gently undulating plain, broken by few well-defined stream channels and containing many undrained depressions and small marshy meadows and sloughs, the remnants of glacial lakes and ponds. The marked topographic contrast is ascribed by Savage to the fact that "The surface features over one portion of the area have been developed through the destructive processes of erosion; those over the other part of the region have been molded by the constructive agency of ice."[1]

The southwestern third of the county drains chiefly through Prairie creek to Iowa river, which barely crosses the corner of the county.

The larger portion of the area drains to Cedar river, which flows across the northeast corner. The divide between Iowa and Cedar rivers passes northwest and southeast through Rogerville and Van Horne.

GEOLOGY.

The surface of Benton county is drift covered except in the broad valleys of the Cedar and Iowa rivers and their larger tributaries, whose flood plains are covered with alluvium and range in width up to two miles or more. Three drift sheets are represented—the Iowan, Kansan, and Nebraskan. Between the Iowan and Kansan occurs in places the interglacial Buchanan gravel, and beneath the Kansan drift the interglacial Aftonian gravel. Loess is also present in places above the drift. Throughout most of the county the drift is underlain by Middle Devonian sediments. In a small area in the extreme southwest corner, however, the drift rests on Mississippian shale (Kinderhook stage). The Middle Devonian rocks are represented chiefly by the Cedar Valley limestone, which shows a maximum thickness of more than 80 feet and by the Wapsipinicon limestone, which is exposed along Cedar river and its tributaries, Pratt and Prairie creeks.

As a rule the indurated rocks lie in conformable parallel beds dipping slightly to the south, this arrangement being modified only by a few slight and unimportant folds. The formations underlying the Devonian are indicated by the geologic sections (Pls. VII, VIII, IX), and by the well sections on pages 430,435.

[1]Savage, T. E., Geol. of Benton county; Ann. Rept. Geol. Survey Iowa, vol. 15, 1905, p. 132.

UNDERGROUND WATER.

SOURCE AND DISTRIBUTION.

Water is obtained from the Buchanan gravel, the Iowan and Kansan drift, the Aftonian gravel, the Devonian limestones, and from deeper artesian aquifers.

In the broad valleys of Cedar and Iowa rivers and their chief tributaries water is obtained chiefly by sand points driven 25 to 30 feet into the Buchanan gravel, which underlies the alluvium at no great depth and overlies the bowlder clay of the Kansan drift. Bored wells of about the same depth, in which the water stands not far from the river level, are also common. A few wells in the Buchanan gravel yield flows, as is illustrated by the 30-foot bored well, on the farm of A. D. Seeley, one mile southwest of Benton, and by the well owned by Joseph Kerling, near the foot of the river bluff in the NW. 1/4 sec. 13, T. 85 N., R. 9 W., the water of which tastes slightly of iron and gives the brownish yellow stain characteristic of iron-bearing waters. The water ordinarily is wholesome, though it is liable to pollution owing to the easy access of organic matter from the surface. The Buchanan gravel is found locally on the uplands but there it affords an uncertain source of water.

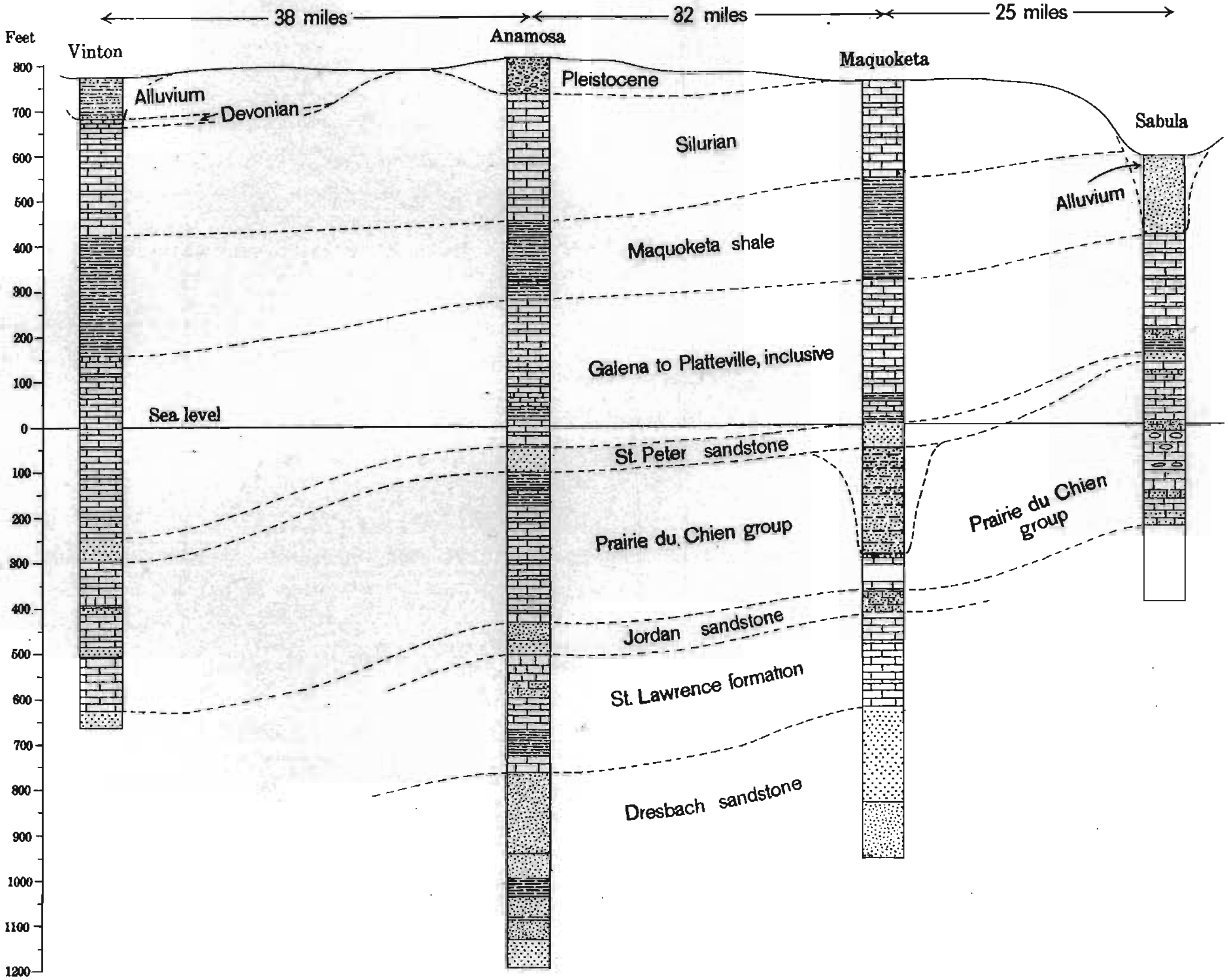
A few fine springs issue from the upper limestone outcrops along the bluffs. A very large spring is on land owned by J. E. Wychoff, in the NW. 1/4 sec. 9, T. 85 N., R. 9 W.

The most common source of water supply in this county is the Iowan and Kansan drift, whose combined thickness ranges from 50 to 300 feet. It is difficult to discriminate these two drift sheets in ordinary shallow wells, but the Iowan is so thin that it is certain that most of the wells in the Iowan region pass through it and end in the Kansan, in which pockets and lenses of sand and gravel afford small but fairly constant supplies of good water.

On the upland prairie in the northeast corner of the county, north and east of the Cedar river valley, water is obtained chiefly by means of shallow dug wells, some of which draw their supply from sand and gravel lenses in the drift, but more from

IOWA GEOLOGICAL SURVEY

PLATE IX



GEOLOGIC SECTION BETWEEN SABULA AND VINTON, IOWA

By W. H. Norton

THE NORRIS PETERS CO., WASHINGTON, D. C.

the porous gravelly beds lying beneath the till and resting on the Cedar Valley limestone. The limestone is reached at depths ranging from 30 to 150 feet and in most places yields a bountiful supply of excellent water. A few wells penetrate the Cedar Valley limestone for a short distance and find in it a good supply of hard water.

In the creek valleys shallow wells easily obtain water near the surface of the ground. South and west toward Cedar river the drift is thinner, and, as the bedrock is nearer the surface, rock wells are more common. The well on the farm of William Pitts, in the NW. 1/4 sec. 1, T. 85 N., R. 10 W., where water is obtained in limestone at a depth of 76 feet, the drift being 46 feet thick, is fairly typical.

Southwest of the Cedar river valley, except in the Belle Plaine artesian basin, bedrock is buried beneath a mantle of drift ranging in thickness from 100 to 300 feet. Most of the wells derive their waters from the sandy layers of the drift but a few enter the Cedar Valley limestone to obtain a more permanent supply. Near Cedar river the surface is deeply trenched by the valleys of tributary creeks in whose banks or bluffs the Devonian limestone outcrops.

In Taylor township, southwest of Vinton, the better and deeper wells are about 125 feet deep and draw water chiefly from gravel at the base of the drift. At the county farm 1½ miles southeast of Vinton, a drilled well 175 feet deep obtains water in the Cedar Valley limestone and supplies a small system of waterworks, the water being distributed by compressed air.

In Canton township, where the limestone is near the surface, stock wells on uplands range in depth from 50 to 300 feet, and obtain water from the overlying gravel or from the limestone itself.

A few good springs occur in the broken uplands near the larger streams. One owned by W. J. White, 1½ miles northwest of Shellsburg, affords a fair perennial supply for stock. A spring one and one-half miles northeast of Shellsburg, owned by Allen Primer, yields a water strongly mineral.

At Garrison bored and dug wells 25 to 50 feet deep are common. Throughout Jackson and Monroe townships, farm wells are ordinarily 200 to 400 feet deep and draw hard water from limestone.

The wells of Homer, Big Grove, and Eden townships obtain water from gravel beds below the till and from the rock immediately beneath them. The water is as a rule good and soft.

In the vicinity of Keystone the common dug wells range in depth from 20 to 30 feet and draw moderate supplies from Kansan drift. On the lower ground, near the streams, a good supply of water for stock is usually found in sandy soils within 8 or 10 feet of the surface. Larger and more permanent supplies are obtained by means of drilled wells, most of which obtain an abundant supply in gravel beds about 100 feet below the surface. One well, however, two miles west of Keystone, enters limestone at 250 feet below the surface.

The Aftonian gravel, which underlies the Kansan drift at a depth ranging from 100 to 300 feet in the southwestern part of the county, furnishes the waters for the Belle Plaine artesian basin. This gravel occupies the preglacial Iowa channel, which extends across the extreme southwest corner of the county, and though by no means continuous is found in many of the deep drift wells of the central and southern parts of the county.

BELLE PLAINE ARTESIAN BASIN.[1]

The Belle Plaine artesian basin includes practically all of Iowa township and a small portion of Kane township in Benton county, somewhat larger areas in the adjacent portions of Tama and Iowa counties, and a small corner of Poweshiek county. It embraces a little more than 100 square miles and occupies a portion of the valley of Iowa river, across which it cuts diagonally at Belle Plaine. The axis of the basin is more nearly north and south than that of Iowa river and their intersection here appears but a coincidence. The basin is six or seven miles wide and the northeast margin, so far as Benton county is con-

[1]Much of the information contained in this brief account is derived from Mosnat's excellent report on the artesian wells of the Belle Plaine area (Ann. Rept. Iowa Geol. Survey, vol. 9, 1898, pp. 521-562). This report contains a large number of well sections and a table giving data for nearly 200 flowing and non-flowing wells in the basin.

cerned, extends from about two miles north of Irving southeast to Luzerne and thence south to the county line. Topographically the area includes some of the high rolling uplands margining the Iowan drift, the more subdued Kansan plain, and the low, flat alluvial valley of Iowa river.

The district became famous by the outbreak of the "Jumbo" well in 1886. A brief history of the "Jumbo" well is given by W. H. Norton,[1] who says:

The notoriety of "Jumbo" was strictly that of a member of the criminal classes, and began with his resistance to control and lasted only until his final imprisonment. Six artesian wells had previously been drilled in the drift at Belle Plaine. In depth they varied from 210 to 301 feet, and the common head of their water was from 3 feet below the surface to 45 feet above it, according to the lie of the ground. * * * The seventh well, "Jumbo," was drilled on lower ground than any of the others and reached the water-bearing stratum of sand and gravel at 193 feet.

Local historians of the well, which they please to term "the eighth wonder of the world" state that the beginning of trouble lay in the fact that the driller attempted to use the force of the flow in reaming out the 2-inch bore, which he had put down for want of a larger drill, to 3 inches, the dimension specified in the contract. This task the water speedily accomplished in the unindurated clays and sands, but not stopping there went on and soon enlarged the bore to over 3 feet in diameter. Through this shaft the water boiled up in a fountain 5 feet in height—the press reports giving several hundred feet as the height of this fountain were exaggerated—flooding streets and yards and covering them with sand. It is estimated that from 500 to 1,000 carloads of sand were discharged from the well. The quantity was certainly so great that only with the greatest effort could the ditches be kept open to carry off the water. Gravel and small pebbles of northern drift were thrown out, and some pieces of fossil wood 2 and 3 feet long. The maximum flow of water was variously estimated at from 5,000,000 gallons to 9,000,000 gallons per diem. Two weeks after the well was drilled Chamberlin calculated its discharge at 3,000,000 gallons for the same period. The enormous flow rapidly drew down the head of the other wells until it sank beneath the surface.

The attempts to case and control the well continued from August 26, 1886, the date when water was struck, to October 6, 1887, when the task was successfully accomplished.

During this time the well, 193 feet deep, devoured, as local historians tell us, 163 feet of 18-inch pipe, 77 feet of 16-inch pipe, 60 feet of 5-inch pipe, an iron cone 3 feet in diameter and 24 feet long, 40 carloads of stone, 130 barrels of cement, and an inestimable amount of sand and clay.

It may be of interest to add that in 1906 the entire flow was

[1]Norton, W. H., Artesian wells of Iowa: Ann. Rept. Iowa Geol. Survey, vol 6, pp. 350-351.

carried underground by an ordinary 3-inch tile drain and that many teams pass daily over the former well site.

Water is obtained in the Belle Plaine area by wells ranging in depth from 90 to 360 feet, depending on location, elevation, and nearness to the middle of the basin. Not all wells in the area yield flows. The flowing wells are most numerous and the head is greatest in the southwest corner of the county on the flood plain of Iowa river in the vicinity of Belle Plaine. To the east and north the head gradually lowers until, on the higher uplands toward Keystone and Van Horne, water is found only at such depths and with such low head that its recovery is difficult. The driller's log of the "Jumbo" well and the interpretation given by Mosnat[1] as typical of all the flowing wells on low ground is as follows.

Record of strata in "Jumbo" well, Belle Plaine.

	Thickness	Depth	Interpretation
	Feet	Feet	
6. Soil with humus	4	4	Recent.
5. Sandy clay	12	16	Loess.
4. Gravel and sand	8	24	
3. Yellow clay	13	37	Weathered Kansan till, or loess.
2. Blue clay, with layers or pockets of sand and gravel and occasional hard bowlders.	172	209	Kansan till.
1. (a) Leaves and wood of an old forest bed		209	Aftonian interglacial stage.
(b) Gravel and sand, water bearing at			
0. Nebraskan till			

These strata, down to No. 1, do not differ from the usual soil, loess and Kansan till, except in thickness. Stratum No. 1, which yields the water, is typical of Aftonian interglacial beds found in many places in the state. The old forest bed in the upper portion is generally reported as about two feet thick, and in this district overlies the gravel of the Aftonian—the aquifer proper. The thickness of the gravel bed ranges from two feet to more than 46 feet, the maximum being unknown as wells do not pass through it where it is thickest. This gravel bed grades upward into fine sand, the thinner deposits being in places entirely of sand.

[1]Ann. Rept. Iowa Geol. Survey, vol. 9, 1898, p. 530.

The aquifer is thicker in the middle of the basin than at the sides. Cross sections worked out by Mosnat show conclusively that the aquifer and the underlying Nebraskan drift sheet lie within an old preglacial valley cut fully 200 feet into the Devonian limestones and shales and that the aquifer dips about $3\frac{1}{2}$ feet per mile southward. The old valley has since been filled by the later drift, on which a new drainage system, independent of the old channels, has been superposed. Unfortunately, the artesian water of the Belle Plaine area is unsuited for general household purposes or for use in boilers or in manufacturing processes on account of the large amounts of calcium and magnesium sulphates and other salts it contains. For watering stock, however, it furnishes an abundant and inexpensive supply, warm in winter, cool in summer, and perennially flowing. It is used on every farm on which it is available.

CITY AND VILLAGE SUPPLIES.

Atkins.—As Atkins (population, 250) is 833 feet above sea level, the drill may be expected to reach the Maquoketa shale about 250 feet above sea level. Possibly some water may be found both in the Devonian and in the Silurian limestones. The dry Maquoketa shale is between 250 and 290 feet thick. It is underlain by the Galena and Platteville limestones, in which some water beds may be discovered. The Saint Peter sandstone, with its assured supply of good water, in this area probably lies about 300 feet below sea level. Any drilling should be carried 300 to 400 feet deeper still in order to tap the large supplies of the Prairie du Chien stage and the Jordan sandstone. The depth of a successful well thus would be probably about 1,300 feet.

Belle Plaine.—City well No. 1 (Pls. VIII, XI), at Belle Plaine (population, 3,121), has a depth of 1,503 feet, and a diameter of 10 inches to 215 feet, 8 inches to 503 feet, 6 inches to 1,300 feet, 5 inches to bottom of well. Its curb is 810 feet above sea level, and its original head 34 feet below the curb; after three months' use the head was 20 feet below the curb. Pump cylinders are set at 63 and at 174 feet below surface; pumping capacity, 100 gallons a minute. The well was completed in 1907.

Water was first found in the Aftonian gravel at a depth of 214 feet. This flow, estimated at 2,000 gallons a minute, gave much trouble and made it impossible to drive the 10-inch casing to bedrock. A second flow, estimated as at least 75 gallons a minute, was struck at 316 feet from the surface at the base of a blue calcareous shale. An analysis shows that this water contained 149 grains of solids to the gallon, including more than ,60 grains of scale-forming salts; magnesium sulphate amounted to nearly 13 grains to the gallon and calcium sulphate to nearly 18 grains. On the advice of W. H. Norton, drilling was continued and water was found in the Galena at a depth of 1,140 feet and in the Saint Peter at 1,280 feet, within 30 feet of the predicted depth. The principal water bed is reported at 1,486 feet.

Ten-inch casing was put down to 215 feet, but it could not be driven to rock. An eight-inch casing was put down to the first limestone, found at 315 feet, and bedded in it without packing. As the water burrowed under this pipe, a six-inch pipe was inserted to 174 feet, and within this a 5-inch pipe was placed whose base was packed with lead at 503 feet. No casing was inserted below this last depth. The total cost of the well, including pumps and pipes connecting with the reservoir, was $4,200. It was drilled by the J. P. Miller Artesian Well Company, of Chicago. A complete record of the well was not kept, but some drillings were saved.

Record of strata in deep well at Belle Plaine.

	Thickness	Depth
	Feet	Feet
Pleistocene chiefly; no samples	283	283
Devonian (142 feet thick; top, 527 feet above sea level):		
Shale, blue, hard, calcareous, siliceous, pyritiferous; in small chips	12	295
Shale, greenish, in concreted masses; two samples	20	315
Limestone, light yellow-gray, rather soft; dull lustre; in small flaky chips; rapid effervescence; six samples	60	375
No sample	10	385
Limestone, drab, hard, microscopically quartzose; with much light blue chert; three samples	40	425
Silurian:		
Niagaran dolomite (305 feet thick; top, 385 feet above sea level)—		
Dolomite, blue-gray, mottled, slightly vesicular; with a little chert; five samples	42	467
Dolomite, buff, in crystalline sand	8	475

	Thickness	Depth
	Feet	Feet
Dolomite, blue, argillaceous	21	496
Dolomite, buff, in sand	3	499
Dolomite, blue-gray, hard, siliceous; three samples	26	525
Dolomite, blue-gray, subcrystalline, compact; some shale at 545 feet; seven samples	60	585
Dolomite, white, minutely arenaceous	10	595
Dolomite, gray, in crystalline sand; three samples	30	625
Dolomite, blue, and white chert; four samples	48	673
Dolomite, white, granular; cherty; with some greenish shale	2	675
Dolomite, gray; two samples	30	705
Dolomite, gray, with much white chert; three samples	25	730
Ordovician:		
Maquoketa shale (290 feet thick; top, 80 feet below sea level)—		
Shale, blue, drab; twenty-four samples	240	970
Shale, brown-drab; two samples	20	990
Shale; drab at 990 feet; greenish below; three samples	30	1,020
Galena limestone to Platteville limestone (260 feet thick; top, 210 feet below sea level)—		
No samples	20	1,040
Limestone, highly argillaceous; in light gray concreted powder and meal; residue cherty and minutely quartzose; effervescence slow	10	1,050
Limestone; in white concreted powder; effervescence slow; six samples	60	1,110
Limestone; in fine meal, argillaceous residue of minute particles of mottled chert	10	1,120
Shale, drab	10	1,130
Limestone as at 1,110 feet	10	1,140
No samples	20	1,160
Dolomite, buff, some chert; in sand; two samples	20	1,180
No samples	10	1,190
Dolomite, with chert	10	1,200
Limestone, gray, granular, rapid effervescence	10	1,210
Limestone, argillaceous, in light gray concreted powder and meal; rapid effervescence; highly arenaceous at 1,260 and 1,270 feet, with minute grains of quartz; seven samples	70	1,280
Saint Peter sandstone (40 feet thick; top, 470 feet below sea level)—		
Sandstone, white, grains well rounded, up to 0.8 millimeter in diameter; some fragments of green shale; three samples	40	1,320
Prairie du Chien stage (182 feet penetrated; top, 510 feet below sea level)—		
Dolomite, light yellow-gray, argillaceous; in concreted powder	20	1,340
Dolomite, light yellow-gray; highly arenaceous; grains of sand rounded, some sharp with secondary enlargements; two samples	30	1,370
"Sand rock;" no samples	100	1,470
Marl, in powder and small white fragments, slow effervescence; highly siliceous, with microscopic quartz; two samples	20	1,490
Sandstone; grains rounded; up to 0.8 millimeter in diameter; clean, slightly yellow from rust films on grains		

Analysis of rock in Belle Plaine city well at 555 feet.[1]

$CaCO_3$	53.89
$MgCO_3$	43.84
$CaSO_4$	.47
SiO_2	1.04
Fe_2O_3	.13
Al_2O_3	.46
H_2O	.18
	100.01

Blairstown.—The town of Blairstown (population, 532) depends for fire protection on cisterns and private wells and hand pumps. A small private system, owned by Mrs. M. L. Kirk, supplies 26 families with satisfactory water pumped by a 2½

[1]Made in chemical laboratory of Cornell College, Mount Vernon, Iowa.

horsepower gasoline engine from a drilled well, sunk 101 feet deep into "rock sand," into two small elevated tanks from which it is distributed by half a mile of mains. Most of the Blairstown wells are dug or bored in the drift 15 to 30 feet. In some wells gravel is found overlying the hard, shelly limestone at a depth of 100 to 120 feet. H. Lipe, in the western part of town, has a 130-foot well which obtains water in sand below the "blue clay." A few sandy layers occur in yellow clay above but contain little water.

The stockyards well evidently penetrates limestone of the Kinderhook stage at 120 feet and it is reported to draw water from that stratum. The section follows:

Log of stockyard well, Blairstown.

	Thickness	Depth
	Feet	Feet
Soil and yellow clay (loess)	7	7
Clay, blue (Kansan)	80	87
Soapstone (Kinderhook)	33	120

Keystone.—Keystone (population, 412) is on an upland prairie. The town water supply is drawn from a large dug well 68 feet deep, in the bottom of which is a drilled hole extending down to 130 feet, all in the drift. The water is drawn from several layers of sand and gravel. It stands 50 feet below the surface, but its level is quickly lowered by pumping.

The water is forced into an elevated tank holding 1,200 barrels, and gives a pressure of about 45 pounds in the business part of town. The water is chiefly used for fire protection, less than 100 barrels being used daily for other purposes. The water is regarded as of good quality. Under agreement with the Chicago, Milwaukee & St. Paul Railway, the town may use water from the railway well in case of fire or other emergency. The railway system uses a large open well which is on lower ground apparently than the town well and has an abundant supply.

Luzerne.—At Luzerne (population, 160) the shallow town well is eight feet in diameter and 25 feet deep. Most of the inhabitants, however, use bored wells, from 15 to 35 feet deep, which furnish an abundance of good, hard water.

Mount Auburn.—At Mount Auburn (population, 228) water for domestic use is commonly obtained from bored drift wells ranging in depth from 20 to 55 feet. Throughout Cedar and Bruce townships the stock wells range in depth from 100 to 250 feet, entering limestone at 75 to 150 feet. These wells furnish a good supply of hard water standing 50 to 100 feet below the surface. They are generally pumped with windmills. In St. Clair township the deep wells are from 120 to 400 feet deep.

Shellsburg.—Shellsburg (population, 527) is situated on the bottom and north side of the valley of Wildcat creek. The public water supply is owned by the town and is obtained from an open well, 24 feet deep and 14 feet in diameter, dug on the hillslope. The surface deposits of sandy alluvium, about five feet thick, pass into fine white sand, which merges into a bed of coarse gravel. This gravel overlies the limestone and is saturated with water. The well is bricked and cemented to the bottom, which is in open gravel. Normally it is about half full of water, but the level is lowered rapidly by pumping until it stands only two or three feet above bottom, where it remains constant with the pump drawing 40 gallons a minute.

The water is forced into a steel tank (capacity, 13,800 gallons) in which an air pressure of 40 pounds is maintained. In case of fire 240 gallons a minute can be delivered under 80 pounds pressure. The water is apparently wholesome, though little is used except for fire protection, on account of the ease with which water can be obtained from the gravels by a dug well. In the lower parts of the town drive points are successfully used to draw water from the same source.

Urbana.—The town of Urbana (population, 306) has no public supply. The shallow wells are dug to rock at a depth of 30 to 50 feet and find "sheet water" in gravel. A few of the better wells are drilled from 100 to 300 feet, and for the most part find the most satisfactory supply in the limestone at about 150 feet. As this water stands 30 to 50 feet below the surface, a source in common with that of shallow wells is indicated.

The well at the Urbana creamery is typical of the better drift wells. Water is obtained from a bed of sand and gravel underlying the blue clay of the Kansan drift and overlying the bedrock at a depth of 180 feet. J. G. Waitman found water at 100 feet under similar conditions in the NE. ¼ sec. 3, T. 86 N., R. 9 W.

Van Horne.—Van Horne (population, 444) is situated on the crest of the divide between Cedar and Iowa rivers. Fire protection is obtained from two large open wells 25 feet deep. The water usually stands 5 to 10 feet from the top and is pumped by hand. At the electric light plant a well 20 feet deep was dug to obtain water for boiler feed. The water was fairly satisfactory, producing little scale, though leaving a heavy white sediment. As the supply was, however, insufficient, a hole six inches in diameter was drilled to a depth of 795 feet and cased to rock at 264 feet. The driller's record follows:

Driller's log of well at Van Horne.

	Thickness	Depth
	Feet	Feet
Soil and yellow clay	30	30
Clay, blue	234	264
Limestone, white	456	720
Shale (Maquoketa), dry; stopped in shale	75	795

The Chicago, Milwaukee & St. Paul Railway dug 136 feet and drilled 111 feet to find water in the rock. The ground-water level is very low. Wells 200 to 300 feet deep are nearly all in drift.

Vinton.—The city of Vinton (population, 3,336) owns two deep flowing wells, 400 feet apart. One, 1,287 feet deep, was drilled by W. N. Casey & Son in 1889; the other, 1,425 feet deep, was sunk by A. K. Wallen in 1892. (See Pls. VII, VIII, IX.) Both are six inches in diameter and the initial head was 28½ feet above curb (800½ feet above sea level); the flow of the first was 62 gallons per minute, of the second 50 gallons a minute. The temperature of their waters is the same—56° F. In well No. 1 sulphurous water, rising within eight feet of the surface, was obtained at a depth of 125 feet; water-bearing strata were also penetrated at depths of 950, 1,230, and 1,280 feet. The casing in this well was carried to a depth of 620 feet. The strata penetrated in these wells are indicated in the following sections:

Record of strata in city well No. 1 at Vinton.

	Thickness	Depth
Quaternary:	Feet	Feet
Alluvial and drift deposits in ancient river valley	115	115
Devonian (20 feet thick; top, 665 feet above sea level):		
Limestone; hard and compact, nonmagnesian, light cream color; fracture subconchoidal	20	135
Silurian:		
Niagaran dolomite (215 feet thick; top 645 feet above sea level)—		
Limestone, magnesian, light buff, porous, subcrystalline	15	150
Limestone, powder, pinkish, argillaceous, cherty; contains some magnesia; associated with some dark clay and light nonmagnesian limestone	18	168
Limestone, powder, white, nonmagnesian, pyritiferous, with white chert and some rounded grains of quartz	82	250
Dolomite, hard, compact, subcrystalline, yellowish in color, with white chert, inclosing centers of gray flint	15	265
Dolomite, powder, white	10	275
Dolomite, bluish gray, subcrystalline, with gray flint	10	285
Clay, light green	5	290
Sandstone, very fine, white; grains angular	5	295
Dolomite, chips soft, light gray, porous, crystalline, with a little dark gray flint	55	350
Ordovician:		
Maquoketa shale (269 feet thick; top 430 feet above sea level)—		
Shale, green, calcareous	25	375
Shale, fine, bluish, calcareous; soluble portion magnesian	167	542
Magnesian limestone or dolomite, chips hard, brown, subcrystalline, ferruginous	23	565
Shale, light and dark gray	9	574
Shale, light bluish, calcareous	45	619
Galena and Platteville limestones (401 feet thick; top 161 feet above sea level)—		
Limestone, powder, light gray; argillaceous; contains some magnesia	111	730
Limestone, powder, cream colored; contains some magnesia	30	760
Limestone, as above	47	807
No sample	13	820
Limestone, gray	15	835
Limestone, soft gray; chips minute	65	900
Limestone, bluish gray, nonmagnesian; chips minute	75	975
Limestone, rather soft, fine-grained, compact, light gray, nonmagnesian; chips thin, flaky	45	1,020
Saint Peter sandstone (55 feet thick; top 240 feet below sea level)—		
Sandstone, with fragments of limestone	20	1,040
Sandstone, clean quartz, grains rounded, of moderate and nearly uniform size; vitreous, limpid; surface ground	35	1,075
Prairie du Chien stage (212 feet penetrated; top 295 feet below sea level)—		
Chert, white; with white dolomite, and greenish slate-like shale	5	1,080
Dolomite, chips subcrystalline, minutely porous, medium dark gray, with much chert	15	1,095
Dolomite, powder, fine, white	5	1,100
Dolomite, chips white and light gray, fine-grained, subcrystalline, with some chert	25	1,125
Dolomite, hard, medium dark gray, and softer white	50	1,175
Sandstone, with considerable dolomite, grains of silica light colored, varying widely in size, largest being about 0.9 millimeter in diameter	15	1,190
Dolomite, chips white and light gray, fine-grained, subcrystalline, with some chert	85	1,275
Chert with minute calcareous fragments	10	1,285
Sandstone, grains mostly rounded, varying considerably in size, largest about 1 millimeter; also considerable dolomite	2	1,287

Driller's log of city well No. 2 at Vinton.

	Thickness	Depth
	Feet	Feet
Surface material	100	100
Limestone, white	200	300
Clay, tough, blue	320	620
Limestone, brown	200	820
Limestone, light gray	150	970
Sandstone, Saint Peter	50	1,020
Sandstone, brown	200	1,220
Sandstone, light (water bearing)	20	1,240
Sandstone, coarse, brown	170	1,410
Sandstone, white, coarse (water bearing)	30	1,440

The agreements of the log of well No. 2 with the record and drillings of well No. 1 are more marked than the discrepancies. In log No. 2 the Niagaran is not discriminated; the top of the Maquoketa is 50 feet higher than in the record of well No. 1; the Maquoketa is 52 feet thicker, and the Middle Ordovician limestones (Galena and Platteville) are as much thinner; the Shakopee dolomite is called "brown sandstone," the drillers not distinguishing the fine sand of angular drill-cut fragments of dolomite from true siliceous sand—a common error. The Saint Peter has the same thickness in both sections, but it is placed 50 feet higher in log No. 2. The thin sandy layer at 1,175 feet in well No. 1 was overlooked in well No. 2. The sandstone at 1,220 feet in well No. 2 is identical with the basal sandstone of well No. 1, and is referred to the New Richmond. "Brown sandstone" at 1,240 feet of well No. 2 is taken to be the Oneota dolomite, and the white water-bearing sandstone at 1,410 feet the Jordan sandstone.

In 1909 the flow from the wells had almost ceased. The casings of black iron had become so deeply corroded in 19 years of use that they were drawn with great difficulty, and on the north well it was considered necessary to use several shots of high explosives. By exceptional good fortune the drill hole was not completely wrecked and the work of repairing the two wells was then intrusted to other hands and was carried forward to successful completion. Both wells were recased with five-inch standard galvanized casing to 612 feet—that is, through the Maquoketa shale. In making the repairs it was found that the first flow was at about 600 feet, near the base of the shale just mentioned. The second flow of 13 gallons per minute was from near the summit of the Saint Peter sandstone, at 1,270 feet. On completion the flow from each well measured 27½ gallons a minute, with a head of 6 feet above the surface of the ground. An air compressor was installed in one well. It works from 173 feet below the surface and yields 162 gallons a minute. The other well is allowed to flow into the cement-lined cistern holding 2,000 barrels, constructed some years before the repairs were made, but the flow of this well is small when the air lift is at work in the adjacent well. The inefficiency of the supply before the repairs were completed compelled the introduction of a second system for which the water was taken from a well 20 feet in diameter and 32 feet deep dug in the sand and gravel 60 feet from Cedar river and fed from the underflow. On hard pumping the water level was lowered rapidly, and it was supposed that at such times the well drew directly through the sands from the river, the water level in well and river ordinarily being the same. Into this well a feed pipe used only in emergencies led directly from the river. A separate pump forced the water from this well into a distinct set of mains and supplied the railroad, several factories, and the street sprinklers. This part of the system consumed about 60 per cent of the total amount pumped daily.

While the repairs on the wells were in progress and entire dependence was placed on the shallow well and river, a considerable epidemic of typhoid fever broke out in the city. The city supply is now drawn entirely from the two artesian wells.

Another valuable flowing well six inches in diameter and reported as 2,000 feet in depth, drawing its supply from the deeper artesian sources, is located about two miles west of Vinton on W. P. Whipple's farm.

About one-third of the population of Vinton is supplied from shallow private wells sunk in the drift. Such wells in so large a town are very liable to be polluted by water entering from the surface.

The Iowa State College for the Blind has a well 160 feet deep, which has not been used for several years because in one summer it failed. The college uses more than 2,500,000 gallons annually from the city supply.

A well owned by C. Fee was drilled many years ago in prospecting for oil. The depth is variously reported as about 2,000 and near 3,000 feet. The water still flows with a head four or five feet above the curb.

WELL DATA.

The following table gives data of typical wells in Benton county:

Typical wells of Benton County.

Owner	Location	Depth	Depth to rock	Source of supply	Head	Remarks (Log given in feet)
		Feet	Feet		Feet	
T. 85 N., R. 9 W. (Parts of Polk and Benton).						
Joseph Kisling	4 miles southeast of Urbana.				8	Cedar river bottoms.
T. 85 N., R. 10 W. (Parts of Taylor and Harrison)						
W. M. Pitts	Sec. 1	76	46	Limestone		
T. 84 N., R. 9 W. (Canton).						
M. White	NW. ¼ sec. 11	40	15	do	— 12	Fine hard water.
Milton Richey	NE. ¼ sec. 20	307		Gravel	—147	
William Hatfield	SW. ¼ sec. 21	120		Gravel	— 60	
James Rife	SW. ¼ sec. 11	130	2	Limestone		Plenty of hard water.
T. 82 N., R. 11 W. (Le Roy).						
Stock yards	Blairstown	120	120	Shale	— 20	"Water crevice in dark slate rock."
C. E. Case	NW. ¼ sec. 27	450				Scanty supply.
H. Lipe	SE. ¼ sec. 28	92	(a)	Sand		Plenty of good water.
T. 85 N., R. 11 W. (Jackson).						
J. Alchorn	SE. ¼ sec 25	220	140	Limestone		
Joseph Kline	NE. ¼ sec. 6	149		do		
William Baldridge	SE. ¼ sec. 1	202		do		
T. 84 N., R. 10 W. (Eden).						
N. D. Boneshel	SE. ¼ sec. 23	130	130	Gravel	— 20	To limestone.
C. E. Bean	SE. ¼ sec. 19	200	198	Top limestone		
John Powers	NE. ¼ sec. 5	125	(b)	Gravel		

Owner	Location	Depth	Depth to rock	Source of supply.	Head	Remarks (Log given in feet)
T. 84 N., R. 11 W. (Big Grove).						
A. W. White	NW. ¼ sec. 2	130	(*b*)	Gravel		
T. M. Anderson	NE. ¼ sec. 1	240	(*b*)	do		
T. 83 N., R. 10 W. (Eldorado).						
Jacob Schlotterbeck	NW. ¼ sec. 10	400		Limestone		Several holes abandoned.
Adam Kranz	SW. ¼ sec. 11	2?0	200	do	—120	
E. S. Thompson	SW. ¼ sec. 29	480				
T. 83 N., R. 9 W. (Fremont).						
A. H. Fawcett	SE. ¼ sec. 8	250	(*a*)	Gravel		Strong well.
T. M. Gregor	SW. ¼ sec. 35	250	(*a*)	Sand		Plenty of water.
T. 82 N., R. 10 W. (St. Clair).						
William Reissers	SE. ¼ sec. 28	140	(*a*)	do		
Charles Parschl	NE. ¼ sec. 34	250	(*a*)	do		

a No rock; drift.
b No rock.

CEDAR COUNTY.

BY W. H. NORTON.

TOPOGRAPHY.

Cedar county is an area of low relief; its highest and lowest elevations differ by only about 325 feet. The strongest topographic contrasts are presented by the uplands of Kansan drift and the Iowan drift plains. The latter comprise two lobate areas. One stretches across the northern tier of townships, its southern boundary coinciding pretty closely with the line of the Chicago & North Western railway, which chose the even surface and low levels of the plain in preference to the rugged Kansan upland. The second lobe enters the county from the west along the left bank of Cedar river and extends nearly to Tipton.

The Kansan upland varies in relief according to the degree of its dissection. In Farmington township its nearly level divides are scored by only the faintest erosion channels; in Fairfield township it is a gently rolling prairie; but bordering Cedar river in Rochester and Cedar Valley townships it has been cut to a maze of the steepest of hills.

GEOLOGY.

The rocks of the county fall into two general divisions. The Niagaran, a buff dolomite, forms the bedrock over the northern and eastern parts, and Devonian limestones of differing lithologic characteristics underlie the southeastern part. (See Pls. X, XI.)

The drift sheets appearing on the surface are the Kansan and the Iowan; a third drift sheet, the Nebraskan, is in places found beneath the Kansan and separated from it by old soils and forest beds (Aftonian) and outwash sands.

The loess, a yellow silt, destitute of pebbles, mantles the Kansan areas.

UNDERGROUND WATER.

SOURCES.

The ground-water supplies of Cedar county are, at present, drawn chiefly from deep-lying sources. The shallow wells which at an early date found plenty of water at the base of the loess in ashen silts and basal sands and in sands separating yellow and blue stony clays have been generally either abandoned or sunk deeper, because of both decreasing supply and increasing demands. On alluvial bottoms, such as the flood plains of the Cedar and some of the larger creeks, shallow wells still are adequate even for farm purposes.

Aquifers largely used are the sands and gravels associated with the drift. These water beds occur as discontinuous lenses in the Kansan and Nebraskan, as extensive sheets parting the stony clays of the drift, and in basal sands parting the Nebraskan till from rock. Sands, locally of great thickness, occur in the well-marked buried ancient river valley which traverses the county from north of Stanwood to the southeast corner. Though these sands are, as a rule, saturated with water, they are in many places too fine to yield a supply of water owing to the impracticability of screening them out with present methods. A very valuable water bed is that formed by the basal sands of the drift and the upper few feet of bedrock, broken and made pervious by preglacial weathering.

In the bedrock water occurs throughout the Niagaran dolomite, where it accumulates in large quantities owing to the impervious floor of the Maquoketa shale on which the latter rests. Water is also found in the Devonian limestones of the southern and western parts of the county. In both limestones it occurs in channels dissolved by waters seeping along bedding planes and joints in porous layers.

DISTRIBUTION.

The areas of Iowan drift of the northern and northeastern parts of the county can hardly be set off from those of the Kansan drift as a distinct underground water province, for the Iowan drift forms but a veneer upon the older drift sheet and cannot influence the distribution of ground water. The low relief of the Iowan allows ground water to stand high and to exude in swales and wet-weather ponds, but in only a few places is the water thus stored sufficient for farm wells. In places on the Tipton lobe sands store water sufficient for house wells.

A well-defined province is that of an ancient rock-cut channel deeply buried by the drift, which may be called "Stanwood Channel," as it extends beneath the town of Stanwood. The surface of the ground gives no indication whatever of the topography of the rock surface lying 300 feet beneath. Enough deep wells have been drilled over this "deep country" to outline its general course, although they fail to define accurately either its gradient or its width. The channel (fig. 4) enters the county in Fremont township and, curving sharply to the east, passes southeast to Stanwood. Trending thence southward, it passes east of Tipton and follows along the east side of Sugar creek. About 2½ miles north of Lime City it turns to the southeast and near Durant joins the ancient buried valley, passing through Scott and Muscatine counties southward.

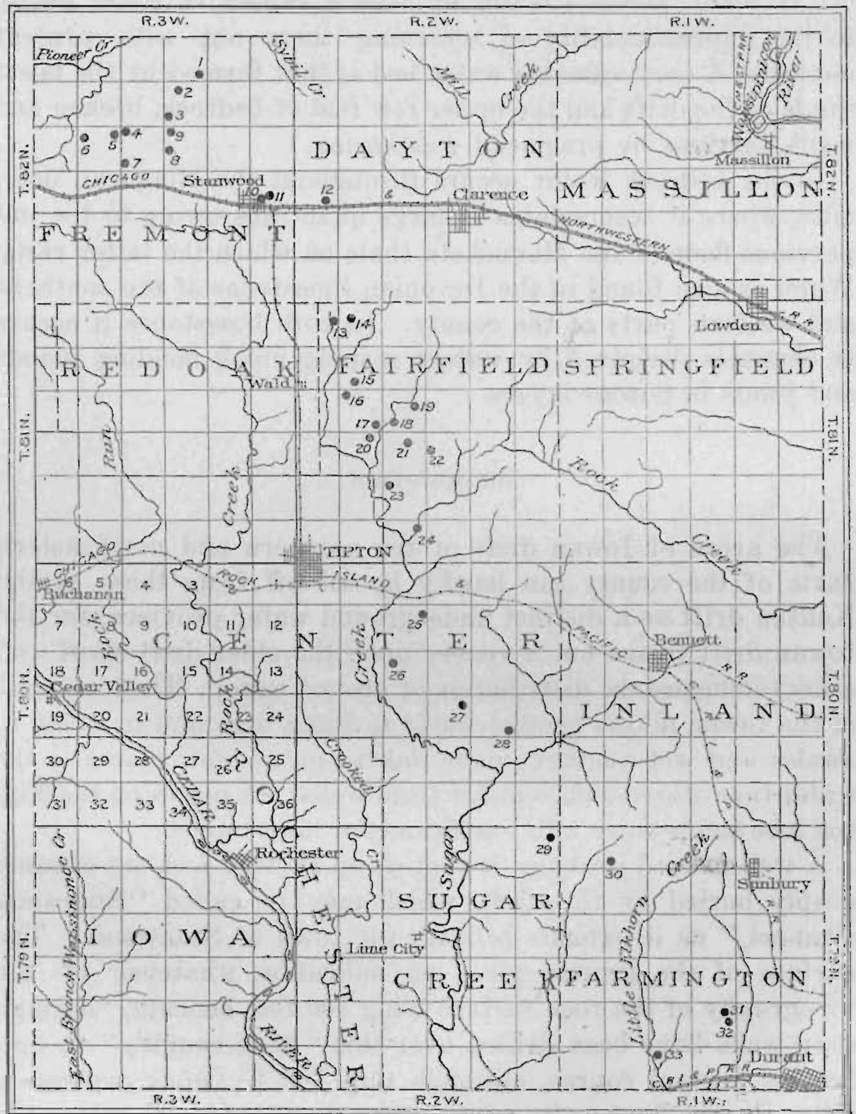


Figure 4.—Map showing location of wells (●) marking the position of the buried Stanwood Channel. Numbers on wells refer to table on p. 446.

At Stanwood the rock floor of the channel is 544 feet above sea level, if correctly reported; five miles southeast of Stanwood rock was struck at 440 feet. In southwestern Scott county the floor of this channel is not higher that 400 feet above sea level.

In Cedar county the channel is aggraded with river sand beneath and glacial stony clays above. At Stanwood it is filled with sand to a height of 116 feet above its floor of rock. At Henry Britcher's place sand 144 feet thick is reported overlying rock. In some wells these sands are replaced by glacial pebbly clays and the work of the driller is much lightened. The sand is generally of fine grain, and that in one well is reported as so fine as to sift through a tobacco sack. It contains streaks and beds of coarser sand and even of gravel. It presents a serious problem for the driller, for though it is saturated, it is for the most part too fine for ordinary types of strainers and affords no ground for casing. The water which makes it a quicksand forms an inexhaustible reservoïr, supplying the gravels at its base and the upper creviced layers of the bedrock.

No "deep country" is reported in Pioneer township, and although the land is considerably diversified in relief, water is found generally from 80 to 100 feet from the surface in Niagaran dolomite. In the northeastern part some wells are drilled as deep as 140 feet.

Outside the deep buried Stanwood Channel wells in Fremont township are of moderate depth. West of this channel rock is generally entered at from 80 to 100 feet. Northeast of Mechanicsville it comes within from 30 to 50 feet of the surface and water is obtained in abundance by wells 80 or 90 feet deep. In sections 21 and 28 rock lies lower than 150 and 170 feet below the surface of the gently-rolling Kansan upland, indicating here a branch of the Stanwood Channel. These wells, like many wells of the main channel, find water at top of the river sand with which these buried valleys have been deeply filled.

In the northern half of Dayton township rock outcrops or is found near the surface. In the southern part the drift is deeper, reaching in places a depth of more than 125 feet. Wells commonly find water in the Niagaran dolomite within from 80 and 90 to 120 feet from the surface, the water rising within 40 feet of the curb.

On the loess-covered dissected Kansan upland west of Massillon, in Massillon township, wells find water within 140 feet, in Niagaran dolomite, which here comes within 80 or 90 feet of the surface. Loess is of unusual thickness and drift clays are thin.

On the high ridge north of Lowden, extending northwest and southeast through sections 20-22, 25-28, 35 and 36, wells on the crests are from 150 to 180 feet in depth, finding water in gravels of the drift. In one well on this ridge rock was entered at 85 feet and water obtained in the Niagaran, the depth of the well being 144 feet.

In Linn, Cass, and Red Oak townships rock lies near the surface and is rarely as far as 70 or 100 feet below it. Water is found chiefly in the Niagaran at depths seldom exceeding 100 and 120 feet. At the large stock farm of Alexander Buchanan, in sections 13 and 18, Linn township, a well was sunk to the very exceptional depth of 300 feet, of which 230 feet were in rock, presumably the Niagaran.

Northwest of Tipton, in Center township, rock underlies the Iowan drift plain at no great depth, and outcrops are not uncommon. Wells find plenty of water within 50 feet or less of the surface. In and about Tipton a greater depth of wells is rendered necessary by the deeper-lying rock. Thus at the fair grounds a well was sunk 201 feet, 105 feet being in rock. At A. Birk's, northeast of town, rock was entered at 175 feet, and the total depth of the well is 275 feet. At H. L. Huker's, on the east side of town, a well 197 feet deep found no rock. There seems to be here either a strong descent to the buried Stanwood Channel, which lies east of Tipton, or perhaps the channel of a tributary. Within the city limits the depth to rock ranges from 85 to 130 feet and water is found either immediately upon or in the rock.

Near the border of the Iowan drift house wells obtain water in the basal sands of the loess. The sands which part the blue and yellow tills also afford a moderate supply.

Over most of the southwestern part of Center township wells find water in limestone, either Niagaran or Devonian, within from 80 to 130 and 140 feet of the surface. Here the bedrock is in few places covered with more than 80 feet of drift. In the eastern part of the township, beyond the belt of "deep country" of the buried Stanwood Channel, the drift is from 80 to 130 feet thick, and wells commonly find water in the Niagaran at depths of from 100 to 150 feet.

Concerning Inland township the facts at hand relate chiefly to wells in the northern part, where stock wells range from 100 to 170 feet, finding water in rock a few feet below its surface. The drift here is 60 to 170 feet thick.

In the maze of steep hills of the Kansan upland of the eastern part of Grover township water is found in rock from 100 to 180 feet below the surface, the cover of loess and till being 70 to 100 feet thick. In the western part of the township the drift is 170 to 200 feet thick and several wells are 190 to 220 feet deep.

In Springdale township the drift is deep, ranging generally from 100 to 180 feet. In the extreme northeast sections the drift is thinner, and at the village of Springdale rock is entered at 50 feet. The wells reported range in depth from 120 to 215 feet, water commonly being found in Devonian limestone.

In Iowa and Rochester townships the Devonian limestones appear at the surface or closely approach it. On the upland of Iowa township rock is found at 40 to 80 feet. In some rock-cut buried valleys the rock lies as deep as 120 feet. In Rochester township, though rock outcrops east of Rochester, it occurs as deep as 120 and 200 feet in the northeastern sections. The wells reported penetrate the limestones to depths ranging from 20 to 100 feet before finding sufficient water, and exceptionally wells are sunk in rock as much as 120 feet. Northeast of Springdale a well 200 feet deep is reported.

In Sugar Creek and Farmington townships, outside the course of the Stanwood Channel, rock approaches within 40 and 59 feet of the surface between Sudbury and Durant and north of Lime City. Northeast of Lime City it lies from 90 to 125 feet below the surface, and one well, which may be on a tributary of the Stanwood Channel, is reported to end in gravel at 325 feet.

In the western part of Farmington township the drift appears to be from 80 to 140 feet thick. Water is found in or on the rock, and wells, except in the buried channel, seldom exceed 130 feet in depth.

Wells in the Stanwood Channel.[1]

No.	Owner	Location	Depth	Depth to rock	Remarks: (Log given in feet)
	T. 82 N., R. 3 W. (Fremont).		Feet	Feet	
1	L. Williams	SE. SE. ¼ sec. 3	154	------	Yellow clay, 30; blue clay, 100; sand, 24.
2	M. Rigby	NW. ¼ sec. 10	162	------	
3	L. Lehrman	SW. ¼ sec. 10	103	------	Blue clay, 90; dark fine sand, 13.
4	A. Pound	NW. ¼ sec. 16	216	------	Drift clays, 125; sand and gravel, 91. Water rises within 60 feet of surface.
5	John Foley	NE. ¼ sec. 17	257	------	
6	J. P. Hines	Sec. 17	197	------	Blue clay, 180; sand, 17.
7	R. A. Bardue	SW. ¼ sec. 16	210	180	Blue clay, 120; sand, 60.
8	George Melton	NW. ¼ SW. ¼ sec. 15	192	------	Drift clays with streaks of sand (one 7 feet thick), 180; sand, 12.
9	J. Ferguson	NW. ¼ NW. ¼ sec. 15	109	------	
10	Tile Works, Stanwood	SW. ¼ sec. 24	340	296	Yellow loess, 20; ashen loess, 7; green clay, 1; yellow, stony clay, 7; blue clay (Kansan), 65; sand, with fragments of wood (Aftonian), 15; blue clay (Nebraskan), 65; sand, 116; shale (Maquoketa), 44.
11	H. S. Hoyman	NW. ¼ SE. ¼ sec. 24	250	220	
	T. 82 N., R. 2 W. (Dayton).				
12	S. M. Davidson	SE. ¼ sec. 19	230	215	
	T. 81 N., R. 2 W. (Fairfield).				
13	Henry Britcher	SE. ¼ NE. ¼ sec. 6	365	327	Yellow clay, 60; blue clay, 123; sand, 144; limestone, 12; blue soapstone, 6; limestone with water, 20.
14	O. T. Johnson	NW. ¼ sec. 5	250	220	Yellow clay, 30; blue clay, 50; fine, white sand; limestone, with water rising within 50 feet of surface, 30.
15	J. Monahan	SE. ¼ SW. ¼ sec. 8	185	------	
16	George Kinney	NW. ¼ NW. ¼ sec. 17	333	320	
17	N. and K. Lay	SE. ¼ sec. 17	240	180	
18	E. E. Heltebrielle	SW. ¼ sec. 16	295	293	
19	M. J. Fay	SW. ¼ NE. ¼ sec. 16	198	177	Yellow clay, 20; blue clay, 155; a little sand on rock.
20	N. Fay	NE. ¼ sec. 20	247	184	
21	T. Wingerd	NE. ¼ sec. 21	302	278	
22	Gus Peters	NW. ¼ sec. 22	298	233	Chiefly blue clay; not 10 feet of sand.
23	D. Moreland	NW. ¼ sec. 28	98	------	
24	F. H. Milligan	NE. ¼ sec. 33	250	248	Drift clays, 80; fine sand, 160; black clay (geest?), 8; porous limestone, 2. Water rises within 30 feet of surface.

Number	Owner	Location	Depth	Depth to rock	Remarks (Logs given in feet)
	T. 80 N., R. 2 W. (Part of Center).		Feet	Feet	
25	W. Stubblefield	NE. ¼ NE. ¼ sec. 9	202	220	Yellow clay, 40; blue clay, 180; sand.
26	G. W. Gary	NW. ¼ sec. 16	304	302	
27	J. B. Carl	NE. ¼ sec. 22	200	------	
28	J. Helmer	SE. ¼ SE. ¼ sec. 23	300	------	
	T. 79 N., R. 2 W. (Sugar Creek; part of Rochester).				
29	B. Ayres	NE. ¼ sec. 1	220	------	
	T. 79 N., R. 1 W. (Farmington).				
30	John Rice	SW. ¼ SW. ¼ sec. 5	110	------	
31	C. H. Nienaber	NE. ¼ sec. 27	196	------	
32	Charles Fitzler	do	272	------	
33	Marx Hartz	NW. ¼ sec. 33	217	------	

[c] For position of wells see fig. 4.

CITY AND VILLAGE SUPPLIES.

Buchanan.—At Buchanan (population, 61) water is obtained from drilled wells 27 to 127 feet deep, a depth of 120 feet being very common. The water in the deeper wells rises within 70 feet of the surface. Springs furnish a small part of the water.

Clarence.—The water supply of Clarence (population, 662) is pumped from a well to an elevated tank giving a gravity pressure of 40 pounds. There are two miles of mains, 11 fire hydrants, and 100 taps. Many house wells, ranging in depth from 20 to 115 feet, are still used. These wells enter rock at 60 feet, and obtain their largest supplies at about 90 feet. The water of the deeper wells rises within 40 feet of the surface.

Durant.—At Durant (population, 720) the public supply is drawn from a well and pumped to an elevated tank with a capacity of 600 barrels, supplying a gravity pressure of 46 pounds. There are two miles of mains and 24 hydrants. House wells ranging in depth from 40 to 50 feet and obtaining water in sand are used largely.

Lowden.—In Lowden (population, 584) water is obtained from wells that range in depth from 20 to 200 feet. A small amount is obtained from springs.

Mechanicsville.—At Mechanicsville (population, 817) water is pumped from wells into a tank, giving gravity pressure of 45 pounds. There are 4,400 feet of mains and 12 hydrants.

Springdale.—At Springdale (population, 125) wells range in depth from 75 to 150 feet.

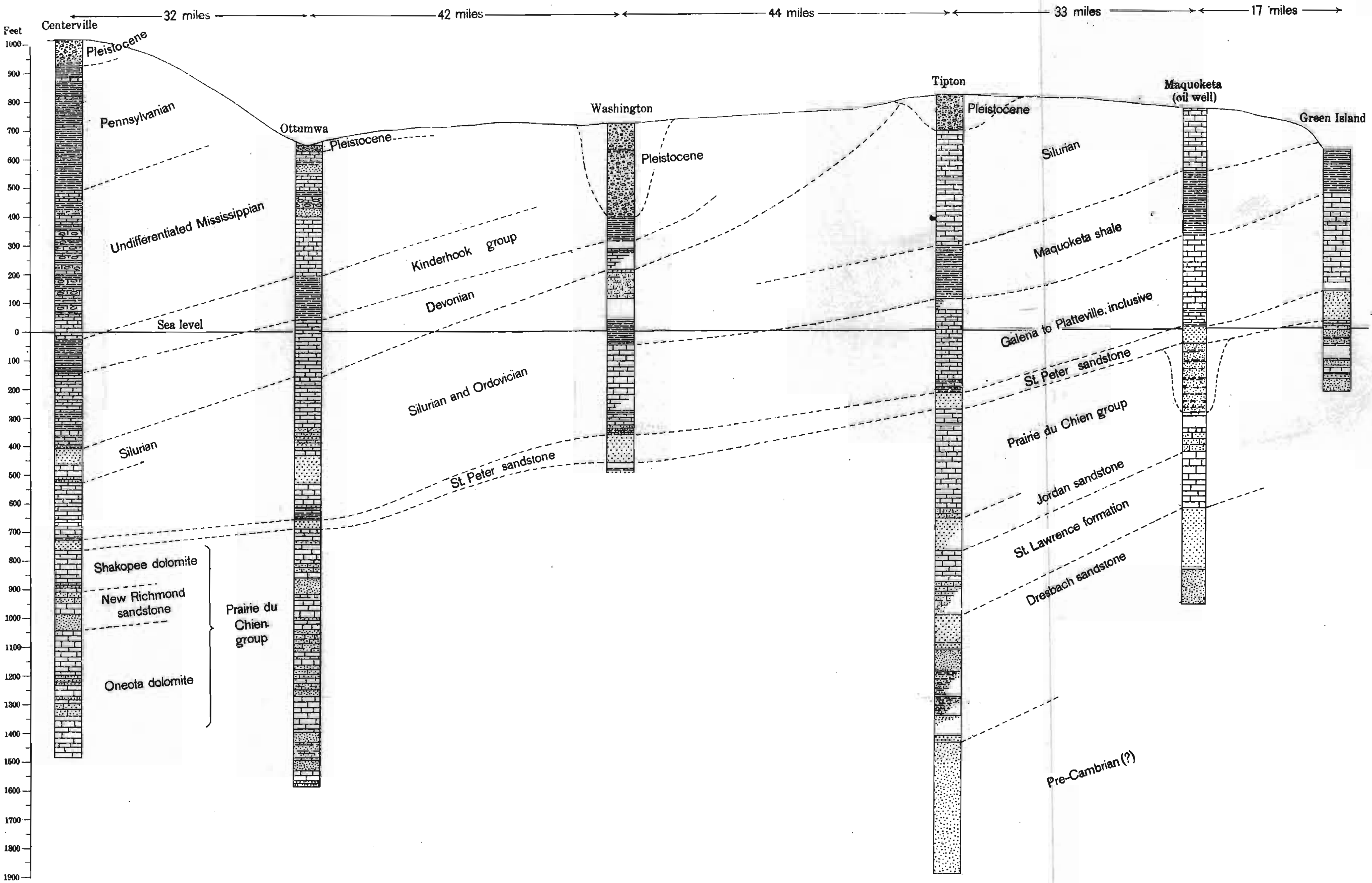
Stanwood.—Open and drilled wells ranging in depth from 20 to 300 feet furnish water at Stanwood (population, 511). The depth to the water-bearing formation in the deeper wells is 120 feet, and water rises within 50 feet of the surface. A well 630 feet deep and ranging in diameter from 10⅝ to 8 inches was sunk at the Chicago & North Western railway track in 1905. (See Pl. XI.) The elevation of the curb is 847 feet above sea level. Water was not found in adequate quantity and the well was abandoned in 1907. The record of this well based on driller's log follows:

Record of strata in railway well at Stanwood.

	Thickness	Depth
	Feet	Feet
Pleistocene (300 feet thick; top, 847 feet above sea level):		
Clay, yellow, soft	30	30
Clay, blue, soft	80	110
Clay, sandy, brown, hard	8	118
Clay, blue, soft	84	202
Sand and mud, soft; some blue and some yellow	98	300
Silurian:		
Niagaran dolomite (70 feet thick; top, 547 feet above sea level)—		
Streaks of clay and lime rock; had to be cased	20	320
Lime rock, light colored, soft; a little water	50	370
Ordovician:		
Maquoketa shale (250 feet thick; top, 477 feet above sea level)—		
Shale, light blue, soft	250	620
Galena limestone (10 feet penetrated; top, 227 feet above sea level)—		
Lime rock; gray, hard	10	630

Sunbury.—In Sunbury (population, 200) water is obtained chiefly from wells and cisterns. A small quantity is also obtained from springs.

Tipton.—The water supply of Tipton (population, 2,048) is drawn from a well 2,696½ feet deep. (See Pl. X.) The diameter is reported as eight inches. The well was originally cased to 120 feet and was recased in 1889 to 225 feet. The curb is 810 feet above sea level, and the original head was 65 feet below



GEOLOGIC SECTION BETWEEN GREEN ISLAND AND CENTERVILLE, IOWA
By W. H. Norton

THE NORRIS PETERS CO., WASHINGTON, D. C.

the curb. The present head is about eighty feet below the curb. The tested capacity of the well is 225 gallons a minute. The water beds are unknown, but the drillers, J. P. Miller & Co., of Chicago, reported no water found below 1,200 feet. The temperature is 57° F.

Record of strata in city well at Tipton.

	Thickness	Depth
	Feet	Feet
Pleistocene:		
Drift	135	135
Silurian:		
Niagaran dolomite (365 feet thick; top, 675 feet above sea level)—		
Limestone and dolomite, light gray, hard; white chert at 135 feet; dolomite, buff, at 300 feet; limestone, soft, medium dark gray, argillaceous, slightly magnesian, at 445 feet	365	500
Ordovician:		
Maquoketa shale (200 feet thick; top, 310 feet above sea level)—		
Shale, greenish; 3 samples	100	600
Shale, gray-green; in fine meal of argillo-siliceous particles, and grains of dolomite; some rather coarse imperfectly rounded grains of varicolored quartz	20	620
Shale, blue; in concreted powder	20	640
Shale, chocolate-brown, slightly bituminous	20	660
Dolomite, brown, argillaceous, earthy	20	680
Shale, blue	20	700
Galena limestone to Platteville limestone (330 feet thick; top, 110 feet above sea level)—		
Dolomite, buff and gray; 4 samples	40	740
Limestone; light buff; soft, magnesian	60	800
Limestone, soft, grayish white, argillaceous	50	850
Limestone, white, slightly magnesian	35	885
Limestone, light gray	15	900
Limestone, darker gray	50	950
Limestone, dark blue-gray; fossiliferous, argillaceous	40	990
Shale, green (probably Decorah shale)	10	1,000
Limestone, dark blue-gray, argillaceous	30	1,030
Saint Peter sandstone (55 feet thick; top, 220 feet below sea level)—		
Sandstone, clean, white; grains rounded; 3 samples	40	1,070
Prairie du Chien stage (377 feet thick; top, 275 feet below sea level)—		
Dolomite, gray; green shale in drillings	15	1,085
Dolomite; some sand in drillings	5	1,090
Marl, white, dolomitic, argillaceous, and minutely arenaceous	10	1,100
Dolomite, gray, buff, and in places white; cherty, especially toward the base; white powder at 1,300 feet; 17 samples	265	1,365
Dolomite and sand	35	1,400
Dolomite, light yellow	10	1,410
Dolomite, with sand	40	1,450
Dolomite, gray; considerable sand	6	1,456
Cambrian:		
Jordan sandstone (118 feet thick; top, 652 feet below sea level)—		
Sandstone, calciferous; fine, light colored; rounded grains of quartz, some showing secondary enlargements; also many minute angular cuttings of white subcrystalline dolomite	6	1,462
Sandstone; buff, 2 samples	23	1,485
Sandstone, fine, white and light yellow; 2 samples	17	1,502
Dolomite, highly siliceous, white	3	1,505
Sandstone, fine-grained, light yellow	10	1,515
Saint Lawrence formation (222 feet thick; top, 770 feet below sea level)—		
Dolomite, yellow	65	1,580
Dolomite, dark gray	36	1,616
Dolomite, gray; in fine sand	34	1,650
Marl, blue-gray	30	1,680
Shale, dark greenish, pyritiferous; much dolomite and chips of fine-grained, argillaceous sandstone	22	1,702
Marl, pink	38	1,740

	Thickness	Depth
	Feet	Feet
Dresbach sandstone and underlying Cambrian strata (443 feet thick; top 992 feet below sea level)—		
Sandstone, clean, white, saccharoidal; grains generally rounded but many faceted with secondary enlargements; largest grains 1 mm. in diameter	62	1,802
Sandstone, white, fine; 3 samples	88	1,890
Sandstone; in fine, siliceous powder	5	1,895
Sandstone, white; grains very fine, mostly angular	5	1,900
Marl, minutely arenaceous	10	1,910
Sandstone, fine, white; shale in drillings	15	1,925
Sandstone, buff, fine	25	1,950
Marl, siliceous and glauconiferous	15	1,965
Sandstone, pink; in minute angular fragments	25	1,990
Marl, siliceous and glauconiferous	5	1,995
Marl, pink-gray; microscopically quartzose; glauconiferous	75	2,070
Marl, reddish, microscopically quartzose; glauconiferous	30	2,100
Sandstone, gray; in fine powder, consisting as seen under the microscope of angular particles of quartz; calcareous cement	50	2,150
Sandstone, buff, fine-grained	10	2,160
Sandstone, fine, white	50	2,210
Sandstone, white; grains of moderate size, mostly broken; some with secondary enlargements	10	2,220
Algonkian (?) (451½ feet penetrated; top, 1,435 feet below sea level):		
Sandstone, clean, pink, 2 samples	50	2,270
Sandstone, red and brown; 3 samples	70	2,340
Sandstone, moderately fine; grains broken, pink	20	2,360
Sandstone, fine, cream colored	5	2,365
Sandstone, pink; angular grains and grains with secondary enlargements	35	2,400
Sandstone, pink, fine; in angular cuttings, 2,420 and 2,430	30	2,430
Sandstone, light yellow	5	2,435
Sandstone, dark brown	40	2,475
Sandstone, terra-cotta red, fine	10	2,485
Sandstone, reddish; 2 samples	35	2,520
Sandstone, buff, fine	15	2,535
Sandstone, reddish	15	2,550
Sandstone, light purplish, fine	10	2,560
Sandstone, reddish brown, fine; 3 samples	25	2,585
Sandstone, dark reddish brown; grains angular, 2,600 and 2,610	25	2,610
Sandstone, purplish; 2 samples	15	2,625
Sandstone, red, pink and brown, fine; grains broken; 15 samples	71½	2,696½

The water is pumped to a standpipe with a capacity of 27,000 gallons, affording a domestic pressure of 45 pounds. Direct pressure is 100 pounds. There are 3½ miles of mains, 46 fire hydrants, and 320 taps. The consumption averages 45,000 gallons a day.

West Branch.—Waterworks were installed at West Branch (population, 643) in 1906. The supply is from an eight-inch well, 65 feet deep, with a capacity of 100 gallons per minute. Pumping 13¼ hours lowered the water to but seven feet below the surface of the ground. The water bed is honeycombed limestone of Devonian age. Rock is entered at six feet. Water is pumped to a tank with capacity of 30,000 gallons, affording a gravity pressure of 103 pounds. There are 1¾ miles of mains and 23 fire hydrants. Village house wells range from 20 to 50 feet in depth.

WELL DATA.

Information concerning typical wells in Cedar county is presented in the following tables:

Typical wells in Cedar County.

Owner	Location	Depth	Depth to rock	Remarks: (Logs given in feet)
		Feet	Feet	
T. 81 N., R. 4 W. (Parts of Cass and Linn.)				
Charles Lodds	SE. ¼ sec. 25	50	25	
Mary Kauffman	SE. ¼ sec. 26	-------	80	Nearly all blue clay; bowlders from 20 to 40.
B. Wilson	Sec. 30	73	50	Yellow clay 20; blue clay, 30.
Charles Pfaff	SW. ¼ sec. 36	118	100	
Philip Hammond	NW. ¼ sec. 4	80	16	
C. Strother	Sec. 12	-------	70	
Elmer Wallick	Sec. 16	120	36	
T. 81 N., R. 3 W. (Red Oak; parts of Cass, Linn, Center)				
R. Stout	SW. ¼ sec. 18	120	100	Drift clays, 100; limestone, 10; greenish pipe clay (Carboniferous cavern filling) 10; limestone to bottom.
Alexander Moffitt	NW. ¼ sec. 6	98	40	
Alexander Buchanan	NW. ¼ sec. 18	300	70	
H. Shank	NE. ¼ sec. 7	65	35	
	SW. ¼ sec. 17	133	40	
E. H. Carl	Sec. 18	160	120	Yellow clay, 60; sand, 60.
T. 80 N., R. 2 W. (Parts of Center and Rochester).				
W. W. Aldrich	Sec. 2	220	60	
D. R Smith	Sec. 3	156	136	On rock was found "red granite," 3 inches thick, which cut drill and was dynamited.
G. Wingert	Sec. 4	109	80	60 feet of sand. Strong flow of gas encountered at 60 feet between clay above and sand; would blow off hat.
C. G. Wright	Sec. 5	160	110	
—— Swartzlander	Sec. 6	156	150	Yellow clay deep in this vicinity.
B. Sandy	NE. ¼ sec. 8	-------	102	Yellow clay, soft, 45; blue clay, 45; pebbles, 2.
William Ford	Sec. 10	156	136	No sand.
J. Huddlestone	Sec. 12	100	73	Yellow clay, 10; blue clay, 63.
George Wilbur	Sec. 13	180	130	Yellow clay, 20, sand, 90.
C. W. Carl	Sec. 15	140	120	
H. L. Snider	Sec. 16	190	51	
E. D. Neirson	Sec. 21	140	70	Yellow clay, 35; blue clay, 35.
R. J. Goodale	Sec. 22	120	60	Yellow clay, 20; blue clay, 40.
J. Kropelin	Sec. 34	121	118	20 feet of sand on rock.
H. Dewell	Sec. 2	108	108	Yellow clay, 20; blue clay, 48; on paha hill.
George McLeod	Sec. 25	105	-------	Blue clay, 20; pebbly hardpan overlying quicksand, 20; gravel, 65.

Typical wells in Cedar County—Continued.

Owner	Location	Depth	Depth to rock	Remarks: (Logs given in feet)
		Feet	Feet	
T. 81 N., R. 2 W. (Fairfield; part of Center).				
Moses Brunker	Sec. 29	156	131	
Adam Birk	Sec. 31	275	176	Yellow clay, 20; blue clay with a very little sand, 156; solid log or limb of wood at 166; no dark soil; rock, 99.
P. Metz	Sec. 32	120	51	
L. Haggerty	Sec. 9	170	110	
Johnson Spear	NW. ¼ sec. 16	198	177	
E. H. Carl	Sec. 18	146	120	
J. C. Casford	Sec. 21	150	--------	Much sand and gravel.
Matt. Fell	Sec. 20	133	110	Yellow clay, 20; blue clay, 80; gravel, 10.
J. Kroeplene	Sec. 34	125	118	Nearly all sand and gravel to rock.
T. 79 N., R. 1 W. (Farmington).				
Charles Moorehouse	SW. ¼ sec. 5	110	--------	Black soil, 10; blue clay, 40; sand, 40; gravel, 20.
J. F. Schroeder	Sec. 8	114	80	
Henry Steffen	Sec. 12	54	46	All yellow clay to rock.
William Miller	Sec. 16	132	132	Yellow and blue clays, 80; sand, 30; blue clay, 22.
Johann Klohn	Sec. 23	100	48	
T. 82 N., R. 3 W. (Fremont).				
R. M. Carll	Sec. 2	190	160	Blue clay, 100; sand and gravel, 60.
P. Farrington	SE. ¼ sec. 4	120	120	Yellow clay, 24; blue clay, 64; sand, 14; muck, 10; blue clay and gravel, 8.
John Schwalpert	S. ½ sec. 8	87	40	
G. S. Burleigh	Sec. 9	146	--------	Foot of Stanwood paha. Mostly blue clay; 3 sand beds.
J. Studer	NE. ¼ sec. 18	65	30	
H. B. Thomas	Sec. 20	93	93	Yellow clay, 20; blue clay nearly to rock; water in gravel on rock.
A. M. House	Sec. 21	111	105	
Alex Caldwell	NE. ¼ sec. 28	168	--------	On NW. ¼ NE. ¼, drift clays, 120; sand, 48. On SE. ¼, NE. ¼ rock was entered at 98, and the drill stopped at 118.
T. 80 N., R. 4 W. (Gower).				
J. A. Armstrong	Sec. 4	120	100	Yellow and blue clay to rock.
A. H. Fisher	Sec. 9	220	180	Drift clays, 140; sand, 40.
T. W. Fitzpatrick	Sec. 13	180	75	Hill.
J. Tucker	Sec. 15	112	100	Yellow clay, 60; blue clay, 40.
B. Ellison	Sec. 27	190	160	
W. W. Totum	SE. ¼ sec. 36	135	95	Yellow clay, 20; blue clay, 75.
T. 80 N., R. 1 W. (Inland).				
A. Dresselhouse	Sec. 3	138	160	8 feet of sand on rock.
M. Sparks	Sec. 4	140	140	Yellow clay, 40; blue clay, 45; sand, 5. Water on rock, head, 40 feet.
E. Bell	Sec. 7	172	165	Yellow clay, 50; blue clay, 50; quicksand, 40; blue clay to rock.
H. Wharton	Sec. 11	138	60	

Typical Wells in Cedar County—Concluded.

Owner	Location	Depth	Depth to rock	Remarks: (Logs given in feet)
T. 79 N., R. 3 W. (Iowa; part of Rochester).				
		Feet	Feet	
J. S. Smith	Sec. 4	70	40	
E. Hanna	Sec. 4	160	60	
—— Hutchins	Sec. 5	102	80	
B. Ellison	Sec. 7	100	65	
C. D. Stottler	Sec. 9	100	60	
J. P. Stottler	Sec. 10	160	80	
B. Woods	Sec. 18	160	120	
—— Dufie	Sec. 21	70	40	Water in blue limestone.
W. Kennedy	Sec. 31	256	50	All yellow clay to rock.
H. Cress	Sec. 34	70	40	Water in blue limestone.
T. 79 N., R. 2 W. (Sugar Creek; part of Rochester).				
J. D. Ridenours	Sec. 5	200	60	From 110 to 120 feet "pipe clay" (shale) underlain by 4 feet of coal
C. A. Ridenours	Sec. 7	50	20	
A. Antons	Sec. 29	177	157	Yellow clay, 70; blue clay, 86; sand, 1, to rock. Hill.
Thomas Matthews	Sec. 29	202	102	First rock shelly limestone, 3; blue shale, 5; hard limestone, 96.
James Ross	Sec. 31	130	100	No sand, rock soft and shaly.
—— Ayers	Sec. 1	220	--------	Soft blue clay, 50; sand and clay mixed, mucky, black, 100; clean fine sand resting on gravel, 70.
Isaac Riser	Sec. 1	245	--------	Across road from Ayers. Clay, 50; muddy sand, 100; clean sand, 75; gravel, 20.
Charles Kiser	Sec. 11	124	84	Yellow clay, 74; sand, 10.
T. 79 N., R. 4 W. (Springdale).				
E. Halloway	Sec. 3	213	110	Pipe clay from 125 to 131.
Samuel Thomas	Sec. 9	160	140	Yellow clay, 20; soft sandy blue clay, 20.
D. Wiggins	Sec. 31	215	180	On belt of "deep country," which starts in west of West Branch and runs west of Downey.
T. 80 N., R. 3 W. (Parts of Center, Rochester, Iowa, Gower).				
O. P. Pratt	Sec. 10	80	30	
T. 82 N., R. 1 W. (Massilon).				
L. Vansickle	SW. ¼ sec. 4	112	82	Well unfinished. Loess, 60; ashen loess, 10; sand, 12, to rock. Hill.
J. S. Erbe	SE. ¼ sec. 14	120	--------	Blue clay, 50; sand, 70. Hill.
Charles Kramer	SE. ¼ sec. 20	183	?	Water at 180; much sand.
E. Schleuter	NW. ¼ sec. 27	172	--------	Yellow clay, 40; blue clay to bottom; water in streak of sand at 110.
T. 82 N., R. 4 W. (Pioneer).				
Louis Seever	NE. ¼ sec. 3	140	120	Yellow clay, 35; blue clay, 85; rock.
D. Foley	Sec. 21	143	--------	Yellow clay, 30; blue clay, 110; river sand, 3.
Jacob Hammond	SE. ¼ sec. 32	80	50	
W. Bennett	SW. ¼ sec. 34	80	42	
W. Elliott	SW. ¼ sec. 35	88	30	
David Rhoudes	NE. ¼ sec. 36	130	70	

CLINTON COUNTY

BY W. H. NORTON.

TOPOGRAPHY.

The upland of the northeastern townships of Clinton county attains a height of 900 feet above sea level and is deeply and intricately dissected. The topography is that characteristic of the driftless area and the belt of Kansan drift immediately adjacent. The entire area of these townships has been reduced by long erosion to valley slopes.

The southern portion of the county consists of a gently undulating plain of Iowan drift, diversified, near the edges, with ridges and elongated hills of the older drift, capped with loess, and trending from northwest to southeast.

Wide alluvial plains occur not only along the Mississippi but also along the entire course of Wapsipinicon river (except a short rock-bound reach at Big Rock), and up the valley of Yankee Run. A broad strip of lowland known as the Goose Lake Channel, crossing the county from north to south, marks an ancient temporary channel of the Mississippi.

GEOLOGY.

The bulk of the Pleistocene deposits of Clinton county consists of the Kansan and the Nebraskan drift sheets, the Iowan drift forming but a veneer on the area allotted to it. The northern dissected Kansan upland is thickly covered with a pebbleless yellow silt or dust, the loess. The foundation rock on which the superficial deposits rest throughout most of the county is the Niagaran dolomite; some deep-cut ancient valleys, however, are filled with drift which reaches to the Maquoketa, a blue plastic shale which outcrops along the base of the bluffs of the Mississippi as far south as Lyons.

UNDERGROUND WATER.

SOURCE AND DISTRIBUTION.

Clinton county offers a wide variety of water beds, including the alluvial plains with their shallow ground water, the glacial gravels associated with the different sheets of glacial drift, and the Niagaran dolomite. Some of the deepest farm wells of the county tap still deeper horizons, in the Maquoketa shale and the underlying Galena dolomite. The artesian wells of Clinton pass through the Ordovician formations and tap the Jordan and Dresbach sandstones, and deeper Cambrian strata.

In Sharon township, on the Kansan upland, the drill strikes the Niagaran dolomite at depths ranging from 70 to 120 feet and finds water within 150 feet of the surface. On the Iowan drift plain in the southern part of the township wells south of Lost Nation find water in glacial gravels less than 150 feet from the surface.

In the northeastern section of Brookfield township, rock appears at the surface. Water is found in the Niagaran at depths seldom exceeding 150 feet. A deep-buried river channel enters the northwestern part of the township from Jackson county, passes east of Elwood, and thence trends southwest. The lowest altitude recorded for the rock floor of this buried valley is 470 feet above sea level. This "deep country" passes through a well-dissected Kansan upland and several wells approach or exceed 300 feet in depth. Water is usually found in gravel before reaching rock, but in one or two wells drilling was continued to some depth in the Maquoketa shale.

In Bloomfield township no well reported exceeds 175 feet in depth. Water is usually found in the Niagaran, which is generally reached from 50 to 125 feet from the surface. Exceptional wells which failed to reach rock and disclose an ancient buried river channel are reported, one on the aggraded valley of Deep creek (section 32), which passed through 144 feet of quicksand and struck rock 171 feet below the surface; and two wells in the hilly country north of Delmar (sections 10 and 11), which reached 200 feet, passing mainly through blue stony clay.

In Waterford township the scanty data at hand indicate that the Niagaran is covered but thinly with drift in many places. Water is commonly found in this dolomite at depths of less than 150 feet. The Maquoketa underlies the Niagaran at moderate depths; in section 3 it occurs not lower than 550 feet above sea level. At Browns, on Sugar creek, an ancient channel was discovered by a well which passed through 199 feet of drift to the Maquoketa shale, whose summit is about 500 feet above sea level.

Most of the wells of Deep Creek township find abundant water in the Niagaran, which there lies 150 feet below the surface. In the marshy lowlands known as Goose Lake Channel, carved and partly aggraded by the Mississippi during one of the great invasions of the state by glacier ice, are many driven and open wells. A drilled well sunk in the channel in section 7 passed through 108 feet of alluvial clays and sands without reaching rock. The rock floor of the channel here lies less than 570 feet above sea level.

In Elk River, Hampshire, Spring Valley and Lincoln townships wells commonly succeed in finding water in the Niagaran within 50 to 180 feet from the surface. Sand wells prevail along the terraces of the Mississippi. The deepest are those which unfortunately fail to find water in the Niagaran and are drilled into the Maquoketa shale, which emerges along the base of the bluffs at Lyons and other localities along Mississippi river and in the valley of Elk creek. In these townships the depth to the Maquoketa—a matter of great importance to the driller—ranges from 100 to 250 feet. At Eagle Point Park the shale, which was found beneath 20 feet of loess and 140 feet of Niagaran dolomite, was 200 feet thick. The well was sunk through the shale and penetrated 104 feet into the Galena dolomite, from which a small supply of water was obtained.

A well in Elk River township, section 31, reached the shale after passing through 142 feet of drift and 100 feet of limestone and found some water in the shale after penetrating it to a depth of 157 feet.

In Center, Comanche, and Eden townships, which are supplied chiefly from the Niagaran, few wells exceed 180 feet in depth.

On the Sullivan farm, 1½ miles southeast of Bryant, a well 409 feet deep enters rock, probably the Galena, near the bottom. The alluvial sands of Goose Lake Channel, a flat-floored valley from one to two miles wide, now occupied by Brophys creek, supply many driven wells. Deep wells have been drilled in the channel and have failed to find the rock floor at depths even of 175 feet (485 feet above sea level). So far as reported only alluvial sands and clays occur in this channel. Driven wells furnish the supply on the Mississippi and Maquoketa flood plains of these townships.

Washington, Orange, Welton, and De Witt townships obtain their supplies from glacial gravels or, more commonly, from the Niagaran dolomite. Few wells exceed 150 or 180 feet in depth or reach the Maquoketa shale. The succession which may be expected in deeper wells is shown by the log of the well of the Chicago & North Western Railway Company, at De Witt.

Log of well at DeWitt.

	Thickness	Depth
	Feet	Feet
Drift	40	40
Limestone (Niagaran)	220	260
Shale (Maquoketa) penetrated	7	267

Driven wells obtain water on the broad flood plain of Wapsipinicon river.

Liberty, Berlin, Spring Rock and Olive townships draw their water supplies from alluvial and glacial sands and gravels and from the Niagaran dolomite. The flood plain of Wapsipinicon river, which below Toronto is more than three miles wide, affords many wells 40 to 60 feet deep. The deeper wells drilled on the flood plain show a filling of the ancient rock-cut valley with 150 and 180 feet of glacial and alluvial deposits and reveal the rock floor at 525 feet above sea level south of Toronto and at 490 feet above sea level northeast of Big Rock. At places near Toronto the Niagaran approaches or reaches the surface, and affords a supply to wells at depths of 50 to 100 feet. Over the larger part of the area of these townships the drift is 70 to 120 feet thick, and wells find water at less than 150 feet from the surface in the upper strata of the Niagaran. In places, however, the drift is far thicker, owing to the filling of preglacial valleys. Thus, north of Bliedorn several wells show drift exceeding 200 feet in depth. This buried valley evidently connects with the preglacial valley which extends from Nashville, in Jackson county, to a point south of Elwood. This channel perhaps makes southwest to the aggraded valley of the Wapsipinicon below Toronto, but the data at hand are not sufficient to trace it.

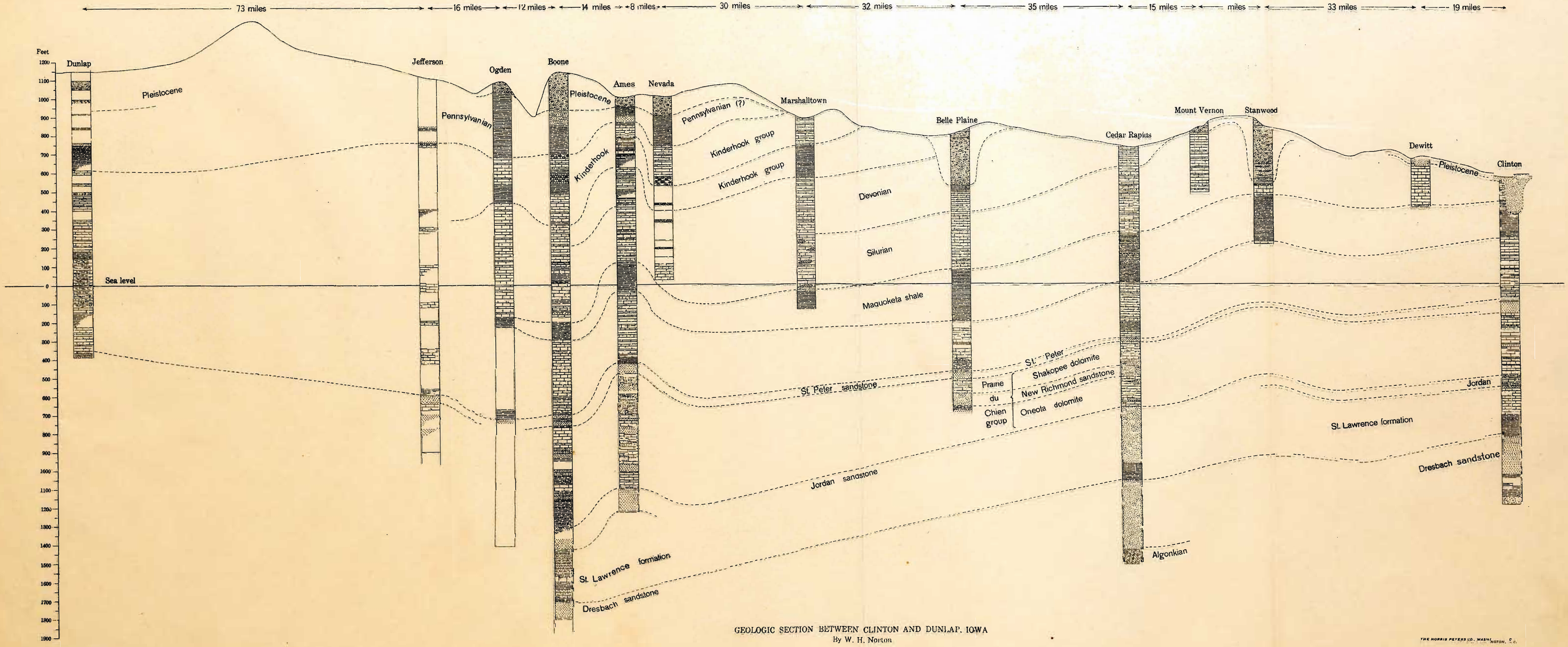
SPRINGS.

Springs are few in Clinton county, except in the northeastern part, where Elk creek and its tributaries have opened their valleys to the base of the Niagaran and have thus cut the waterways developed at that horizon near the summit of the impervious Maquoketa shale. Springs from the Niagaran occur along Rock Run in Spring Rock township and on the creek near Grand Mound and DeWitt.

CITY AND VILLAGE SUPPLIES.

Clinton.—The water supply of Clinton (population, 25,577) is notable in that it is drawn entirely from five artesian wells (Pl. XI), which yield enough to meet the daily consumption of 2,000,000 gallons. The water from these wells is pumped into a reservoir with a capacity of 10,000,000 gallons and thence direct through 42 miles of mains with a domestic pressure of 60 pounds and a fire pressure of 100 pounds. There are 400 fire hydrants and 3,000 taps.

At Clinton the geologic horizon at the surface is somewhat below the summit of the Maquoketa shale, the shale appearing at the base of the bluffs, just north of Lyons, a town now incorporated into Clinton. Some of the wells, however, as for example that of the Clinton Brewery Company, find the lower layers of the Niagaran and much of the upper part of the Maquoketa cut away by a preglacial channel of Mississippi river.



GEOLOGIC SECTION BETWEEN CLINTON AND DUNLAP, IOWA
By W. H. Norton

THE NORRIS PETERS CO., WASHINGTON, D. C.

Water may be found in the Galena and Platteville limestones at numerous levels, but in such small amounts as to be negligible when compared with the large yields to be obtained from deeper terranes. The water in the Saint Peter sandstone is now so overdrawn that no large yield can be expected from this formation. The Prairie du Chien stage contributes a good deal of water from its creviced limestones and sandy beds to each of the Clinton wells.

The main flow of all the Clinton wells except the deepest comes from the Jordan sandstone at depths ranging from 1,100 to 1,290 feet, and at present sufficient water for industrial plants can be obtained from this horizon.

The Cambrian sandstones underlying the Dresbach, reached now by but three wells, yield far more generously than the upper water beds. Under present conditions they may be expected to furnish more than double the amount supplied by all the higher terranes combined, and in the future the proportion will naturally become still larger owing to the depletion of the upper beds. Fortunately the water of these Cambrian strata at Clinton is of exceptionally good quality and no fear need be felt that it will be salty or highly mineralized. To reach the first sandstone beneath the Dresbach it is necessary to go about 1,650 feet below the level of the Clinton plain. The second sandstone, whose summit is reached at about 1,700 feet, contains two water beds, one within the upper 100 feet, the other between 1,400 and 2,100 feet from the surface. As the overdraft, which has already brought the artesian head down to approximately the surface of the ground, increases, the higher terranes may in time be largely exhausted and the Dresbach and earlier Cambrian sandstones become the chief dependence for artesian water.

Waterworks well No. 1 has a depth of 1,400 feet and a diameter of 5 to 8 inches; casing, 135 feet, packed at base with rubber and lead. The curb is 588 feet above sea level. The original head was 44 feet above the curb and the head in 1896 was 35 feet above the curb. The original discharge was 500,000 gallons a day. Temperature, 64° F. The well was completed in 1886 by J. P. Miller & Company, of Chicago.

Waterworks well No. 2 has a depth of 1,246 feet and a diameter of 5 inches. The curb is 588 feet above sea level and the original head, 44 feet above the curb. The original discharge was 500,000 gallons a day. Temperature, 64° F. The well was completed in 1886 by J. P. Miller & Company, of Chicago.

Waterworks well No. 3 has a depth of 1,685 feet and a diameter of 8 inches to 1,200 feet and 6 inches to bottom; casing to 135 feet, packed with lead. The curb is 588 feet above sea level. The original head was 44 feet above the curb and the original discharge 600 gallons a minute, measured on a weir. The first flow was from 335 feet; continuous flow from 1,050 feet; from 625 to 725 feet, 150 gallons a minute, 8-inch bore; from 1,025 to 1,150 feet, 400 gallons a minute, 8-inch bore; from 1,400 to 1,675 feet, 600 gallons a minute, 6-inch bore. Temperature, 63° F. The well was completed in 1890 by J. P. Miller & Company, of Chicago.

Waterworks well No. 4 at De Witt Park has a depth of 1,497 feet and a diameter of 8 inches to 1,279 feet and 5 inches to 1,300 feet; casing to 700 feet to cut off caving sands. The curb is 588 feet above sea level. The discharge was originally 600,000 gallons a day. Temperature, 63° F. The well was completed in 1893, by J. P. Miller & Company of Chicago. The drillers report that the full flow was reached at 1,100 feet. The well ceased to flow and was disconnected from the waterworks system.

Waterworks well No. 5 has a depth of 1,763 feet and a diameter of 8 to 6 inches; 8-inch casing to 125 feet into shale, and 6-inch from 739 to 840 feet. The curb is 588 feet above sea level. A small flow began at 850 feet, followed by a considerable increase from 1,140 to 1,160 feet; at 1,230 feet, flow of 165 gallons a minute; at 1,295 feet, 200 gallons; at 1,613 feet, 238 gallons; at 1,710 feet, 266 gallons; and at 1,763 feet, 303 gallons. Temperature, 64° F. The well was completed in 1902 at a cost of $3,506 by J. P. Miller & Company, of Chicago.

Log of city well No. 5 at Clinton (Pl. XI).

	Thickness	Depth
	Feet	Feet
Surface material	6	6
Limestone	125	131
Shale	227	358
Limestone	318	676
Shale	14	690
Sandstone	50	740
Shale	92	832
Limestone	308	1,140
Sandstone mixed with limestone	25	1,165
Limestone	155	1,320
Shale	93	1,413
Sandstone	252	1,665
Shale	55	1,720
Sandstone	43	1,763

This log shows the thickness of the Niagaran dolomite (6 to 131 feet) and the entire thickness of the Maquoketa shale (131 to 358 feet), as the well was put down at one side of the preglacial channel of the Mississippi.

The thickness of the Niagaran given in this log is corroborated by the logs of several other wells. The Dresbach sandstone of the brewing company well section is included in the sandstone reported from 1,413 to 1,665 feet in the city well No. 5. Apparently the shale at the bottom of the brewing company's well rests on a bed of sandstone, below which is a 55-foot bed of shale, which in turn rests on the water-bearing sandstone that was penetrated to a depth of 43 feet in the city well. The record of the city well shows an increase in flow of about 65 gallons a minute from this basal sandstone.

The waterworks well No. 6 has a depth of 2,101 feet and a diameter of 10 feet to rock, 15½ inches to 354 feet, 12½ inches to 870 feet, and 10 inches to bottom; casing to 364 feet; packing, lead. The curb is 588 feet above sea level and the head 14 feet above the curb. The first overflow was from the second Cambrian sandstone beneath the Dresbach. The discharge at 1,940 feet was 70 gallons a minute; on completion, 225 gallons. Temperature, 70° F. The well was completed in 1911 by J. D. Shaw, of Davenport, Iowa.

During the drilling of the well water from the upper artesian horizons stood 14 feet below the surface until the water bed of the second sandstone beneath the Dresbach was reached. The head of this bed is therefore now about 28 feet higher than that of the higher artesian sources. On the completion of this well the first drilled well of the Clinton Gas, Light & Coke Company, is said to have been raised 2 feet. It is reported by the officials of the Clinton Water Company that the well of the Treitschler & Tiesse Malting Company at Lyons began to overflow at the same time. On the other hand, no change was observed in the head of the wells of the Sugar Refining Company, the Clinton Paper Company, the Clinton Brewing Company, the Chicago & North Western Railway Company, the Fulton waterworks, and L. Iten & Sons. The officials of the Clinton Waterworks Company are confident that on the completion of their new well the head of artesian water was lifted about 3 feet over an area extending 2,000 to 3,000 feet from their well. This implies an enormous leakage from the well and that the water from the second sandstone beneath the Dresbach, with its higher head, finds lateral escape through the higher water beds which feed the other wells and thus increases their head. The volume of water from the sandstones underlying the Dresbach must be immense to supply not only the flow of the well but also the enormous supposed leakage into the surrounding strata. It is the intention of the water company to thoroughly test the well with a current meter, ascertaining the places and amounts of leakage and then to case off the outlet strata above the Dresbach sandstones.

Record of strata in waterworks well No. 6 at Clinton.

	Thickness	Depth
	Feet	Feet
Alluvium	10	10
Niagaran dolomite (115 feet thick; top, 578 feet above sea level)—		
Dolomite, buff; 4 samples	115	125
Ordovician:		
Maquoketa shale (225 feet thick; top, 463 feet above sea level)—		
Shale, blue, plastic; 7 samples	225	350
Galena dolomite and Platteville limestone (350 feet thick; top, 238 feet above sea level)—		
Dolomite, gray and brown, crystalline; 8 samples	200	550
Limestone, brown, hard; rapid effervescence; 6 samples	143	693
Shale, dark green, fissile	7	700
Saint Peter sandstone (50 feet thick; top, 112 feet below sea level)—		
Sandstone, white; rounded grains, fine	25	725
Sandstone and dolomite; sandstone, white, coarser than above; dolomite gray (Shakopee?)	25	750

Record of strata in waterworks well No. 6 at Clinton—Continued.

	Thickness	Depth
	Feet	Feet
Prairie du Chien stage—		
Shakopee dolomite (150 feet thick; top, 162 feet below sea level)—		
Dolomite, brown and gray, 5 samples	150	900
New Richmond sandstone (35 feet thick; top, 312 feet below sea level)—		
Dolomite and sandstone; color in mass, buff; all in fine sand; oolitic	25	925
Dolomite, arenaceous, cream colored and pink, cherty	10	935
Oneota dolomite (230 feet thick; top, 347 feet below sea level)—		
Dolomite, whitish; in fine sand; 2 samples	10	945
Marl; in finest argillo-silico-calcareous powder	5	950
Dolomite, whitish, cherty; some oolitic chert; 8 samples	50	1,000
Dolomite, light gray; 7 samples	165	1,165
Cambrian:		
Jordan sandstone (155 feet thick; top, 577 feet below sea level)—		
Sandstone, calciferous; or dolomite, highly arenaceous; fine grains, moderately well rounded; some chips of dolomite; some fragments show quartz grains in dolomitic matrix	155	1,320
Saint Lawrence formation (120 feet thick; top, 732 feet below sea level)—		
Dolomite, gray; in small chips	15	1,335
Marl, white, residue after solution, microscopic silica and clay	10	1,345
Dolomite, light gray; in sand and powder	10	1,355
Marl, pink, glauconiferous; microscopic quartoze and argillaceous residue after solution	1	1,356
Sandstone and dolomite; sandstone, dark red, argillaceous, of finest grain; dolomite, gray, glauconiferous	14	1,370
Sandstone, fine-grained; grains imperfectly rounded; glauconiferous with some hard fissile green shale	30	1,400
Shale, highly arenaceous, glauconiferous, fine-grained; in light green flour	40	1,440
Sandstone, fine-grained; grains imperfectly rounded, highly glauconiferous, in chips; and arenaceous red shale	5	1,445
Dresbach sandstone and underlying strata (656 feet penetrated; top, 852 feet below sea level)—		
Sandstone, white; larger grains reaching diameter of 1 millimeter	5	1,450
Sandstone, clean, white, fine-grained quartz sand	5	1,455
Sandstone, pinkish; larger grains 1 millimeter, some reaching 1.5 millimeters	20	1,475
Sandstone, white, fine-grained; 3 samples	35	1,510
Shale, drab, plastic	10	1,520
Shale, bright green, highly glauconiferous, arenaceous; driller's log gives shale from 1,510 to 1,550	30	1,550
Sandstone, light pink; larger grains 0.8 millimeter in diameter, well rounded	20	1,570
Sandstone, moderately fine, white	30	1,600
Sandstone, pinkish, glauconiferous	30	1,630
Shale, light green, fissile, glauconiferous; 2 samples	55	1,685
Sandstone, light buff; fine-grained, hard	35	1,720
Sandstone, white; grains mostly below 0.5 millimeter in diameter	20	1,750
Sandstone; as above, but coarser; chips of arenaceous dolomite; 2 samples	50	1,800
samples	50	1,800
Sandstone, white, moderately fine, at		1,849
Sandstone, white; larger grains, about 0.7 millimeters in diameter; moderately well rounded, fairly uniform; a few show secondary enlargements, at		1,880
Sandstone; grains less uniform; light pink at 1,910; buff at 1,925, at		1,925
Sandstone, white; grains moderately well rounded; larger 0.8 and 1 millimeter in diameter; well overflows from this water bed, at		1,940
Sandstone; as above; white and some buff or red from rusting of drillings; 7 samples		1,998
Sandstone, light buff; larger grains 1 millimeter in diameter, secondary enlargements; some hard green fissile shale, at		2,068
Sandstone, pink, moderately fine, at		2,065
Sandstone, darker buff; larger grains 1 millimeter in diameter, imperfectly rounded, at		2,101

The Chicago & North Western Railway well No. 1, located at the shops, has a depth of 1,159 feet and a diameter of 10 to 4 inches. The curb is 588 feet above sea level and the original and present head 12 feet above the curb. The tested pumping capacity is 500 gallons a minute. Temperature, 56.5° F. The well was completed in 1896 by J. P. Miller & Company, of Chicago. Owing to a decrease in pressure and contamination of the water, it was recased in 1905 by inserting 30 feet of 8-inch, 72 feet of 5-inch, 315 feet of 4-inch, and 27 feet of 3-inch casing, and its flow was thereby increased.

The Chicago & North Western Railway well No. 2 at the South Clinton roundhouse has a present head of about 20 feet below the curb. The temperature of the water is 57° F. The well was drilled about 1900. It ceased to flow in July, 1908, on the completion of the new Clinton Sugar Refining Company's well; it regained its flow when the latter was closed. In the summer of 1910 an air lift was used on these two wells from a depth of 300 feet. The discharge from the two wells combined was 1,500,000 gallons a day.

The Clinton Gas, Light & Coke Company's well No. 2 has a depth of 1,605 feet and a diameter of 12 inches to 8 feet, 10½ inches to 35 feet, 8 inches to 853 feet, and 6¼ inches to bottom. Its curb is 579 feet above sea level and its head is 2 feet above the curb. The pumping capacity is 500 gallons a minute; temperature, 72° F. The well was completed in 1911 by H. W. Hambrecht, of Sterling, Illinois.

Record of strata in Clinton Gas, Light & Coke Company's well No. 2.

	Thickness	Depth
	Feet	Feet
River deposits:		
Cinder filling	5	5
Loam, black	4	9
Sand	3	12
Clay, red	17	29
Sand	24	53
Gravel	12	65
Sand	4	69
Silurian:		
Niagaran dolomite—		
Loose rock	1	70
Lime rock	44	114
Ordovician:		
Maquoketa shale—		
Flint, yellow-white, and blue and brown shale	121	335
Galena dolomite and Platteville limestone—		
Lime rock	326	671
Shale	14	685
Saint Peter sandstone—		
Sandstone	61	746
Prairie du Chien stage—		
Shale	2	748
Cambrian:		
Jordan sandstone—		
Lime rock	560	1,308
Saint Lawrence formation—		
Shale	105	1,413
Dresbach sandstone—		
Sandstone	192	1,605

The chief water beds were at 550 feet (Galena dolomite, which furnishes the principal supply), at 800 feet (Shakopee dolomite), at 1,200 feet (Jordan sandstone), and 1,500 feet (Dresbach sandstone).

The Trietschler & Tiesse Malting Company's well has a depth of 1,132 feet and a diameter of 8 to 5 inches; 8-inch casing to 150 feet; casing also between 700 and 800 feet. The original head was 3 feet above the curb, and the original flow 300 gallons a minute. Most of the water comes from 1,050 to 1,130 feet. Temperature, 60° F. The well was completed in 1897 by J. P. Miller & Company, of Chicago.

Driller's log of Trietschler & Tiesse Malting Company's well.

	Thickness	Depth
	Feet	Feet
Surface	40	40
Limestone	80	120
Shale	200	320
Limestone	352	672
Shale	8	680
Sandstone	65	745
Limestone	387	1,132

Five years after the completion of the well an air lift was installed but shortly afterwards the brewery was closed and the well is not now in use.

The two wells of the Clinton Sugar Refining Company have a depth of 1,226 feet and a diameter of 12 inches to 422 feet, 10 inches to 727 feet, 8 inches to bottom; 10-inch casing to 422 feet; 8-inch casing from 666 feet to 747 feet. The curb is about 586 feet above sea level. The original flow was 191 gallons a minute and the tested pumping capacity 400 gallons a minute. The first flow was very slight, at 760 feet, but markedly increased at 935 feet, gradually from 935 to 1,100 feet, and largely at 1,190 feet; no further increase was noted. Temperature, 62° F. The well was completed in 1908 by J. D. Shaw, of Sioux City, Iowa. The sinking of the wells seriously affected the supply of the well of the Chicago & North Western Railway Company at the roundhouse at South Clinton.

Record of strata in well of Clinton Sugar Refining Company.

	Thickness	Depth
	Feet	Feet
Silurian:		
Niagaran dolomite (177 feet thick; top, 586 feet above sea level)—		
Dolomite, buff and light cream color; in powder and fine sand; six samples	60	60
Dolomite, buff, subcrystalline; in small chips and coarse sand; five samples	40	100
Dolomite, very light gray, cherty; seven samples	67	167
Dolomite, light blue-gray, cherty; in fine chippings	10	177
Ordovician:		
Maquoketa shale (213 feet thick; top, 409 feet above sea level)—		
Shale; greenish gray to 340 feet; below, olive-green-gray and drab; 20 samples	213	390
Galena dolomite and Platteville limestone (335 feet thick; top, 196 feet above sea level)—		
Dolomite, yellow-gray, crystalline; nine samples	105	495
Dolomite, brown and gray, cherty; six samples	75	570
Dolomite, yellow-gray and brown-gray; two samples	25	595
Dolomite, light yellow, highly argillaceous, cherty	20	615
Dolomite, brown, blue-gray and buff; three samples, from 625 some nonmagnesian limestone chips in drillings	30	645
Limestone, yellow, gray and blue-gray, earthy, nonmagnesian; in flaky chips; seven samples	70	715
Shale, greenish drab; in molded masses	10	725
Saint Peter sandstone (30 feet thick; top, 139 feet below sea level)—		
Sandstone, white, clean; rounded grains, attaining a diameter of 1 millimeter; two samples	20	745
Sandstone, white, fine; considerable diversity in size of grains	10	755
Prairie du Chien stage—		
Shakopee dolomite (180 feet thick; top, 169 feet below sea level)—		
Dolomite, gray; some sand (first water)	10	765
Dolomite, gray; much quartz sand; two samples	35	800
Dolomite, gray, cherty, considerable sand	10	810
Dolomite, light gray; considerable sand and some bright green shale; three samples	25	835
Dolomite, light gray; clean of sand; in chips and sand; six samples	60	895
Dolomite, light gray; cherty, little quartz sand	10	905
Dolomite, brown-gray; with oolitic white chert, three samples	30	935
New Richmond sandstone (20 feet thick; top, 349 feet below sea level)—		
Dolomite, highly arenaceous, cherty, whitish; two samples	20	955

	Thickness	Depth
	Feet	Feet
Oneota dolomite (160 feet thick; top, 369 feet below sea level)—		
Dolomite, whitish, clean of sand; three samples	30	985
Dolomite, whitish, highly cherty	10	995
Dolomite, yellow-gray, brown and buff, and blue-gray; cherty at 995, 1,025, and 1,105 feet; eleven samples	120	1,115
Cambrian:		
Jordan sandstone (100 feet penetrated; top, 529 feet below sea level)—		
Sandstone, white, fine-grained; grains show secondary enlargements, many grains fractured; some chips of light buff dolomite	10	1,125
Dolomite, light buff; some rounded grains of quartz sand	10	1,135
Sandstone, white, fine; secondary enlargements; a little dolomite	10	1,145
Dolomite, light buff, some sand; two samples	20	1,165
Sandstone, white, fine-grained; secondary enlargements, some chips show sand grains and calcareous and cherty matrix	10	1,175
Dolomite, light gray; some sand	10	1,185
Dolomite, blue-gray and buff, cherty; oolitic chert at 1,185 feet; two samples	15	1,200
Dolomite, light gray, fine-grained, and sandstone, some whitish marl	15	1,215

The well of the Excelsior Laundry Company has a depth of 737 feet and a diameter of 10 to 8 inches. The head is 11 feet below the surface. Date of completion, October 31, 1910; driller, M. P. Peterson, Madison, Wisconsin. On the average there are pumped 20,000 gallons a day. Continuous pumping lowers the well 3 or 4 feet. No account of the water beds was kept, but as the well extends to or below the base of the Saint Peter, it may be taken for granted that the supply is from that formation and from the Galena and Platteville limestones.

The well of Curtis Brothers has a depth of 1,150 feet and a diameter of 12 inches to 27 feet, 8 inches to 745 feet, and 6¼ inches to bottom; casing, 24 feet of 12 inch at top, 311 feet of 8 inch immediately below; 92 feet of 6¼ inch from 653 to 745 feet. The head is 3 feet below the surface; driller, H. W. Hambrecht, Sterling, Illinois. Date of completion, February 10, 1911. Temperature 60° F.

Record of strata in Curtis Bros. well at Clinton.

	Thickness	Depth
	Feet	Feet
Surface deposit:		
Filling of sawdust	12	12
Clay	8	20
Silurian:		
Niagaran dolomite—		
Lime, yellow, loose	7	27
Lime, yellow	33	60
Lime, white	12	72
Lime, blue	63	135
Ordovician:		
Maquoketa shale—		
Shale, blue and brown	203	338
Galena dolomite and Platteville limestone—		
Lime rock	335	673
Shale, green	14	687

	Thickness	Depth
	Feet	Feet
Saint Peter sandstone—		
Sandstone	58	745
Prairie du Chien stage—		
Lime rock	410	1,155
Cambrian:		
Jordan sandstone—		
Sandy lime	8	1,163

The well of the Clinton Ice Company has a depth of 1.561 feet and a diameter of 10 inches to 62 feet, 8 1-8 inches to 745 feet, and 5 1-8 inches to bottom. The head is 9 feet below the curb and the pumping capacity 75 gallons a minute. Temperature about 68° F. Date of completion, 1910; driller, H. W. Hambrecht, of Sterling, Illinois.

Record of strata in Clinton Ice Company's well at Clinton.

	Thickness	Depth
Surface deposit:	Feet	Feet
Filling	8	8
Clay	12	20
Silurian:		
Niagaran dolomite—		
Lime, yellow	92	112
Lime, blue	10	122
Ordovician:		
Maquoketa shale—		
Shale, blue	150	272
Shale, brown	58	330
Galena dolomite and Platteville limestone—		
Lime rock	90	420
Lime, brown	143	563
Shale, blue	123	686
Saint Peter sandstone—		
Sand rock	52	738
Prairie du Chien stage—		
Lime rock	367	1,105
Sand rock	42	1,147
Lime rock	33	1,280
Lime rock, red	8	1,288
Lime rock, brown	12	1,300
Cambrian:		
Saint Lawrence formation—		
Shale	102	1,402
Dresbach sandstone—		
Sand rock	159	1,561

The paper company's well has a depth of 1,076 feet and a diameter of 8 to 6 inches; 6-inch casing to 84 feet. The curb is approximately 588 feet above sea level. The original head was 42 feet above the curb; head in 1896, 8 feet above curb; present head (1909), 2 feet above the curb. The original flow was about 200 gallons a minute. Temperature, 59° F. The well was completed in 1883 by J. P. Miller & Company, of Chicago. The well showed considerable loss of pressure within four years after its completion. As it had been closed nights and Sundays, it was thought that much of the water was forced by the pressure on the sides of the bore hole into crevices of the rock. In 1893 the well was reamed and another casing inserted. At the bottom of the first casing the rock was found so eroded by the water that the reamer dropped 7 feet. A casing was then put in to the depth of 160 feet, and packed with rubber, but without increasing the flow.

The well of C. Lamb & Son has a depth of 1,230 feet and a diameter of 5 inches; casing to 125 feet. The curb is 588 feet above sea level. The original head was 60 feet above curb; the present head is much lower, and the well ceases to flow when pumps are working on Sugar Refining Company's well, about 500 feet distant. Temperature, 59½° F. The well was completed in 1888 at a cost of $2,128 by J. P. Miller & Company of Chicago. It has passed into the ownership of the National Papier Mache Company, and is not now in use except as a drinking fountain.

L. Iten & Sons' well has a depth of 1,180 feet and a diameter of 6¼ inches; casing, 200 feet. The curb is about 588 feet above sea level. The head is slight, flowing 75 to 100 gallons a minute. The first good flow was from 1,025 feet, and the next noticed was from 1,180 feet. Temperature, 62° F. The well was completed in 1907, at a cost of $3,000, by J. D. Shaw, of Sioux City, Iowa. This well flows from 9 p. m. to 10 a. m., and then the water sinks to about 1 foot below the curb.

The Clinton Brewing Company's well has a depth of 1,620 feet and a diameter of 10 to 6 inches; 10-inch casing to 99 feet, 8-inch to 212 feet, 6-inch to 300 feet. The head is 2 feet below the curb. Temperature, 62° F. The well was completed in 1907 by L. Wilson & Company, of Chicago. Although many deep wells have been drilled at Clinton, no adequate record of the strata penetrated was available until 1907, when this well was put down. Samples of the drillings were taken every 5 or 10 feet.

Record of strata in well of the Clinton Brewing Company.

	Thickness	Depth
Quaternary (205 feet thick; top 588 feet above sea level):	Feet	Feet
Soil, black, sandy	3½	3½
Sand, coarse, gray	4	7½
Sand, light gray, fine	12	19½
Gravel	2½	22
Gravel and sand	13	35
Sand, gray, fine	4	39
Gravel and sand	½	39½
Gravel, coarse, well rounded, 2 samples	12½	52
Sand and gravel, yellow-gray	14	66
Gravel, coarse; pebbles up to 2 inches in diameter	1	67
Sand, yellow-gray, coarse	10	77
Clay, pink, friable, noncalcareous	½	77½
Gravel, pebbles reaching 1½ inches in diameter	19½	97
Clay, dark-colored slate, sandy	3	100
Clay, sand and gravel, yellow	10	110
Gravel, coarse	3	113
Sand, orange, medium fine	9	122
Gravel, coarse	3	125
Sand, light yellow	8	133
Gravel, coarse; with limestone pebbles 1½ inches in diameter	7	140
Sand, yellow, fine	20	160
Clay, light yellow, calcareous	2	162
Sand, yellow, fine	12	174
Clay, light yellow, calcareous	3	177
Sand, fine, yellow	4	181
Clay, yellow, hard, calcareous	2	183
Gravel, coarse	3	186
Sand and gravel	2	188
Gravel, coarse, with glaciated pebble	7	195
Sand and gravel, with fragments of granite bowlder	2	197
Clay, hard, yellow, calcareous	1	198
Sand, yellow, fine	7	205
Ordovician:		
Maquoketa shale (125 feet thick; top, 383 feet above sea level)—		
Shale, blue-green; 2 samples	125	330
Galena dolomite to Platteville limestone (340 feet thick; top 258 feet above sea level)—		
Dolomite, gray, crystalline; cherty from 435 to 450 and from 460 to 470 feet; 16 samples	170	500
Dolomite, gray, cherty	10	510
Dolomite, gray or light buff, vesicular at 510 feet; crystalline; 7 samples	55	565
Dolomite or magnesian limestone, brown, crystalline; with brown fossiliferous and bituminous shale	5	570
Shale, brown, highly bituminous and fossiliferous	5	575
Limestone, magnesian, brown	12	587
Limestone, magnesian, drab, subcrystalline; cherty at 600 feet; 4 samples	33	620
Limestone, blue-gray, nonmagnesian, compact, fossiliferous, thin, laminated, in flaky chips; 4 samples	25	645
Limestone, light yellow-gray, soft, earthy, fossiliferous, in thin flakes	5	650
Limestone, light blue-gray, fossiliferous; rapid effervescence	5	655
Shale, brown, bituminous, in thin flaky chips; and limestone, compact, earthy; rapid effervescence	10	665
Shale, blue-green, pyritiferous, flaky	5	670
Saint Peter sandstone (60 feet thick; top, 82 feet below sea level)—		
Sandstone, white; largest grains 1 millimeter in diameter; 5 samples	55	725
Sandstone, light buff, fine-grained, with angular sand of dolomite	5	730
Prairie du Chien stage (345 feet thick; top, 142 feet below sea level)—		
Dolomite, gray; in chips; considerable sand	18	748
Dolomite, gray, slightly arenaceous	5	753
Dolomite, gray; with arenaceous laminae; in chips	7	760
Dolomite, gray; with hard dark shale	15	775
Dolomite, gray; pyritiferous and blue-gray at 783 feet; 2 samples	18	793
Sandstone, in detached rounded grains of moderate fineness; and dolomite in chips	7	800
Dolomite, light gray, compact; large cherty and argillaceous residue	10	810
Marl; in whitish powder, highly calcareous; large argillaceous and arenaceous residue; grains diverse in size, but none coarse, imperfectly rounded	15	825
Dolomite, light gray to dark drab, crystalline, vesicular; in places cherty; 3 samples	70	895
Dolomite, light gray; in fine chips, with grains of quartz sand	8	903
Dolomite, light gray; in fine chips; sandstone in detached grains	8	911

	Thickness	Depth
	Feet	Feet
Sandstone, light gray, calciferous, hard, fine-grained; in chips	9	920
Dolomite, light gray and pink; cherty at 920 feet; 4 samples	45	965
Chert, white, and whitish dolomite; in chips	5	970
Dolomite, light yellow, cherty; in sand; 2 samples	20	990
Marl; in light yellow powder; large residue of minute and microscopic angular flakes of cryptocrystalline quartz with some of crystalline quartz	10	1,000
Dolomite, light gray and blue-gray; in places cherty and in places arenaceous; 8 samples	75	1,075
Cambrian:		
Jordan sandstone (65 feet thick; top, 487 feet below sea level)—		
Sandstone, light gray, calciferous, fine-grained, glauconiferous; in chips; and dolomite, gray	15	1,090
Dolomite, light gray, arenaceous, quartz grains, fine, rounded	30	1,120
Sandstone, light gray, calciferous; in small chips and fine sand	20	1,140
Saint Lawrence formation (255 feet thick; top, 552 feet below sea level)—		
Dolomite, buff, cherty; in sand; according to log cuttings flowed away between 1,130 and 1,240 feet	70	1,210
Dolomite, light brown, hard, crystalline; in chips	10	1,230
Dolomite in chips, slightly siliceous and glauconiferous	10	1,230
Dolomite, pink, highly siliceous; with minute quartzose particles; glauconiferous; in chips	10	1,240
Dolomite, gray, siliceous; in chips, 3 samples	30	1,270
Dolomite, light pink, highly siliceous, with minute quartzose particles; glauconiferous	10	1,280
Marl, pink, calcareous; in powder and easily friable compacted masses; residue argillaceous and microscopically quartzose; glauconiferous	32	1,318
Shale, light blue, calcareous, plastic	77	1,395
Dresbach sandstone and underlying strata (225 feet penetrated; top, 807 feet below sea level)—		
Sandstone, light buff, friable; grains rounded; considerable diversity in size; largest 1 millimeter in diameter	15	1,410
Sandstone, white; grains, 0.25 millimeter in diameter	10	1,420
Sandstone, light yellow; grains well rounded; largest grains, 0.75 millimeter in diameter	10	1,430
Sandstone, light yellow; fairly well rounded; larger grains 0.5 millimeter in diameter	10	1,440
"Sand rock;" cuttings washed away	162	1,602
Shale, cuttings washed away	18	1,620

The geologic section is continued 140 feet deeper by the log of city well No. 5 (p 460).

The gas company well has a depth of 1,085 feet and a diameter of 8 to 5 5-8 inches; casing, 6 feet to rock. The curb is 579 feet above sea level and the original and present head 35 feet above curb. It flows 230 gallons a minute. Water was found at 1,000 feet; temperature, 59° F. The well was completed in 1901 at a cost of $1,800 by J. P. Miller & Company, of Chicago.

Delmar.—The water-supply system of Delmar (population, 548) includes wells of depths not reported, a standpipe, and 2,700 feet of mains with six fire hydrants. The pressure is 46 pounds. For the most part the town draws its domestic supply from drilled wells 30 to 250 feet deep, 100 feet being the most common depth. Wells enter rock at 90 feet and the largest supply is found at 100 feet.

De Witt.—At De Witt (population, 1,634) the water supply is drawn from two wells, 274 feet and 524 feet deep. (See Pl.

XI.) The deeper well is 10 inches in diameter, enters rock at 40 feet, and finds water at 500 feet. Water stands 100 feet below the curb after long pumping and rises ten feet when pumping ceases. The 274-foot well is 8 inches in diameter and finds its main supply at 270 feet. Water heads at 40 feet below the curb, but long pumping lowers it to 150 feet. The Maquoketa shale at De Witt is struck at about 260 feet from the surface, and the city well evidently passed entirely through it and found water in the Galena dolomite. It is regretted that no record of the well was kept showing the thickness of the shale.

If the city well or the well of either of the railway companies at De Witt should fail to yield enough water, recourse may be had to water in the Saint Peter sandstone, which lies 800 to 850 feet below the surface; its water will rise within easy pumping distance. Water will also probably be found in the limestones (Platteville and Galena) overlying the Saint Peter, but this can not be assured.

Grand Mound.—At Grand Mound (population, 428) the gravity system is employed, a pressure of 32 pounds being afforded by a standpipe. There are 13 fire hydrants, 55 taps, and 1 mile of mains. The supply comes from a well 6 inches in diameter and 87 feet deep. Rock is entered at 70 feet and water was found in the Niagaran at 80 feet. It heads 30 feet from the surface. The maximum yield by pumping is 1½ barrels a minute.

Wheatland.—The supply of Wheatland (population, 539) is drawn from a well and distributed from a tank by the gravity system through 1¼ miles of mains. There are 10 fire hydrants and 24 taps. A large part of the population is supplied by house wells which range in depth from 11 to 178 feet. The city well is 6 inches in diameter and 189 feet deep and enters rock at 14 feet. It is cased to 185 feet.

Minor supplies.—Information concerning supplies in the smaller communities is presented in the following table:

Village supplies in Clinton County.

Town	Nature of Supply	Depth	Depth to water bed	Depth to rock	Head Below Curb	
					Shallow	Deep
		Feet	Feet	Feet	Feet	Feet
Brown	Wells	Below 200	--------	10-50	--------	--------
Bryant	Drilled wells	--------	--------	--------	--------	--------
Buena Vista	Wells	90-100	35-50	40-100	5	50
Charlotte	Drilled wells	32-120	100	24-160	20	30
Comanche	Driven wells	30-38	--------	--------	28	--------
Elvira	Drilled wells	50-100	--------	25	--------	40
Folletts	Driven and drilled wells	30-60	36	--------	28	45
Goose Lake	Drilled wells	60-90	--------	--------	--------	--------
Lost Nation	Do.	45-140	100	50-120	40	80
Low Moor	Open, driven and drilled wells	18-120	--------	--------	20	20
Malone	Drilled wells	30-120	100	40-60	25	50
Teeds Grove	Wells	16-100	--------	--------	115	15
Toronto	Drilled wells	40-125	106	60	35	40
Welton	Do.	13-25	--------	--------	13	--------

WELL DATA.

The following table gives data of typical wells in Clinton county:

Typical wells in Clinton County.

Owner	Location	Depth	Depth to rock	Water-bearing Formation	Remarks: (Logs given in feet)
		Feet	Feet		
T. 83 N., R. 1 E. (Sharon).					
Chicago, Milwaukee & St. Paul Ry.	Lost Nation	95	47	Limestone	Alluvium, 7; yellow clay, 40; limestone, 48.
W. Jaronsen	do	135	130		Soil, 3; yellow clay, 30; blue clay, 97; limestone, 5.
J. G. Garder	Lost Nation. NE. ¼ NE. ¼ sec. [illegible]	137	-----		Creek bottom. Soil, 4; yellow clay, 4; very fine sand, 125; coarse gravel, 3.
J. Mulverhill	SE. ¼ sec. 6	140	70		Yellow clay, 35; blue clay, 35; limestone, 70.
Mrs. P. Pitch	SW. ¼ SW. ¼ sec. 31	140	80		Upland. Fine red sand, 80; limestone, 60.
T. 83 N., R. 2 E. (Brookfield).					
J. W. Whitsell	Sec. 9	277	257		Upland. Soil, 2; yellow clay, 40; blue clay, 215; limestone, 20.
J. Toskey	N. ½ NE. ¼ sec. 28	329	-----	Gravel	Base of bluff. Yellow bowldery clay, 37; blue clay 100; quicksand, 115; blue clay, 75; coarse gravel, 2.

Typical wells in Clinton County—Continued.

Owner	Location	Depth	Depth to rock	Water-bearing Formation	Remarks: (Logs given in feet)
		Feet	Feet		
----------	NE. ¼ NW. ¼ sec. 9	82	35	----------	
----------	NW. ¼ SE. ¼ sec. 9	256	201	----------	Yellow clay, 20; blue clay, 80; sand with some water, 1; blue clay, 80; sand and water, 20; rough hard blue clay without grit (Maquoketa shale), 55; ends in red gravel. Heads 156 feet below curb.
—— Benton	NW. ¼ sec. 22	268	----------	----------	About same as above; ends also in red gravel.
—— Anderson	SE. ¼ SW. ¼ sec. 15	300	----------	----------	About same as above.
----------	½ mile S. of Elwood on creek.	200	----------	Gravel	Flowing well.
Hans Christianson	SE. ¼ SE. ¼ sec. 30	501	----------	----------	Slope. Heads 40 feet below curb. Diameter 3 inches; depth to water bed, 490 feet. Yellow till, 40; blue till, 310; sand, 50; greenish gray rock, hard, 101. Udden's record: Black soil, 4; yellow clay, 35; blue clay, 136; river sand, 25; blue clay, 100; soapstone, 100; blue shale, 100.
John Wirth	Sec. 29	306	300	----------	
J. A. Anderson	NW. ¼ SW. ¼ sec. 14	125	50	----------	
J. A. Anderson	SW. ¼ sec. 14	315	295	----------	Yellow clay, 30; blue clay, 190; quicksand, 75; limestone, 20.
----------	SW. ¼ SW. ¼ sec. 1	410	13	----------	Hill. Drift, 13; limestone, 107; soapstone (shale) 290.
----------	Sec. 4	85	70	----------	Considerable blue till.
----------	Sec. 12	90	20	----------	
E. S. Hiner	Sec. 22	188	----------	Gravel	
Do.	Sec. 23	63	45	----------	
J. A. Hiner	Sec. 26	156	----------	Gravel	Heads 73 feet below curb.
H. G. Scott	SE. ¼ SE. ¼ sec. 25	110	50	Limestone	Yellow clay, 20; blue clay, 30; limestone, 60.
T. 83 N., R. 3 E. (Bloomfield).					
Chicago, Milwaukee & St. Paul Ry.	Delmar	90	36	do	
----------	do	102	56	----------	Ridge. Yellow clay, 15; blue clay, 41; limestone, 16.
----------	SE. ¼ SE. ¼ sec. 21	130	126	Sand	Yellow clay, 25; blue clay, 97; sand with water, 4; limestone, 4.
----------	SW. ¼ SW. ¼ sec. 23	107	95	Limestone	wood, between 50 and 60.
J. Dennis	S. ½ NW. ¼ sec. 31	170	72	do	Black soil, 2; yellow clay, 40; blue clay, 30; limestone, 98.
E. A. Fitch	NW. ¼ sec. 32	175	171	Quicksand	Yellow clay, 27; quicksand, 144; limestone, 4.
D. Eckard	Sec. 10	200	----------	Sand	
R. F. Rossiter	Sec. 11	200	----------	Gravel	Mainly blue till.
W. McCloy	Sec. 12	184	80	Limestone	
T. 83 N., R. 4 E. (Waterford).					
----------	Brown Station	199	199	----------	Surface deposits and soft blue clay, 30; blue till, 52; sand and gravel, 28; blue till, 22; pebbles, drab silt, 30; blue clay with pebbly streaks, 31; chocolate colored clay, 6; Maquoketa shale.

Typical wells in Clinton County—Continued-

Owner	Location	Depth	Depth to rock	Water-bearing Formation	Remarks: (Logs given in feet)
		Feet	Feet		
— Niehaus	Sec. 1	100		Sand and gravel	Near-by wells on higher ground reach rock at 50 feet
J. Powers	Sec. 3	166	60	Limestone	Drift, 60; Niagaran dolomite, 96; Maquoketa shale, 10.
M. Omara	Sec. 18	140	20	do	
J. Reife	Sec. 8	190	30	do	Drift, 30; limestone, 40; blue mucky shale, 40; limestone, 80.
Anton Tur	Sec. 8	160	6	do	Yellow clay, 6; limestone, 154.
	SE. ¼ NE. ¼ sec. 29	111	29	do	
T. 83 N., R. 5 E. (Deep Creek).					
Otto Kreuse	NE. ¼ SE. ¼ sec. 14	175	50		Plenty of water, though a well 50 feet distant and 300 feet deep was not a success, both striking rock at the same depth.
Thomas Farrell	NW. ¼ NE. ¼ sec. 34	108	55		
Church	Bryant	128	70	Limestone	
	SW. ¼ SW. ¼ sec. 1	200	68	do	Yellow clay, 30; blue clay, 38; limestone, 135.
	NE. ¼ SE. ¼ sec. 23	156		Gravel	Yellow clay, 30; blue till, 116; gravel, 10.
	SE. ¼ NE. ¼ sec. 24	180	125	Limestone	High ridge.
	SW. ¼ SE. ¼ sec. 26	160		Gravel	Ridge. Yellow clay, 20; blue till, 135; gravel, 5.
	SW. ¼ SW. ¼ sec. 26	225	125	Limestone	Drift, 125; limestone, 100.
— Hicks	Sec. 7	108			Goose Lake Channel. Alluvial clay and sand.
T. 83 N., R. 6 E. (Part of Elk River).					
George Egger	SE. ¼ SW. ¼ sec. 35	212	212	Sand	
J. Sullivan	NW. ¼ sec. 31	399	142	Shale	Drift, 142; limestone, 100; shale, 157; 80 rods north on same place a well found limestone 180 feet thick 75 feet from surface.
F. Naeve	NW. ¼ NE. ¼ sec. 27	97			Soapstone (Maquoketa shale) at 97 feet.
	Teed's Grove, sec.10	100	88		Alluvium and blue till to rock.
J. F. Diercks	Sec. 33	220	50		
T. 83 N., R. 7 E. (Part of Elk River).					
— Shattock	W. ½ sec. 31	190		Sand	Terrace 60 feet above water level in Mississippi river. Stops in sand under blue mucky clay.
Frank Naeve	Andover, S. ½ sec. 22	200	60	Shale	Surface deposits, 60; limestone, 30; shale, 110; water heads near surface.
T. 82 N., R. 6 E. (Hampshire; Part of Spring Valley).					
J. Lindmeyer	SE. ¼ sec. 14	118	45		
Peter Ehlers	NW. ¼ NW. ¼ sec. 28	100	90		
Peter Swartz	NE. ¼ NW. ¼ sec. 3	150	63		
A. Clausmann	NW. ¼ SE. ¼ sec. 10	48	20		
Claus Knutson	SE. ¼ NE. ¼ sec. 18	170	80	Limestone	High ground; all yellow clay.
James Hand	N. ½ sec. 30	150	55		
George Lange	SW. ¼ SE. ¼ sec. 5	192	140		
	Sec. 8	240	140	Limestone	

Typical wells in Clinton County—Continued.

Owner	Location	Depth	Depth to rock	Water-bearing Formation	Remarks: (Logs given in feet)
		Feet	Feet		
B. Manning	Sec. 9	110	50		
G. F. Cook	Sec. 12	157	90		
T. 82 N., R. 7 E. (Part of Spring Valley).					
Eagle Point Park	Lyons	464	20		Loess, 20; Niagaran dolomite, 140; Maquoketa shale, 200; Galena dolomite, 104; a weak well.
Marion Gates	Lyons	200	30		Bluff. Ends on shale.
Oakland Cemetery	do	276	60	Sand veins in shale.	Loess and drift, 60; limestone, 116; shale, 100.
T. 82 N., R. 5 E. (Center).					
James McDevitt	Sec. 3	84		Sand	Goose Lake Channel. All sand. Head, 1 foot below curb.
William Wiese	NE. ¼ NE. ¼ sec. 11	82		Gravel	Hillside, about 25 feet above creek; flowed for several years from gravel under blue clay.
	NW. ¼ NW. ¼ sec. 14	425	30		Valley. Drift, 30; limestone, 120; shale, 180; Galena dolomite, 95.
Hans Wiese	SW. ¼ SW. ¼ sec. 9	250	106	Limestone	Ends in Niagaran dolomite.
A. Steudemann	SW. ¼ SE. ¼ sec. 15	132		Sand	Goose Lake Channel. All sand.
Do.	SW. ¼ sec. 14	175		do	Goose Lake Channel.
William Buech	SE. ¼ NE. ¼ sec. 14	230	130		Upland overlooking Goose Lake Channel.
Center Grove Creamery.	SW. ¼ SW. ¼ sec. 2	170	130		
Town	Elvira	118		Sand	Alluvium, 5; yellow clay with sandy streaks, 50; sandy blue clay, 60; sand, 3.
T. 82 N., R. 4 E. (Washington; (Part of Dewitt).					
	NE. ¼ sec. 6	158	132		Yellow clay, 40; blue clay nearly to rock; a little sand on rock; blue quicksand 50 feet on rock.
	SW. ¼ NE. ¼ sec. 17	87	51		Lowland.
M. Shannon	E. ½ sec. 23	118	75		High ground.
William Burka	Sec. 9	66	64		
E. Kelly	Sec. 10	175	125		Hard blue till, 105.
J. McDermott	Sec. 10	187	180		Hard blue till, 120
T. Naughton	SW. ¼ NE. ¼ sec. 15	194			Clay; no rock. High land.
	NW. ¼ NW. ¼ sec. 15	225		Gravel	Yellow clay, 40; hard blue till, 80; quicksand, 70; coarse sand and gravel, 35. Surrounding wells struck rock at about 125.
T. 82 N., R. 3 E. (Welton; Part of Dewitt).					
M. Duffy	Sec. 1	160			Curb 770 feet above sea level; hence rock less than 610 feet above sea level.
E. Parker	Sec. 4	160	158		Loess and yellow till, 25; rather soft blue till with sand streaks 75; blue till, compact, 58.
William Betts	Sec. 6	140	100	Limestone	
P. H. Ryan	NE. ¼ NE. ¼ sec. 11	106	66	do	Yellow clay, 36; blue clay, 30; limestone, 40.
W. Rilly	NW. ¼ sec. 16	130	100	do	Yellow clay, 20; sand, 50; limestone, 30.

Typical wells in Clinton County—Continued.

Owner	Location	Depth	Depth to rock	Water-bearing Formation	Remarks: (Logs given in feet)
		Feet	Feet		
L. A. Loofboro	SE. ¼ SE. ¼ sec. 17	180	80	do	Yellow clay, 30; blue clay, 50; limestone, 100.
— Reedinger	Old Welton	227	227	Gravel	Yellow clay, 35; blue clay to gravel on rock.
T. 82 N., R. 2 E. (Berlin).					
Mary Hassett	SW. ¼ sec. 2	132		do	High upland. Yellow clay, 30; blue clay, 98; gravel, 4.
A. Galloway	Sec. 3	326	324		High upland; curb 840 feet above sea level. Black soil, 3; yellow clay, 30; blue clay, 288; red clay, 3; limestone, 2.
Dougherty Estate	Sec. 4	175	80	Limestone	High upland. Yellow clay, 30; blue clay, 50; limestone, 95.
Patrick Conners	S. ½ sec. 7	162	160	Sand	Sandy soil, 20; blue clay, 20; sand, 120; limestone, 2.
H. Schocker	SE. ¼ sec. 8	117	102	Limestone	
M. J. Pinter	SE. ¼ SE. ¼ sec. 12	242	222	do	Yellow clay, 32; blue clay, 190; limestone 20.
P. Peterson	SE. ¼ sec. 13	210	205	do	Yellow clay with sand, 50; blue clay, 30; quicksand, 15; blue clay, 110; limestone, 5.
William Rock	NE. ¼ sec. 23	130	85	do	
William Betts	SE. ¼ sec. 28	70	30	do	Sandy soil, 30; limestone, 40.
Kohler Bros.	Center of S. ½ sec. 36.	180		Gravel	Sandy yellow clay, 32; blue clay, 40; sand, 10; blue clay, 96; gravel, 2.
J. M. Wolfe	SE. ¼ sec. 36	85	40	Limestone	
T. 82 N., R. 1 E. (Liberty).					
J. Figly	Sec. 5	100	70	do	Sand, 70; limestone, 30.
J. E. Wolfe	Sec. 14	140	110		Wapsipinicon bottoms. Sand, 110; limestone, 30.
T. Horstman	Sec. 27	175	155		Wapsipinicon bottoms. Yellow clay, 35; blue clay, 120; limestone, 20.
T. 81 N., R. 1 E. (Spring Rock).					
M. Pingel	SW. ¼ sec. 4	130		Sand	Soil, 1; sand, 120; hardpan, 9.
City of Wheatland	Wheatland	171	87	Limestone	Iowan plain. Alluvium, 5; yellow clay, 43; blue clay, 39; limestone, 84.
K. Jergenson	NE. ¼ NE. ¼ sec. 25	229	180	do	Wapsipinicon bottoms. River sand, 60; blue clay, 80; black hard clay, 40; blue shale, 40; limestone, 9.
L. Homrighausen	SE. ¼ NE. ¼ sec. 28	287	185	do	Bluffs.
T. 81 N., R. 2 E. (Olive).					
O. Reming	Sec. 5	117	102	do	Soil, 2; sand, 100; limestone, 15.
A. Tumpani	S. ½ SE. ¼ sec. 11	55	48		Yellow clay, 48; limestone, 7.
O. F. Ludwigson	Sec. 20	230	228	Sand	Sand, 100; blue clay, 20; sand, 108; limestone, 2.
Bruce Walker	Calamus	137	120		Yellow clay, 20; blue clay, 100; limestone, 17.
T. 81 N., R. 3 E. (Orange and part of Dewitt).					
Town of Grand Mound	Grand Mound	88	41	Limestone	Soil and gravel, 41; limestone, 47.

Typical wells in Clinton County—Concluded.

Owner	Location	Depth	Depth to rock	Water-bearing Formation	Remarks: (Logs given in feet)
		Feet	Feet		
George Jordan	Grand Mound	144	15	Limestone	Heads 80 feet below curb. Diameter, 4 inches; depth to water bed, 125 feet.
T. 81 N., R. 4 E. (Part of Dewitt).					
Chauncey Herrington.	1 mile NW. of De Witt.	130	130		High ridge.
Town of DeWitt No. 1.	De Witt	524	40	Limestone	Yields 50 gallons a minute. Diameter, 10 inches.
Chicago & North Western Ry.	do	267		do	Soil and sand, 40; limestone, 220; shale, 7.
H. E. Vickery	SW. ¼ NE. ¼ sec. 36	47	7	do	
T. 80 N., R. 5 E. (Parts of Eden and Camanche.)					
E. B. Wilkes	Folletts	51	37	do	Sand, 37; limestone, 14.
Maple Grove School.	2 miles W. of Folletts.	97		Limestone at bottom.	
C. Van Epps	NW. ¼ sec. 3	172		Gravel	Sand, 40; blue clay, 130; gravel, 2;

IOWA COUNTY

BY O. E. MEINZER AND W. H. NORTON.

TOPOGRAPHY.

The surface of Iowa county is well dissected and contains only isolated tracts of relatively level upland. The largest stream is Iowa river, which meanders through a broad flood plain.

GEOLOGY.

The bedrock consists of indurated limestones, sandstones, and shales which belong to the Devonian and Carboniferous systems and dip gently southwest. (See Pl. XV.) Though the main body of the Pennsylvanian series (Upper Carboniferous) is found farther south and west, there is reason to believe that thin outliers of this series occur in this county, lying on an erosion surface of the older formations. The unconsolidated deposits, which rest on the bedrock, range in thickness from a mere veneer to more than 300 feet, this difference being due not only to the relief of the present surface but also to notable irregularities in the surface of the bedrock. There is evidence of the existence of two distinct drift sheets, the Kansan and Nebraskan, separated by the Aftonian gravel.[1] Throughout most of the county the drift is concealed beneath loess, but in the principal valleys alluvial deposits are at the surface.

UNDERGROUND WATER.

SOURCES.

Alluvial sand or gravel furnishes generous and permanent supplies of water wherever it occurs, but elsewhere most of the water comes from the drift or associated porous materials. Many of the older wells were dug or bored a short distance into the drift and these furnish only a scanty and precarious supply, but at present many drilled wells range in depth from 50 to more than 300 feet, ending in layers of sand and gravel interbedded with bowlder clay or lying immediately below the drift. Most of these latter wells are two inches in diameter and are finished with screens that become incrusted after a few years of service.

On account of the irregularities of the rock surface great differences are found in the occurrence and water-bearing capacity of the drift aquifers and in some localities the drill enters rock before it encounters a satisfactory source of water. The sandstones and some of the limestone strata will yield water, but the shales and argillaceous or massive limestones are of little value as aquifers. Many successful rock wells of only moderate depths have been drilled, but in some places the indurated formations have been penetrated for several hundred feet without finding water. Where the drift is underlain by shale it is advisable to finish wells in the drift whenever possible, but in localities in which a good water-bearing sandstone or limestone lies within a few hundred feet of the surface it may be more satisfactory to case out the fine sand deposits that will give trouble by clogging the screens and to end the well in rock.

The water from the alluvium and upper part of the drift is

[1]Ann. Rept. Iowa Geol. Survey, vol. 9, p. 523 et seq., vol. 20, p. 172 et seq.

only moderately hard; that from the deeper beds of sand differs greatly in mineralization, some being harder than that of the shallow water and some too hard and corrosive for either domestic or boiler use. The water from the rock formations is generally rich in dissolved solids.

At Marengo three or four flowing wells end at depths of several hundred feet in what is supposed to be Devonian limestone. Farther up the valley of Iowa river and also in the valleys of Honey creek and Bear creek many flowing wells obtain water in the Aftonian gravel and a few are supplied from rock strata. These flows belong to the famous Belle Plaine artesian basin (pp. 426).

CITY AND VILLAGE SUPPLIES.

Amana.—At Amana (population, 621), which is located in the wide valley of Iowa river, there is a 1,640-foot artesian well and also a well about 475 feet deep which passes through shale and ends in what is supposed to be Niagaran dolomite.

The deeper well is 6 inches in diameter. The curb is 730 feet above sea level. The original head was 30 feet above the curb and the head in 1908, 20 feet above the curb. The original flow was 200 gallons a minute; in 1896 the flow was 100 gallons and in 1908 it was 50 gallons. The temperature of the water is 68° F. This well is located in the SW. 1/4 NW. 1/4 sec. 36, T. 81 N., R. 9 W. From the start in 1881 to the finish in 1883, it was drilled wholly by the labor and skill of the Amana Society. Originally it was cased to a depth of 400 feet with 6-inch pipe which withstood the corrosive action of the water about four years, when a 4-inch pipe of equal length was inserted and made tight at the bottom with secure packing.

Water began to flow at a depth of about 400 feet, 330 feet above sea level, about the horizon of the Independence shale member of the Wapsipinicon limestone. Like the flow from this horizon at Davenport, the yield was very small, not over 8 gallons a minute. A slight increase, raising the discharge to 16 gallons a minute, said to be from the Maquoketa shale, was the only addition met with until the Saint Peter, 80 feet thick, was reached at a depth of 1,020 feet, when the discharge rose to 30 gallons. At about 1,200 feet (440 feet below sea level), in the Jordan sandstone, a rapid increase began and the full flow was reached at 1,640 feet. The water is used only for scouring in the woolen mill of the Society.

Record of strata in Amana well.

	Thickness	Depth
	Feet	Feet
Pleistocene deposits	50	50
Shale (Carboniferous and Devonian)	300	350
Limestone (Niagaran)	200	550
Shale (Maquoketa)	220	770
Limestone (Galena and Platteville)	250	1,020
Sandstone (Saint Peter)	80	1,100
Limestone (Prairie du Chien)	540	1,640

In the shallower well at Amana the water at first rose 7 feet above the valley surface but now stands 6 or 8 feet below the surface. It has been pumped at the rate of 29 gallons a minute.

Water diverted from the river and led through a canal to this settlement for use in power plants is used in the factory boilers and also supplies the small gravity system of waterworks. As it is softer than the underground water, it is generally employed for washing, but water from shallow wells is used for drinking and for culinary purposes.

East Amana.—At East Amana a 475-foot well is supposed to end in Niagaran dolomite. It is located on somewhat higher ground than the wells at Amana and hence does not overflow. A similar well was drilled at West Amana. At South Amana the waterworks are supplied from a drilled well 600 feet deep, and at Middle Amana from a shallow dug well; at High Amana a spring is largely relied upon.

Homestead.—At Homestead the society has a well 2,224 feet deep which is located on higher ground and hence does not overflow, although it yields well when pumped. (See Pl. XV.) It supplies a small gravity system of waterworks similar to the one at Amana.

This well, which was drilled by J. P. Miller & Company, of Chicago, is 10 inches in diameter to 340 feet, 7 5-8 inches to 750 feet, 6 inches to 1,560 feet, 5 inches to 2,023 feet, 4 inches to 2,224 feet. The curb is 868 feet above sea level. The water originally stood 117 feet below curb, and the present head is 87 feet below curb. Water was found at 600 feet in the Niagaran, rising to 150 feet below the curb, and at 1,700 feet in the Jordan, rising to 117 feet below curb. Date of completion, 1895. Casing was carried from the top to 340 feet, from 335 to 525 feet, and from 750 to 1,000 feet. No packing was used. The present yield of this well is 80 gallons a minute.

The strata penetrated are indicated by the following log and record:

Driller's log (geologic correlation added) of Amana Society well at Homestead.

	Thickness	Depth
	Feet	Feet
Pleistocene, Carboniferous and Devonian (505 feet thick, top 868 feet above sea level):		
Clay	300	300
Shale	205	505
Silurian (Niagaran dolomite, 245 feet thick; top, 363 feet above sea level):		
[illegible]	245	750
Ordovician:		
Maquoketa shale (250 feet thick; 118 feet above sea level)—		
Shale	250	1,000
Galena and Platteville limestone (300 feet thick; top, 132 feet below sea level)—		
Limestone	300	1,300
Saint Peter sandstone (100 feet thick; top, 432 feet below sea level)—		
Sandstone	100	1,400
Prairie du Chien stage (370 feet tbick; top, 532 feet below sea level)—		
Sandy limestone	370	1,770
Cambrian:		
Jordan sandstone (100 feet thick; top, 902 feet below sea level)—		
Sandstone	100	1,870
Saint Lawrence formation (230 feet thick; top, 1,002 feet below sea level)—		
Limestone	230	2,100
Dresbach sandstone and earlier Cambrian strata (124 feet penetrated; top, 1,232 feet below sea level)—		
Sandstone (penetrated)	124	2,224

Record of strata in well at Homestead.

	Depth in ft.
Shale, greenish yellow; many siliceous pebbles	275
Shale, yellow; numerous small brick-red ocher nodules; ferruginous, arenaceous; practically noncalcareous	285
Shale, light greenish gray, fissile, slightly calcareous; some red ocherous nodules and a few fragments of limestone, chert, quartz, and dark shales	475
Limestone and shale, light blue-gray; chips of light gray compact limestone of earthy luster and highly argillaceous; in highly calcareous concreted powder	500
Dolomite, blue-gray, vesicular; in small chips	600
Dolomite; in white powder	750
Shale, greenish	805
Sand and gravel, superficial and recent	970
Limestone, drab; in thin flakes; earthy, fossiliferous	1,010
Shale	1,030
Shale, calcareous	1,250
Sandstone, fine, white	1,345
Sandstone, calciferous; chiefly quartz sand with considerable dolomite and chert	1,475
Sandstone, cream-yellow; coarser than at 1,345 feet; grains mostly rounded	1,800
Sandstone; very fine, white angular quartz sand; considerable dolomite and chert	1,825
Sandstone; in white powder of microscopic quartz	1,850
Dolomite, gray	2,025
Sandstone, red, highly calciferous; argillaceous and calcareous "from 2,100 to 2,200"	2,200

The wells at Homestead and Amana are less than four miles apart, but their records are gravely inconsistent. The summit of the Maquoketa in one is at 180 feet above sea level and in the other at 118 feet above sea level; the summit of the first sandstone in one is 290 feet below sea level and in the other is 432 feet below sea level. The record of the Homestead well, inexact at it may be, is used in the geologic section from Davenport to Des Moines.

Marengo.—The public supply of Marengo (population, 1,786) is derived from a well located in the valley and sunk through sand and clay into a bed of gravel lying at a depth of 35 feet. The well is 18 feet in diameter and is cased with brick. Water stands 2 to 12 feet below the surface, according to the season, and it is reported that when this level is lowered 6 feet by pumping water flows into the well at the rate of 350 gallons per minute. The analysis (p. 183) indicates that the water is only moderately hard and is relatively good for boiler use. Before the present well was dug, a system of driven sand points was used but was not satisfactory because of the clogging of the strainers.

The water is lifted into a tank elevated upon a tower and is thence distributed by gravity through a system of mains. It is used by about half of the people and by the Chicago, Rock Island & Pacific Railway, approximately 65,000 gallons being consumed in an average day.

Forecasts for an artesian well at Marengo have special interest because of the difficulty usually experienced in getting good water from the shale of the Kinderhook (Mississippian), which forms the country rock in the vicinity.

After penetrating this shale the drill will enter the Devonian rocks, which also may be expected to contain considerable shale. Below these lie the Silurian dolomites (Niagaran), which probably contain some water under a head high but not sufficient to reach the curb. The Silurian here may include the Salina (?) formation which contains some gypsum or anhydrite, either disseminated or in layers or lenses, and the water from this formation may be rather highly sulphated. The dry Maquoketa shale should be next reached at a depth of about 638 feet (about 100 feet above sea level) and may be 250 feet thick. The next formations in descending order, the Galena limestone, Decorah shale, and Platteville limestone, will yield some water, which may contain sulphureted hydrogen. The Saint Peter sandstone lies about 450 feet below sea level (about 1,200 feet from the surface). Drilling should not be stopped at the Saint Peter, however, but should be carried a few hundred feet deeper, through the Prairie du Chien stage—creviced dolomites with sandy layers—and through the water-bearing Jordan sandstone.

The water from the Jordan may be expected to flow with a pressure of about 10 pounds. The well should not be sunk deeper than 1,800 feet except under the advice of a competent geologist who has examined a full set of drillings from the well and to whom all the facts as to the water found have been submitted.

The quality of the water will depend in part on how effectively the upper waters—those of the Kinderhook and possibly the Silurian—have been cased out. Analyses should be made of all flows so that deleterious waters may be shut off and good waters with high heads admitted. With due precautions a fair drinking water should be obtained.

Victor.—Victor (population, 640), situated on the banks of Big creek, has a system of waterworks that is supplied from an open shallow well.

Williamsburg.—The waterworks at Williamsburg (population, 1,060) are supplied from two wells at separate pumping stations—one in the valley of Old Man creek and the other recently drilled on somewhat higher ground. The old well is eight inches in diameter and 110 feet deep, and ends with a 20-foot screen in a bed of sand below blue clay, the water rising within about 45 feet of the surface. The new well is also eight inches in diameter and ends with a long screen in what is apparently the same bed of sand. Starting from higher ground, it goes to a total depth of 145 feet with the water remaining at about 85 feet below the surface. With the cylinder at a depth of 128 feet, the well is reported to have been tested at 200 gallons a minute and is usually pumped at about 100 gallons. The water, as shown by analysis (p. 183), is only moderately mineralized. The water is stored in two compression chambers on relatively high ground and the pressure is supplied in part by gravity and in part by compressed air. The mains have a total length of about two miles and there are 24 fire hydrants and approximately 175 points at which the water is used. A large portion of the inhabitants are supplied and an average of 20,000 gallons are consumed daily.

The railway supply is obtained from a well which is similar to the two village wells and which has been tested at 250 gallons a minute.

JACKSON COUNTY.

BY W. H. NORTON.

TOPOGRAPHY.

The larger part of the upland of Jackson county has been carved by running water to high complex ridges whose rounded crests and gently sloping flanks descend to deep and in many places rock-walled valleys. The topography is that of the driftless area. The earlier invasions of the glacial ice probably covered nearly the entire county, the northeast corner alone being excepted; but the thinner deposits of the earlier ice sheets only slightly modified the preexisting relief, and the thicker ones were afterwards sculptured to much the same form. The thorough dissection of the area is due not only to the length of time in which it has been exposed to weather and running water, but also to its differences in elevation. In the northeast part of the county the surface stands nearly 1,200 feet above sea level, whereas Sabula, in the southeast corner, is but 603 feet above the sea.

The lower and more level lands include a small area in Butler township referred to the Iowan drift and one of the same general characteristics extending from Monmouth to Maquoketa and thence into Clinton county, together with the forested or grassy flood plains of the Mississippi and the wide valley floors developed in the weak Maquoketa shale by the broad ancient temporary channel of the Mississippi from Green Island to Spragueville and thence south to the county line.

GEOLOGY.

The drift commonly exposed to view is the Kansan, a stony clay, reddish where weathered but blue-gray originally, and where unaffected by weathering. Over all the uplands of the area, except in a small tract in Butler township allotted to the

Iowan drift, is spread the loess, a yellow dust or silt reaching a maximum thickness of 25 or 30 feet.

The formations immediately underlying the drift in Jackson county comprise the Niagaran dolomite, the Maquoketa shale, and the Galena dolomite. (See Pls. IX, X.)

The Niagaran is a hard dolomite, which, except on some small areas underlain by the Maquoketa, forms the bedrock on which the surface materials are spread over all the uplands of the county.

The Maquoketa comprises a blue plastic shale, 150 feet thick, reached by the drill in different portions of the county and at once recognized by its clayey nature and by the fact that it immediately underlies the limestone which forms the country rock of the uplands and is the first shale to be reached by the drill. The Maquoketa forms the bedrock of the valleys of the creeks tributary to the Mississippi and of an area of several square miles about Preston.

The Galena, a hard dolomitic limestone, cut by the drill into sharp glistening yellow sand, is exposed at Bellevue near water level in the Mississippi (its southernmost outcrop) and forms conspicuous bluffs in the northeast townships of the county.

UNDERGROUND WATER.

SOURCES.

The available water beds of Jackson county are chiefly in the indurated rocks. Drift deposits, such as those at the base of the loess, and the gravels interbedded with stony clay or overlying rock, have generally been left dry, or at least inadequate for stock wells, by the gradual lowering of the ground water. In localities where thirty years ago water for domestic purposes could be obtained by wells 100 feet deep it is now necessary to drill to 150 and 175 feet.

The sands of the wide flood plain of the Mississippi between Bellevue and Sabula, the smaller flood plain areas along the Maquoketa, and an area a mile wide which extends from Green

Island to Spragueville, are saturated nearly to the surface and yield water to driven wells. The ancient terraces of alluvium along Mississippi river also afford water at moderate depths.

Over the larger part of the county wells are compelled to enter rock to find permanent ground water adequate for farm or village supply. The chief water horizon is the Niagaran. This dolomite, in changing from its original form of a non-magnesian limestone, became vesicular and porous, so that water seeps slowly through it, especially in certain layers. Moreover, percolating water has dissolved out passageways in the soluble rock, thus securing an active circulation. Furthermore, the Niagaran is underlain by an impervious shale bed, the Maquoketa, which by arresting the descent of ground water tends to keep the lower portions of the limestone saturated. For this reason water is often found some distance above the summit of the shale. It occurs in porous granular beds cut by the drill to sharp shining fragments the size of sand, thus giving the false impression that the drill is working in sandstone. The layers of limestone interbedded with thin layers of chert or flint which occur near the base of the Niagaran are generally water bearing. Abundant supplies may be obtained when the drill happens to strike a crevice or other opened passageway of ground water.

DISTRIBUTION.

Two areas in which water occurs in the drift are of special interest inasmuch as they mark river channels long since abandoned by the streams which formed them.

Goose Lake Channel, carved and in part filled by the diverted Mississippi, crosses the southwestern part of Van Buren township, passing thence into Clinton county. A well in the southwest quarter of section 32 of Van Buren township, probably representative of much of the area, has the following log:

Log of well in Van Buren Township.

	Thickness	Depth
	Feet	Feet
Soil, black	10	10
Clay, blue, hard, and gritty; old forest bed at 30 feet	30	40
Quicksand	40	80
Gravel	10	90

A well in Preston, on the same lowland, shows the following sequence:

Log of well at Preston.

	Thickness	Depth
	Feet	Feet
Soil, dark	10	10
Soft yellow "stuff"	15	25
Clay, blue, gritty; 5-foot streak of yellow "stuff"	90	115
Gravel	10	125

On the other hand, a well sunk by the town of Preston to a depth of 140 feet on the same ancient channel is reported to have been entirely in sand and gravel. A well at the stockyards at Preston ends in sand and gravel at 128 feet.

A second ancient channel forms a plain one to two mile wide, utilized by the tracks of the Chicago & North Western Railway from Monmouth to Maquoketa, and extending southward from the latter city. To the west it ends abruptly a short distance from Monmouth, where Bear creek descends to it through a rock-walled gorge. An investigation of the wells of the vicinity has not disclosed any westward extension of the buried channel into Jones county. At Monmouth, on the south side of the town, wells reach rock within about 70 feet of the surface (670 feet above sea level) and find their supply in the upper eight or ten feet of porous and water-logged limestone, the head being sufficient to bring the water within ten feet of the surface. But on the north side of town few wells exceed fifty feet in depth and they reach rock from two to twenty-five feet from the surface.

On the plain between Monmouth and Baldwin some wells about sixty feet deep end in gravel, and the rock floor is found at forty feet from the surface. At Baldwin the rock floor is about 650 feet above sea level, wells near the Chicago & North Western Railway station entering it at ninety feet. In the NW. 1/4 sec. 25, Monmouth township, a well is reported as 225 feet deep, reaching rock at 200 feet, but one-fourth mile farther west rock outcrops seventy-five feet higher than the well curb. In section 29, South Fork township, a well 240 feet deep ends in gravel, the drill having passed through blue clay and quicksand; the rock floor here lies below 520 feet above sea level. On the section south of that just mentioned the preglacial valley is partly covered with heavy drift cut into hills rising to more than 100 feet above the plain. Here wells go more than 200 feet—one goes to 240 feet—without entering rock, the rock floor of the ancient valley being here below 580 feet above sea. Water is obtained in gravels overlain by quicksand forty feet thick, the whole being buried beneath 200 feet of till. In sections 33 and 35 wells on this plain 90 and 120 feet in depth end in gravel, the rock floor here not rising above 610 feet above sea. In the southeastern part of the township the rock beneath the plain lies much nearer the surface; wells are known to reach it at twenty and forty feet, finding water in the underlying limestone within eighty feet of the surface.

At Maquoketa, on the eastern border of this plain, the depth to water and the elevation of the rock surface are both variable. Rock outcrops near the station of the Chicago & North Western Railway and comes within six feet of the surface at the station of the Chicago, Milwaukee & St. Paul Railway. Six rods west of the last-named station, however, the drill finds rock more than eighty feet below the plain, and southwest of the station does not reach it for nearly 100 feet. In the southwestern part of the town there are wells 140 feet deep which fail to reach rock, whose surface must here lie below 600 feet above sea. The succession of deposits here is as follows:

Section at Maquoketa.

	Thickness in ft.
Clay, yellow, at surface	20
Clay, soft, blue, gritless	25
Quicksand, blue	100

The quicksand, which is found in many wells in town, is water bearing, but as it is too fine to afford footing for the casing the wells are continued to gravel or to rock and the sand cased out. How sharp are the descents to this narrow buried valley may be seen from the fact that rock is found at forty feet on the next street west from the one on which wells go 140 feet without finding rock. On the hill east of the high school a well eighty-four feet deep penetrated blue clay nearly to the bottom of the well without entering rock, but within one block rock was found fifty feet below the surface and water in the Niagaran dolomite 120 feet below.

The depth of wells in the Niagaran varies greatly. Wells located in ancient rock-cut valleys obviously need to go a shorter distance to reach the base of the Niagaran than wells on the summits or sides of hills. The height of the hills is in many places accentuated by deposits of drift and loess, and the depth of wells therefore depends in part on the thickness of these surface clays. With the dip of the strata to the southwest the Niagaran thickens and may reach 250 feet or more in Monmouth township. It thins to the north and east, and in Tete de Mort township overlooks the valleys in steep cliffs forty to sixty feet in height. An upfold of the strata which extends from Sabula northwest for twenty miles, together with subsequent denudation, has thinned the Niagaran and brought the Maquoketa shale nearer to the surface over a considerable area in the southeastern part of the county, thus reducing the depth of ordinary wells. In southern Van Buren and Fairfield townships the Niagaran has been widely removed by erosion and the Maquoketa forms the country rock. Fortunately the deep valleys excavated in the weak shales in preglacial time have been deeply filled with drift in which water is usually found so that it is not necessary for wells to enter the dry shales. In general, wells supplied from the Niagaran horizons range in depth from less than 100 feet to 230 or 260 feet.

The Maquoketa almost everywhere consists of dry shales, and where water is not found above it the driller must choose between abandoning the drill hole for one in another location or continuing the drilling with the definite expectation of having to pass through the entire body of shale before finding water at a greater or less depth in the Galena dolomite. Inasmuch as the limestones of the Middle Maquoketa found in counties lying farther north are absent in Jackson county, there need be no expectation of finding water before reaching the base of the Maquoketa.

As examples of the depths needed to get water if it is not found above the Maquoketa shale three wells situated not far west of the Niagaran escarpment near Sabula may be cited. One of these (section 24, Union township) gives the following section:

Section of well in Union Township.

Formation	Thickness	Depth
	Feet	Feet
Drift	40	40
Niagaran dolomite	154	194
Maquoketa shale	120	314
Galena dolomite	30	344

Another well, on the farm of L. P. Hunderad, in section 35, Iowa township, is reported as 450 feet in depth; and a third well, in section 34, same township, is said to reach a depth of more than 500 feet, the Maquoketa shale being entered at 150 feet.

In the valleys of Tete de Mort, Spruce and Mill creeks, excavated in the Maquoketa shale, wells find water in the Galena dolomite within moderate distances from the surface.

SPRINGS.

Large springs are numerous along the bluffs bordering the Mississippi and the sides of the valleys of its tributaries at the summit of the Maquoketa shale. Transitional upper impure limestones of the Maquoketa, twenty to thirty feet thick, and the massive Niagaran dolomite serve as a reservoir whose floor is the impervious shale beneath. As examples may be mentioned the springs of George Egan (SE. 1/4 SE. 1/4 sec. 15, T. 86 N., R. 4 E.), of Nicholas Leg (SW. 1/4 SW. 1/4 sec. 16), of Peter Schreiner and of John Wagner (NW. 1/4 NW. 1/4 sec. 29), all on Little Mill creek west of Bellevue. Some of these springs flow a rippling stream of crystalline clear water two feet wide and three or four inches deep. They emerge from talus slopes at the base of the bluffs, about thirty feet below the massive ledges of Niagaran dolomite or from near the base of the yellowish, thin-layered beds which form the transition between the Niagaran and the Maquoketa. The August temperature of these springs is 50° F. As the valley floor rises above the base of the Niagaran up valley the series of springs comes to an end, the last one noted being that of Peter Wagner (NW. 1/4 NE. 1/4 sec. 29, T. 86 N., R. 4 E.). The same description applies to the large springs on Mill creek up Paradise Valley, the largest being on the farm of L. R. Potter (NW. 1/4 SW. 1/4 sec. 10) and that of Anton Earnst (SW. 1/4 SW. 1/4 sec. 6).

The springs issuing along the upper reaches of Tete de Mort creek in secs. 4, 9 and 16, T. 87 N., R. 3 E., have given name to the civil township of Prairie Spring. They emerge low down along the bluffs somewhat above the summit of the Maquoketa shale.

In eastern Jackson township in all the valleys which transect the summit of the Maquoketa shale, springs almost universally take the place of wells. Each farm has its spring house for dairy purposes, and the supply is usually ample for all uses of home and farm.

CITY AND VILLAGE SUPPLIES.

Bellevue.—Bellevue (population, 1,776) draws its town supply from a shallow well located near the brink of Mississippi river. The fire supply is taken directly from the river. A reservoir furnishes gravity pressure of 100 pounds. Two double stroke Smedley steam pumps have a combined capacity of 1,000,000 gallons per 24 hours. There are 24 double hydrants and 3½ miles of mains.

Green Island.—At Green Island (population, 128) water is obtained from drilled wells, thirty to seventy-five feet deep, entering rock at thirty feet, and from small springs.

The Chicago, Milwaukee & St. Paul Railway Co. has a well 823 feet deep, eight to four and three-quarters inches in diameter, cased with eight-inch pipe to 140 feet, and with six-inch pipe put down in 1906 (four years after the well was completed) to 180 feet from the curb and packed with rubber. The curb is 601 feet above sea level, and the head is 64.5 feet above the curb. Water was obtained from sixty feet and from 504 to 564 feet. The strata penetrated are indicated by the following table:

Record of strata of railway well at Green Island (Pl. X).

[Based on drillers log.]

	Thickness	Depth
Ordovician:	Feet	Feet
Maquoketa shale (140 feet thick; top, 601 feet above sea level)—		
Clay, blue, and shale	140	140
Galena dolomite to Platteville limestone (335 feet thick; top, 461 feet above sea level)—		
Lime rock	310	450
Rock, gray	25	475
Saint Peter sandstone (106 feet thick; top, 126 feet above sea level)—		
Sand rock	25	500
Shale	4	504
Sand rock	77	581
Prairie du Chien stage (242 feet penetrated; top, 20 feet above sea level)		
Rock, gray	25	606
Shale	2	608
Sand rock	28	636
Shale	5	641
Rock, gritty, hard	20	661
Shale, blue	5	666
Rock, gray	45	711
Shale	5	716
Sand rock	25	741
Rock, flinty	20	761
Shale	4	765
Sand and gravel	11	776
Shale	5	781
Limestone, shaly	42	823

La Motte.—The waterworks at La Motte (population, 288), used chiefly for fire protection, comprise a well, a standpipe, mains extending for five blocks, and five hydrants. Drilled wells, in depth from 75 to 100 feet, with some as deep as 190 feet, entering rock at about forty feet, furnish the domestic supply.

Maquoketa.—Maquoketa (population, 3,570) takes its water from a well and from Maquoketa river. The water is pumped to a standpipe and is distributed under a domestic pressure of seventy pounds and a fire pressure of 125 pounds. There are thirteen miles of mains and 102 fire hydrants. Drilled wells 100 to 160 feet deep are largely used for domestic supply.

The possibility of obtaining water from deep wells at Maquoketa is indicated by the record of a prospect hole for oil put down by the Texas Drilling Company in 1907 to a depth of 1,716 feet in the SW. 1/4 sec. 11, T. 82 N., R. 3 E. (See Pls. IX, X.) The mouth of the hole is about 760 feet above sea level; ten-inch casing was carried to a depth of 277 feet, and eight and one-fourth-inch casing to 1,103 feet. Water was struck in the Niagaran dolomite at a depth of 155 to 215 feet, heading 85 feet below curb; at 215 feet, in the base of the Niagaran; at 486 to 695 feet, in the Galena dolomite; at 1,110 to 1,190 feet, in the Jordan sandstone; at 1,338 to 1,596 feet, and at 1,695 and 1,716 feet, in the Dresbach and underlying sandstones. At 1,716 feet the water overflowed while the drill was in the well.

Record of strata in prospect hole at Maquoketa.

	Thickness	Depth
Residual and recent (6 feet thick):	Feet	Feet
Soil	1½	1½
Clay, hard, yellow	4½	6
Silurian:		
Niagaran dolomite (209 feet thick; top, 754 feet above sea level)—		
Dolomite	209	215
Ordovician:		
Maquoketa shale (225 feet thick; top, 545 feet above sea level)—		
"Sand and shale in seam second water"	¼	215¼
Shale, light blue; and limestone blue-gray, hard, close textured; slight effervescence	63¾	279
Shale, blue	151	430
Shale, chocolate brown, fissile; rather hard; petroliferous, burning with strong flame	10	440
Galena dolomite (255 feet thick; top, 320 feet above sea level)—		
Dolomite, porous, subcrystalline, gray; in log called "hard white shale"	46	486
Dolomite, light buff, crystalline; in log, "mixed lime and shale hard"	79	565
Dolomite, light buff, cherty; in angular sand	130	695
Decorah shale (15 feet thick; top, 65 feet above sea level)—		
Shale, bright green, fissile, fossiliferous; with dark gray, fossiliferous, nonmagnesian pyritiferous limestone; log—"slate and shale"	15	710
Platteville limestone (46 feet thick; top, 50 feet above sea level)—		
Limestone, gray, earthy, compact, nonmagnesian	5	715
Limestone, brown, nonmagnesian, hard; in flaky chips	7	722
Limestone, light gray, soft, earthy	28	750
Shale, blue, plastic, with some chips of brown limestone; in log "slate soft, blue" (Glenwood shale of Iowa State Survey)	6	756
Saint Peter sandstone (59 feet thick; top 4 feet above sea level)—		
Sandstone, clean, white; grains well rounded, moderately coarse, many having diameter of 1 millimeter or more	59	815
Continental deposits of time interval between Shakopee and Saint Peter (?) (241 feet thick; top, 55 feet below sea level)—		
Sandstone, fine, brick-red; considerable red argillaceous or ferric admixture; when washed in hot water, drillings remain pink owing to films of ferric oxide on grains of quartz sand; grains rounded, many broken, said by driller to contain seams of red shale; in log "red sandstone"	241	1,056
Oneota dolomite (54 feet thick; top, 296 feet below sea level)—		
Dolomite, light yellow-gray; with much dark red and dark brown hard fine-grained shale, some light green shale, a fine yellow quartz sand, a fragment of red fine-grained sandstone set with pieces of green shale; all except dolomite probably foreign, at 1056	54	1,110
"Shale, soft gray;" of log; sample supposed to represent this stratum consists of sand grains of Saint Peter facies, but with an occasional grain showing secondary enlargement; rather fine, with considerable foreign red and light green shale and some chert and chips of dolomite		
Cambrian:		
Jordan sandstone (80 feet thick; 350 feet below sea level)—		
"Sandstone, soft water;" of log; sample said to represent this stratum consists for the most part of angular sand of light gray dolomite with some arenaceous admixture; a sample at 1,125 feet is of sandstone, some grains showing secondary enlargements, along with some chert and dolomite	80	1,190
Saint Lawrence formation (198 feet thick; top, 430 feet below sea level)—		
Dolomite, light yellow-gray	110	1,300
Dolomite, purple-brown	20	1,320
Dolomite, light gray	68	1,388
Dresbach sandstone (208 feet thick; top, 628 feet below sea level)—		
Sandstone, soft, white; grains well rounded, fairly uniform in size, largest 1 millimeter in diameter	208	1,596
Undifferentiated Cambrian strata (120 feet penetrated; top, 836 feet below sea level)—		
Sandstone; in buff sand with the appearance of dolomite to unaided eye, but seen under the microscope to consist of microscopic grains of crystalline quartz with dolomitic cement, along with some fine rounded grains of quartz sand and some glauconite at		1,596

Record of strata in prospect hole at Maquoketa.

	Thickness	Depth
	Feet	Feet
Sandstone as above, with some gray shale	54	1,650
Sandstone of same composition as above; white	45	1,695
Sandstone, fine-grained, light buff; in minute detached grains and in angular chips as above	5	1,700
Sandstone, white, clean, fine; grains imperfectly rounded, most grains from 0.0075 to 0.01 inch in diameter; "quicksand" of log	16	1,716

In sinking a deep well at Maquoketa, it is expected that the drill will pass through the country rock (Niagaran dolomite) and discover the Maquoketa shale at 184 feet below the surface (about 500 feet above sea level). Some water will probably be found in the Niagaran and also in the dolomite beds generally present in the Maquoketa in this part of Iowa. About 200 feet deeper the drill will enter the Galena dolomite, passing thence into the Decorah shale and the limestones and shales forming the Platteville limestone, and the yield should be augmented from these horizons. The Saint Peter sandstone should be reached about thirty-five feet below sea level, or about 720 feet below the surface at the Chicago and North Western Railway station.

For industrial enterprises, hotels, liveries, etc., the yield from these beds should be ample, but for a city supply the wells should be sunk about 1,200 feet, or to 500 feet below sea level, so as to secure the full yield of the Prairie du Chien stage and the Jordan sandstone, and may indeed profitably go to 800 or 850 feet below sea level to tap the Dresbach sandstone. The limit of 1,500 or 1,600 feet from the surface need not be exceeded, as at about this depth the drill should pass into close-grained dry sandstones or marls underlying the Dresbach.

A flowing well with a head of about twenty feet is indicated, but is not assured, and to secure the best results the yield should be increased by the use, sooner or later, of deep cylinder pumps or air compressors.

At Bellevue the base of the Maquoketa shale is 617 feet above sea level, and a deep well drilled there will pass through about 350 feet of Galena dolomite, Decorah shale, and Platteville limestone before reaching the Saint Peter sandstone. Water from the dolomite and limestone will probably flow, but in insufficient quantity. The Saint Peter should afford water in moderate quantity, but it is recommended that the drill should probe also the the lower-lying creviced and sandy dolomites and sandstones, all water bearing, to a depth of 850 to 950 feet from the surface. This will give a flow of the purest water in quantity beyond all present needs of the town under a pressure at first adequate for fire protection. The well should be situated some rods back from the river front so as to avoid the old channel of the river filled deeply with alluvial sands and gravel and so as to encounter within a few feet the Galena dolomite. As the town is situated on a sand-covered rock bench, the well should be so located and so carefully cased as to reduce the danger of surface contamination to a minimum.

Miles.—At Miles (population, 334) water is obtained from drilled wells ranging in depth from fifty to ninety feet and entering rock at twelve feet.

Monmouth.—At Monmouth (population, 221) wells, dug and drilled, range in depth from 16 to 100 feet. These wells reach rock twenty-five feet below the surface. Water stands ten to twenty feet below the curb.

Nashville.—At Nashville wells are 40 to 50 feet deep, and the water level is 20 to 30 feet below the curb.

Preston.—At Preston (population, 642) the water-supply system is owned by a private corporation. Water is obtained from a well 108 feet deep and six inches in diameter, entering rock at 100 feet, and yielding from a vein in rock seventy-five gallons a minute. The well is located on a hill ninety feet above the level of the business street, and the water heads sixty to eighty feet below the curb.

Water is distributed from a tank with a capacity of 70,000 gallons under a domestic pressure of fifty pounds. The fire pressure is seventy-five pounds. There are one and one-half miles of mains, ten fire hydrants, and 150 taps. The consumption is 30,000 gallons daily.

Sabula.—The water supply of Sabula (population, 918) is drawn from one of the finest artesian wells in the state. (See

Pl. IX.) The water is pumped directly through three miles of mains under a domestic pressure of twenty-eight pounds, and fifty pounds for fires. There are twenty-eight fire hydrants and about 400 taps.

This well is 973 feet deep, eight to six inches in diameter, and is cased to 173 feet (rubber packed). The curb is 582 feet above sea level. The original head was seventy-four feet above curb; in 1905 it was forty-one feet above curb. The original flow was 720 gallons a minute. Water was obtained at 400 feet (Saint Peter sandstone), at 525 feet, and at 700 feet (Prairie du Chien stage); total discharge at this depth, 350 gallons a minute; the strongest vein was struck at 950 feet (Cambrian). Temperature, 59° F. Drilling was completed in 1895 by J. P. Miller & Company of Chicago.

With the original pressure of thirty-two pounds, the well furnished fire protection, as well as a superabundant water supply. With the diminution of pressure to eighteen pounds, about 1904, it was found necessary to install a 32-horse power gasoline engine and triplex pump, which are used only in case of fire. In 1908 the pumping capacity was reported at 500 to 600 gallons a minute.

Record of strata in city well at Sabula (Pl. IX).

	Thickness	Depth
	Feet	Feet
Quaternary (163 feet thick; top, 582 feet above sea level):		
Sand, alluvial; in ancient channel of Mississippi river	163	163
Ordovician:		
Galena dolomite to Platteville limestone (262 feet thick; top, 419 feet above sea level)—		
Dolomite, hard, rough, crystalline, buff and gray; some vesicular, 10 samples	212	375
Sandstone, argillo-calcareous; drillings consist of light green-gray powder, with fragments of dark gray sandstone; calciferous; grains not so well rounded and uniform in size as is common with the Saint Peter	25	400
Shale, green, fissile, arenaceous, slightly calcareous	25	425
Saint Peter sandstone (25 feet thick; top, 157 feet above sea level)—		
Sandstone, grains moderately fine, rounded, and ground; a large proportion of drillings consists of angular chips of gray dolomite; much green shale, probably from the superior shale	25	450
Prairie du Chien stage (325 feet thick; top, 132 feet above sea level)—		
Shakopee dolomite—		
Dolomite, medium dark gray; in angular fragments, clean except for a few pieces of green shale	15	465
Dolomite, highly arenaceous; drillings consist of rounded grains of quartz and minute angular fragments of dolomite, in some of the larger of which quartz sand is embedded	10	475
Dolomite, gray and light brown; drillings contain sand, probably from above; 2 samples	35	510
Dolomite, light brown, arenaceous	15	525
Dolomite, gray and buff; 3 samples	50	575
New Richmond sandstone—		
Sandstone, argillaceous and calciferous	25	600
Oneota dolomite—		
Chert; in fine white powder, calciferous; 2 samples	50	650
Dolomite, gray, cherty	90	740
Dolomite, white, highly arenaceous, and cherty	10	750
Dolomite, white, cherty, slightly arenaceous	25	775
Cambrian:		
Jordan sandstone and underlying Cambrian (198 feet penetrated; top, 193 feet below sea level)—		
Sandstone, white, calciferous, cherty; grains of sand, mostly fragmental, but many rounded; 3 samples	35	810
Unknown, cuttings washed away; reported by drillers to be no change	163	973

WELL DATA.

Information concerning typical wells in Jackson county is presented in the following table:

Typical wells in Jackson County.

Owner	Location	Depth	Depth to rock	Depth to waterbed	Source of supply	Head below curb	Remarks: (Log given in feet)
		Feet	Feet	Feet		Feet	
T. 84 N., R. 1 E. (Monmouth).							
T. Volker	NW. ¼ NE. ¼ sec. 20	68	58			10	Red sand and gravel on rock.
J. H. Sokol	NW. ¼ NW. ¼ sec. 21	48			Gravel		Bear creek; ends in gravel.
	NW. ¼ NE. ¼ sec. 21	120	40		Limestone		Loess, 20; yellow till, 20; Niagaran dolomite, 80.
Brown	NW. ¼ sec. 2	202	65	200	do	192	Clay to rock.
	Sec. 7	173	65		do		High ground. Flint from 153 feet to bottom.
	NW. ¼ SE. ¼ sec. 19.	42			Sand		Low ground. Black soil, 8; blue clay, 31; sand, 3.
John Wood	NE. ¼ NE. ¼ sec. 30.	151	63		Limestone		High ground.
	SE. ¼ sec. 2	194	32			162	Bluff. Water in porous rock.
	NW. ¼ NW. ¼ sec. 32.	281	20			251	Upland.
Amanda Littell	NW. ¼ sec. 25	228		200	Gravel	20	Valley.
Charles Long	Sec. 31	270	Slight		Niagaran dolomite.		Maquoketa shale at 240 feet.
Schoolhouse	Baldwin	126	60		do		Hill.
Baldwin	Near railway Station,	96	90			26	Bear creek bottoms.
Wright	Nashville	53			Gravel		All sand and gravel.
	Millrock	102	10				Rise above creek bottoms.
	SW. ¼ sec. 28	73	50				Creek bottoms, 60 rods from creek.
Will Campbell	SW. ¼ NW. ¼ sec. 12.	71	50			41	Hollow; mostly yellow clay to rock.
W. T. Clapp	NE. ¼ NE. ¼ sec. 28.	96	90				Soil, 10; black quicksand, 80.
Graywich	NE. ¼ SW. ¼ sec. 28.	60	3				Creek.
T. 85 N., R. 1 E. (Brandon).							
William Miller	SE. ¼ SW. ¼ sec. 31.	69	61				Valley. Black soil, 10; fine white sand, 51.
T. 86 N., R. 1 E. (Butler).							
	NE. ¼ NE. ¼ sec. 32.	244	53		Porous limestone.	211	Bluff. Gravelly red clay (till), 53; limestone, 191.
D. Duggan	Sec. 26	217	22				Loess, 2; till, 10; gravel 10 to rock.

Typical wells in Jackson County—Continued.

Owner	Location	Depth	Depth to rock	Depth to waterbed	Source of supply	Head below curb	Remarks: (Log given in feet)
		Feet	Feet	Feet		Feet	
T. 84 N., R. 2 E. (South Fork).							
H. B. Griffen	SE. ¼ SW. ¼ sec. 30.	124	40	120	Niagaran dolomite.	78	High hill.
W. G. Marster	S. ½ NW. ¼ sec. 13.	135					East side of deep ravine; rock at surface.
D. Stevens	NE. ¼ NE. ¼ sec. 31.	76	6				Ridge.
Heming	Maquoketa, west side.	135	50				Sand and sandy clay, 50 feet; limestone, 85 feet.
	SW. ¼ SE. ¼ sec. 32.	240			Gravel		Drift, mostly blue till, 200; quicksand, 40; ends in gravel.
	SW. ¼ SW. ¼ sec. 32.	206			do		Ends in gravel.
Walker	SW. ¼ SW. ¼ sec. 29.	240			do		Bottom. Blue clay and quicksand; ends in gravel.
Richard Elwood	SE. ¼ NE. ¼ sec. 33.	120			do		Ends in gravel.
W. P. Dunlap	SE. ¼ SE. ¼ sec. 35.	90			do		Blue till, 82; gravel, 7; blue till, 1.
Chapman	SE. ¼ SE. ¼ sec. 35.	85	40				Level land.
	NE. ¼ SE. ¼ sec. 36.	82	37				
Wilson	Sec. 11	138	80				
T. 84 N., R. 5 E. (Van Buren).							
Knack	SW. ¼ NW. ¼ sec. 25.	100	10		On shale		
Peter Kuhl	NE. ¼ NE. ¼ sec. 12.	190	40				Drift, 40; Niagaran dolomite, 85; Niagaran dolomite, gray cherty, 60; Maquoketa shale 5.
Prussia	S. ½ NW. ¼ sec. 14.	225	30			125	Drift, 30 feet; Niagaran dolomite, 195 feet.
H. Gosh	SW. ¼ SW. ¼ sec. 4.	175	20		Limestone		Maquoketa shale not struck.
Klemm	NE. ¼ SW. ¼ sec. 35.	175	40				Maquoketa shale at 170 feet.
Roe	NE. ¼ SE. ¼ sec. 16.	170	40		On shale		Maquoketa shale at 170 feet.
	SW. ¼ SE. ¼ sec. 15.	125	40				Stony blue clay, 40; Niagaran dolomite, 85. On rise rom bottoms.
	NW. ¼ SW. ¼ sec. 16.	202	40		Limestone		Yellow clay, 20; blue clay, 20; limestone, 162.
E. A. Clausen	Sec. 2	230	36				Drift, 36; Niagaran dolomite to shale at bottom, 194.

Typical wells in Jackson County—Concluded.

Owner	Location	Depth	Depth to rock	Depth to waterbed	Source of supply	Head below curb	Remarks: (Log given in feet)
		Feet	Feet	Feet		Feet	
T. 85 N., R. 5 E. (Part of Washington).							
Henry Schultz	NE. ¼ SW. ¼ sec. 25.	225			Gravel		Mostly gritty blue clay; ends in gravel.
	SE. ¼ SW. ¼ sec. 32.	90			do	60	Goose Lake Channel. Black soil, 10; hard, gritty blue clay, 30; quicksand, 40; gravel, 10. Old forest bed at 30.
	Green Island	200			do		Bottoms. Soft blue clay, 50; dirty yellow clay, 20; gritty blue clay, passing into gravel, 130.
T. 84 N., R. 6 E. (Iowa).							
	NE. ¼ NE. ¼ sec. 34.	500-600			Galena dolomite.		High ridge; 150 feet to Maquoketa shale.
	NE. ¼ SW. ¼ sec. 32.	125	30		Limestone		
	SW. ¼ SW. ¼ sec. 19.	190	20		do		
	NE. ¼ SW. ¼ sec. 24.	344	40	320	Galena limestone.		About 820 feet above sea level. Drift, 40; Niagaran dolomite, 154; Maquoketa shale, 120; Galena dolomite, 30.
L. P. Hunderad	Sec. 35	450	40				
Crawford	SE. ¼ SE. ¼ sec. 23.	673	40				Yellow clay, 20; blue clay, 20; limestone, 110; shale, 222; Galena dolomite, 301.
T. 84 N., R. 4 E. (Fairfield).							
	NE. ¼ NE. ¼ sec. 26	80			Gravel		On rise from creek. Yellow clay, 25; hardpan, 50; gravel, 5.
T. 85 N., R. 2 E. (Farmers Creek).							
J. W. Sagers	SW. ¼ sec. 20	236	60	200		146	
Emory Dutton	Sec. 20	136	12	114	Limestone.	14	
Walter Dutton	Sec. 30	240	90	150	do	130	
Walter Hutt	Sec. 21	180	26	150	do	150	
John S. Burrows	Sec. 20	[illegible]	36	168	do	68	
George Willison	Sec. 18	186	28	150	do	150	
Robert Wood	Sec. 35	217	40			102	
Schoolhouse	Sec. 31	223	100				Much quicksand.
T. 86 N., R. 4 E. (Part of Bellevue).							
H. Steich	Sec. 1	106	96		Limestone		A large amount of sand and gravel beneath loess.
Golden	West of city limits of Bellevue	100	50		Limestone, Galena.		Terrace in Mill creek valley.
T. 87 N., R. 4 E. (Tete de Mort).							
H. Soppe	Sec. 36	54			Gravel		Loess-capped terrace 90 feet above Mississippi.

JOHNSON COUNTY

BY A. O. THOMAS.

TOPOGRAPHY.

The surface of Johnson county is chiefly of the prairie type. Along the principal streams are belts of rather heavy native timber, much of which is being rapidly cut away.

Because of the location of the territorial capital at Iowa City, Johnson county was one of the earliest west of those bordering Mississippi river to be settled. Its pioneers found an abundant supply of water in the main streams and their tributaries and in shallow open wells, but as population increased more reliable sources of supply, free from contamination and from possible exhaustion during times of drought, had to be sought. Now drilled wells pumped by windmills or gasoline engines are a part of the equipment of each up-to-date farm.

Far more than half of the county is covered by Kansan drift, which is extensively overlain by loess, although in some areas along Old Mans creek, the loess is so thin that the preloessial topography may still be recognized. Except for the broad alluvial flood plain of Iowa river, which intersects it in a north and south direction, the southern half of the county is characteristically Kansan. The ridges and divides are much dissected, as a rule narrow, and in many places loess-covered.

Several lobes of the Iowan drift sheet cross the northern part of the county. These lobes are characterized by bowlder-strewn fields and rich black loam which covers in a general way the entire surface of the drift. The freshness of the light-colored bowlders, the incomplete drainage, and the comparatively level surface, free from loess, present a marked contrast to the rougher and much-eroded Kansan drift. One lobe of Iowan drift crosses the eastern part of the northern boundary of the county and trends southeastwardly to Solon. Its level plains are well developed just north of that town. A second and larger lobe comes down to and a little beyond the village of North Liberty, covers Monroe and parts of Jefferson, Oxford, Madison and Penn townships. It is crossed in an east-west direction by Iowa river whose broad flood plain blends into the drift plain on the south. The limits of these lobes are not yet definitely determined along their entire length. Their terminal moraines, though high and prominent in many places, are in others very indefinite, due to some extent to post-Iowan erosion.

A broad alluvial plain has been developed along Iowa river from the point where it enters the county to section 22, Madison township, where it flows into a narrow, rock-walled, tortuous channel from which it emerges near Iowa City after winding about for more than twenty miles. Here it again enters a broad valley with extensive flood plains, which continue until it has passed out of the county. A flood plain about two miles wide and six to eight miles long extends along Cedar river in Cedar township.

The larger tributaries of Iowa river, like Old Mans, Clear, and Rapid creeks, have developed alluvial flood plains of some extent, especially in that part of their valleys nearest the Iowa. That of Old Mans creek is the most extensive, being eighteen to twenty miles long and from half a mile to a mile or more in width.

Study of the course of Iowa river through the county shows that a preglacial channel must have existed between the east end of its northern flood plain and the north end of its southern flood plain, for the present course between these two points is neither the most direct nor the most easily constructed.[1] Well records are, however, too meager to afford data from which to project the valley of this ancient stream. It is certain that the buried channel affects the water supply of the area under which it lies, and it is to be hoped that future borings will clearly establish its approximate limits.

[1] Calvin, Samuel, Ann. Report, Iowa Geol. Survey, vol. 7, p. 48.

GEOLOGY.

Indurated rocks are exposed only in the northern and northeastern parts of Johnson county. The rocks dip to the southwest (Pl. XV), a fact of special interest to the well driller, for he must drill through a greater thickness of rock in the southwestern part of the county than in the northeastern part when seeking one of the deep-seated aquifers like the Saint Peter sandstone. The character and kind of rocks which underlie the drift in the southern part of the county are indicated by such rock exposures as those along English river in the northern part of Washington county.

Silurian rocks (Niagaran dolomite) are typically exposed along Cedar river in the northeastern part of the county. Southwesterly from this Silurian outcrop the lower beds of the Middle Devonian appear at Solon and elsewhere.

Rocks of Carboniferous age are exposed in only a few small outliers belonging to the Des Moines stage (Pennsylvanian). The largest of these outliers is a body of coarse-grained sandstone in the southern part of Monroe township just north of Iowa river and extending westward into Iowa county. Another is located immediately north of Iowa City and occupies an old deep pre-Carboniferous valley whose course runs at a wide angle to that of the present Iowa river valley and whose bottom is sixty feet or more below the bottom of the latter.

The drift of the southern part of the county is probably underlain by the Kinderhook stage (Mississippian) of the Carboniferous. No record of well borings encountering these rocks has been obtained, but they doubtless have been reached by drillers in southern Washington and Sharon townships. Interglacial sands and gravels known as the Aftonian gravel and the Buchanan gravel are widely distributed, the former beneath the Kansan drift and the latter above the Kansan, and form aquifers of considerable importance in the county as a whole.

UNDERGROUND WATER.

SOURCES.

The exceedingly rough preglacial topography of Johnson county precludes expectation of finding extensive well-defined water-bearing formations in the drift deposits, which range in thickness in different parts of the county from an exceedingly attenuated layer to a deposit measuring 300 feet. Nevertheless, the most constant aquifer of the drift is the bed of sand and gravel (Aftonian) that underlies the stiff blue clay beds of the Kansan drift. Most of the deeper wells of the county derive their supply from this stratum, though well drillers frequently report failure to obtain water in it and are obliged to try elsewhere or go deeper. Locally, however, the sand and gravel bed is absent and the drill passes directly from the Kansan clay to the hard rock. In the southern and southwestern townships of the county, in parts of Madison and Jefferson townships, and elsewhere in the areas covered by the Iowan drift sheet, these sands and gravels (Aftonian and Buchanan) yield a fairly abundant supply of good water to wells ranging in depths from 50 to 250 feet. In areas in which the drift is thin and the country rock lies close to the surface, most of the wells penetrate rock to some distance and obtain water either in a rock crevice or in a gritty layer which does not seem to lie at any regular horizon. The expense of sinking wells in these areas is usually greater than in the areas of deep drift and the possibility of failure is greater. The wells along Iowa river west and north of Iowa City are mainly of this type. Another area of this sort is in the vicinity of Solon, where the country rock comes almost to the surface; the town well of Solon, for example, strikes rock at a depth of seven feet.

In the alluvial flood plains of the principal streams, an abundant supply of water is obtained cheaply by shallow dug wells curbed with cheap lumber, or by "sand points" driven into the earth to a depth of fifteen to 25 feet and attached to hand pumps. "Drive wells" are abundant along Iowa river in Liberty and Lucas townships and in the valley of Clear creek in

Clear Creek township.

In the northeast part of Lucas township the wells average 100 feet and obtain water in the gravel above the rock.

Hundreds of shallow wells on the farms of every community, which are being slowly supplanted by deeper drilled wells, draw principally from the ground water below ground-water level, though some of them are filled by the surface run-off, for which they act as catch basins.

CITY AND VILLAGE SUPPLIES.

Coralville.—The water supply of Coralville (population, 151) is taken from shallow wells fifteen to thirty feet deep.

Hills.—The water supply of Hills (population, 195) is all from shallow wells. Many of them are "driven wells" and these obviously furnish a purer supply than that of the shallow open wells.

Iowa City.—In Iowa City (population, 10,091) water for the city mains is pumped from the river to a large standpipe on an eminence in the north part of the city. River water is unfit for drinking unless it is boiled. When the city was visited the water company was installing a filter plant said to be capable of filtering all the water needed.

The homes on the west side of the river obtain satisfactory water from wells sunk into the limestone. Some of the wells are open but most of them are drilled. Many shallow wells, twenty to fifty feet deep, are still in use.

An artesian forecast by Norton is of interest in view of the probability that sooner or later one or more deep wells will be drilled for artesian water for the city or for the State University.

The bedrock here is the Cedar Valley limestone (Middle Devonian). After passing through this formation the drill will enter the Wapsipinicon limestone (also Middle Devonian), which is characterized by brecciated beds, shaly and cherty layers, fine-grained and thin-bedded limestones, and magnesian limestones, which overlie the hard Silurian dolomites (Niagaran). In both the Devonian and Silurian formations water will probably be found in crevices and porous layers. If the head of these waters is higher than that of the main flows to be reached farther down, they may be allowed to enter the drill hole and thus augment that of the deeper flows; but if their head is less they should be cased out to prevent the escape of the deeper water through their channels. The drill will pass from Silurian rocks into a dry Ordovician shale, the Maquoketa, probably more than 200 feet in thickness, which should be cased to prevent caving. The Galena and Platteville limestones, which lie beneath the Maquoketa, contain large stores of water in irregular channels, crevices, or porous beds, but no assurance can be given that the drill will strike one of the waterways. The head of any inflows from these limestones should be tested and their waters analyzed for comparison with those of the main water horizons underneath.

After passing through the basal shale of the Platteville, which will need casing, the drill will enter the Saint Peter sandstone at 1,000 to 1,050 feet below the surface (350 to 400 feet below sea level). A good yield is assured although exact estimates can not be made, as the sandstone varies in thickness and also to some extent in size of grains and porosity. It is not at all probable that the water obtained thus far will be sufficient to meet any large demands. The well should be drilled 500 or 600 feet deeper, or to 1,650 feet below the surface, in order to tap the large stores of water carried by the dolomites and interbedded sandstone of the Prairie du Chien stage, and especially by the subjacent Jordan sandstone (Cambrian). The drill should stop at the heavy glauconiferous shales and marls of the Saint Lawrence formation, the next terrane in descending order.

A flow may be confidently expected and while estimates of head are notoriously uncertain, it may be said that the head may reach fifty feet above the river.

A single well will yield a supply sufficient for such university use as a gymnasium, but for a city supply more wells should be sunk and the installation of an air compressor to increase the yield will be probably found advantageous, as at Waterloo, although the natural pressure of a well at Iowa City may be expected to considerably exceed that of one at Waterloo.

In choosing a location for city or university wells, the possibility of contamination from ground water through leaky or defective casings should be considered, and upvalley sites, other things being equal, should be given preference. Too much care can not be taken to exclude absolutely all soil and subsoil waters.

Lone Tree.—The town of Lone Tree (population, 782) has one of the best public water-supply systems in the county. A drilled well, 130 feet deep, penetrates, beneath deep drift, a gravel bed (possibly Aftonian) from which an abundant supply of pure water is obtained. A gasoline engine furnishes the power for pumping.

North Liberty.—The village of North Liberty (population, 200) has no public water supply. The shallow wells are twelve to thirty feet deep, the rise of water in them depending on the season. The village greatly needs a drilled well, especially because it is located on nearly level, poorly drained land, and the water in its shallow wells is within a few feet of the surface for the greater part of the year.

Oakdale Sanitarium.—Oakdale Sanitarium is an institution maintained by the state for the treatment of incipient cases of consumption. It is located in section 25, Clear Creek township. As a large well-stocked farm is part of the general equipment a considerable supply of water is needed for domestic and other purposes. In the summer of 1909, a three-inch well was sunk to 360 feet, at which depth water was obtained in a layer of "gritty shale," which underlies about 250 feet of limestone. The water rises in this well within 100 feet of the surface and is of excellent quality.

An artesian forecast made by W. H. Norton, in 1906, when the question of good water was a factor in the location of the sanitarium, predicted that the Saint Peter sandstone would be reached at a depth of 300 to 400 feet below sea level and that this formation, with other water-bearing beds higher up, would furnish a supply sufficient for the institution, reckoned at 30,000 gallons a day. To obtain a larger supply it was recommended that the well be sunk into the Jordan sandstone, here probably about 700 feet below sea level.

Oxford.—At Oxford (population, 614) the water supply system is owned by the town. Water is pumped from a shallow well not fifty feet deep and is distributed from a standpipe. Many shallow wells twenty to forty feet deep, are in use over the town.

Solon.—The public at Solon (population, 450) is abundantly supplied with water from a six-inch well, which penetrates the limestone for 140 feet. The glacial mantle above the limestone is only seven feet thick. The water is of good quality.

Shueyville.—The town of Shueyville (population, 100) has no public supply, the people depending mainly on shallow wells. Judging from experience on near-by farms, a well about 150 feet deep would develop an adequate supply.

Swisher.—The water supply of Swisher (population, 40) is obtained from shallow wells fifteen to twenty feet deep.

Tiffin.—The water supply of Tiffin (population, 176) is from shallow wells averaging about thirty feet in depth.

WELL DATA.

The following table gives data of typical wells in Johnson county:

Typical wells of Johnson County.

Owner	Location	Depth	Depth to rock	Source of supply	Remarks: (Log given in feet)
	Sec.	Feet	Feet		
T. 81 N., R. 7 W. (Jefferson; part of Madison).					
F. Novotny	13	74	18	Rock	Yellow sandy clay, 18 feet; very hard rock.
Anna Becicka	13	77	77	Gravel	Hill. Yellow clay, 20; the rest blue clay; gravel bed thin.
J. Louvar	14	210	70	Rock	Yellow clay, 20; blue clay, 50.
M. Herdlicka	27	156	24	Soft rock	High ridge above river; rock hard and bedded except the last 7 or 8 feet.
William Roberts	28	70		Gravel	Gravel bed thin.
T. 81 N., R. 6 W. (Big Grove; part of Penn).					
James A. Ulch	25	282	60	Soft rock	First water at 130, but flow not good.
J. Pesarek	4	158	72	Rock	A log struck at 60; loam, yellow clay, blue clay; thin layer of sand on rock.
T. 81 N., R. 5 W. (Cedar).					
John A. Henick	17	235	No rock	Sand	Yellow sandy clay; blue to 145; yellow sandy clay to 200; sand. Well 35 feet in this sand.
W. Verba	6	160	132	Rock	Reddish clay, 20; blue clay, yellow sandy clay, and red clay; 2 of black soil at 120; brownish clay and yellow clay to rock.

Typical wells of Johnson County—Continued.

Owner	Location	Depth	Depth to rock	Source of supply	Remarks: (Logs given in feet)
	Sec.	Feet	Feet		
T. 80 N., R. 7 W. (Parts of Madison. Clear Creek and Penn.)					
George Hoover	10	262	142	Rock	Loam; blue clay; no sand above rock.
H. Lininger	10	90		Sand	Same as last, but sand bed thick.
M. M. Snavely	7	115		do	Yellow clay; blue clay; water in sand.
J. C. Bowman	15	312	120	Rock	No sand at bottom of mantle rock; compare Hoover's well.
J. D. Colony	19	144		Gravel	Yellow clay; blue clay; gravel bed thin but coarse-grained.
J. J. Craig	27	213	100	Rock	High ridge; no water in drift; the supply comes from a crevice in the rock.
Edw. Craig	27	65		Sand	Usual drift, underlain by sand.
Walter Cox	36	50		do	Drive well; many of this type in neighborhood.
Charles E. Colony	24	100		do	Water just above rock.
T. 80 N., R. 6 W. (Parts of Penn and Newport).					
Martha Bowman	19	288	98	Rock	High knoll; no water in drift; rock hard; water band "gritty."
Samuel Green	18	300	110	do	Very similar to Bowman well.
Do	18	140		Sand	Water at bottom of drift in thin sand.
Jos. Hemphill	31	126		Gravel	
James Hotka	23	108		Sand	Yellow clay; blue clay; gravel.
T. 80 N., R. 5 W. (Graham; part of Newport).					
J. J. Dvorsky	18	62	57	Rock	Yellow clay; blue clay; no gravel; water in "crevice" in rock.
James J. Krall	18	217	50		Water in shaly rock, beneath very hard rock; unsatisfactory water bed at 100.
M. F. Dvorsky	19	110		Gravel	Yellow clay; blue clay; gravel.
T. 79 N., R. 7 W. (Union; part of Clear Creek).					
County Farm	13	172	168	Rock	Yellow clay, about 60; blue clay, over 100; little or no gravel.
Do	13	174	166	do	
Mrs. H. Schnarre	12	170		Sand	Similar to the county farm well.
Evan Williams	11	318	172	Sandy rock	Drift very similar to the preceding, but no gravel; three trials to find water at top of rock failed; water bed is shaly brownish red sandstone or gritty limestone.
R. Williams	11	140		Sand	Sand bed thin; the well became dry in a few months.
Do	11	282	174	Rock	Yellow and blue clays; thin bed of sand; rock well bedded; the drill dropped into a crevice at the bottom and well yields an abundance of water.
John Hradek	10	340	100	Shale	Similar to Evan Williams well, but with shale below the gritty limestone.
Geo. Wicks	10	126		Sand	Yellow and blue clays.
J. R. Breese	17	90		do	This well is located in a hollow.
Chas. Rohret	20	130		do	Yellow clay, about 60; blue clay to 120; the water seems to run in a "vein' in the sand.
John Lloyd	24	100		do	Yellow and blue clays.
E. T. Davis	22	100		do	Yellow clay, about 20; blue clay, over 70.

Typical wells in Johnson County—Continued.

Owner	Location	Depth	Depth to rock	Source of supply	Remarks: (Logs given in feet)
	Sec.	Feet	Feet		
Anna Zingula	24	170	170	Gravel	Yellow and blue clays; water on top of rock.
H. E. Edwards	19	179		do	On top of rock.
Julius Tudor	25	96		do	On lower ground than the preceding.
H. Rowland	30		240		No water; driller gave it up.
S. E. Pate	31	400	260	Shale	Yellow clay, 30 to 40; blue clay, 200; sand; tough clay to the rock, which is quite hard down to the limy shale.
Lumley Tudor	36	90		Sand	
Mrs. H. Rowland	30	106		do	Water bed loose sand, into which the drill sank for some distance by own weight.
D. W. Jones	30	205		do	Yellow and blue clays.
T. 79 N., R. 6 W. (Lucas, part of Union).					
Black Estate	9	135	2	Shaly rock	Rock hard and well bedded.
Wm. Cannon	16	148	40	Rock	Yellow clay, 40; a little gravel; "bird's-eye" limestone, 40; blue limestone, over 60; water in a crevice.
Mark H. Clear	7	200	200	On rock	Yellow clay, 40; blue clay, over 150; no gravel.
Edw. Rohret	16	64	64	Gravel	Yellow clay, 20; blue clay, 35; coarse gravel to rock.
O. Byington	9	190	40	Shale (?)	Residual material, mostly loess with some gravel below; water in "honey-combed" shale.
J. Cropley	17	126	126	On rock	Yellow and blue clays; no gravel; water bed on the rather friable rock.
A. R. Payne	16	116	116	Gravel	Clays as in the last, but the gravel is 10 to 15 feet thick.
Mrs. W. Black	16	200	50	Rock	Compare with Byington well.
Edw. Rohret	8	140		Gravel	Yellow clay, 30; blue clay, about 100; fine sand; coarser sand.
Mack Stevens	18	150	150	Sand	Yellow clay; blue clay; gravel.
J. K. Hemphill	6	108	108	Gravel	Yellow clay; blue clay; water on top of rock in gravel.
Mary A. Lindsey	16	140		Sand	
J. R. Breese	17	116		do	
H. Garnett	16	124		do	On top of rock.
Geo. Lewis	20	139	139	do	All on same ridge, not over three-fourths of a mile apart.
T. H. Morford	20	120	120	do	
W. J. Davis	20	120	120	do	
Owen Davis	20	108	108	do	
R .P. Jones	20	120	120	do	
Byron Dalton	20	40		Sand (?)	"Drive well" along a creek.
Rich. P. Jones	29	207		Sand	Yellow clay, 20 to 30; blue clay, over 150; thick sand.
Elias J. Hughes	33	140		Gravel	
S. C. Jones	32	286	246	Rock	No water in gravel above rock; water bed rather shaly.
Robt. E. Jones	32	306	256	do	Similar to last.
Jas. McCollester	22	40			Dug well; near river.
Chas. A. Vogt	26	30		Sand	"Drive well."
Alfred Ohl	23	200	50	Soft shale	Not enough water on top of rock.
Lovell Swisher	13	186	100	Rock	Yellow clay; blue clay; thin gravel.
Nellie Swisher	13	62	62	Sand	Plenty of water.
Jno. C. Shrader	12	64			Low part of the farm.
Do	12	140	60	Rock	Hill.
Main's factory	East Iowa City	62	57	do	4-inch well; abundant water; yellow clay, 20; blue clay, 37.
W. F. Main	do	162	60	do	Water in a shaly rock.

Typical Wells in Johnson County—Concluded

Owner	Location	Depth	Depth to rock	Source of supply	Remarks: (Logs given in feet)
	Sec.	Feet	Feet		
Elmer Buck	19	162		Sand	
D. H. Hastings	30	200		do	On top of rock.
Sarah Hastings	25	220		do	Do.
T. 79 N., R. 5 W. (Scott).					
Frank Lord	20	220	200	Rock	
E. Westcott	18	180	175	do	Water in friable rock.
R. Hunter	16	196	190	On rock	Water in top layer of rock.
Edw. Greer	34	260	240	Soft rock	No sand above rock.
Benj. Price	21	260	216	Rock	Soil and yellow clay, 36; blue clay, 180; no sand; limestone, 16; yellowish clay, 8; hard rock, 20, to water.
Geo. Bothel	34	232	232	Sand	Yellow and blue clays; the water in sand.
Jos. Krellek	35	104		do	"Quicksand " below blue clay.
Chicago, Rock Island & Pacific Ry.	4	116	116	Gravel	4-inch well; plenty of water.
J. T. Strubble	7	224	100	Rock	Yellow and blue clays.
Lemuel Hunter	6	220	200	do	
T. 78 N., R. 8 W. (Washington).					
J. P. Wagner	15	135		Sand	Yellow clay and loam, 45; blue clay, 90.
Jno. Fry	10	140		do	Very similar to the last.
C. Swartzendruber	16	140		do	Do.
T. 78 N., R. 7 W. (Sharon).					
Jno. Hughes	2	120		Sand	Hill. Yellow clay, 20 to 30; blue clay, about 90.
P. Zahner, sr.	2	84		do	Foot of Hughes Hill. Soil and yellow clay, 15; blue clay, about 60.
R. R. Hughes	1	127		do	Below blue clay.
W. J. Davis	12	125		do	Yellow and blue clays, then sand.
T. 78 N., R. 6 W. (Liberty: part of Pleasant Valley).					
John Knebel	32	120		Sand	Yellow clay and soil, 30; blue clay, 85; sand, fine-grained. Mr. Knebel reports that there are no wells down to rock in the township and that the general depth is about the same as his own. Along Old Mans creek and on Iowa river bottom drive wells are about 20 feet deep.
T. 77 N., R. 5 W. (Fremont).					
Town well, Lone Tree	10	130		Sand	Soil and yellow clay, about 30; blue clay, about 95; sand, about 5 to 8, with pieces of wood and bark at top. The driller penetrated a bluish tough clay below the sand to some distance, but withdrew the drill and made the sand the water bed.

JONES COUNTY.

BY W. H. NORTON.

TOPOGRAPHY.

Alternating belts of upland and lowland, of loess-covered Kansan ridges and Iowan drift plains, give to the surface of Jones county a peculiar "fluted" topography. The trend of these singular belts and of the rivers which cross them is northwest-southeast and the streams flow with seeming indifference either through wide post-mature valleys adjoining the plains or, leaving the lower lands cleave the ridges lengthwise with deep gorges.

Thus, on the right bank of the Maquoketa, a bold ridge, loess-covered and fringed with lenticular loess-capped hills of drift, called paha, extends as far southeast as Monticello and its trend is continued by a lower ridge of similar character near Scotch Grove. These ridges overlook to the southwest a belt of prairie four or five miles wide, diversified in places with low, long swells of drift trending northward. Southwest of this prairie plain of Iowan drift, on which are located the towns of Onslow, Center Junction and Langworthy, rises another upland. Northwest of Langworthy it is narrow, and its pahoid, forest-covered crests rise 100 feet and more above the level of the adjacent lowlands. From Amber southeast to the county line it is more massive, attaining a height of 140 feet above the neighboring valleys. A narrow belt of lowland parts this ridge from a massive upland cut by Wapsipinicon river to a depth of 220 feet, beyond which to the southwest lie other narrow belts of upland separated from one another by long enchained pahoid hills.

GEOLOGY.

The geologic structure of Jones county is of the simplest. The drift sheets of the county are the Iowan and the deeply buried Nebraskan and Kansan. The two last named are for the most part hard, blue, stony clays called "hardpan" by many of the drillers. The Kansan, however, may be reddened and loosened in texture by long weathering to a depth of from ten to twenty feet from the surface. The Iowan lies on the surface of the lowlands—a brown sandy and gravelly drift with bowlders or a pale yellow stony clay. On the hills and ridges the yellow dust or silt deposit known as loess has accumulated to a depth in places of forty feet, although thin or entirely absent on the adjacent prairies. Throughout, the rock lying beneath the drift is the Niagaran dolomite (Pl. IX), except probably over a few square miles in the extreme southwestern part, where the heavy drift may conceal Devonian limestones.

UNDERGROUND WATER.

SOURCES.

The diversified surface, in which well-dissected uplands where ground water stands far below the crests alternate with low young prairie plains only slightly scored by drainage channels where ground water stands high, makes it exceedingly difficult to give any averages as to the depth to water supplies, even in areas so small as townships.

The most important water-bearing formation is the Niagaran dolomite. The water occurs in porous beds and in waterways opened by solution along joints and bedding planes, but not in any definite stratum whose depth at any point can be predicted. Water is found also in drift sands and gravels, both in those contained within the drift sheets and in those which separate them.

WATER PROVINCES.

Province northeast of Maquoketa River.—In Highland, Washington and the northeastern part of Monticello townships the Niagaran dolomite lies everywhere at no great distance below the surface and outcrops in numerous ledges on the hillsides and in discontinuous high rock walls along the deeper valleys. North and South forks of Maquoketa river below Monticello flow through narrow winding valleys destitute of flood plains. In these valleys wells find rock a few feet from the surface, but must penetrate it deeply to obtain sufficient water.

On the uplands the deep and intricate dissection of most of the area allows ground water to sink. Few wells find it within less than 100 feet, and many are compelled to go more than 200 feet. In a few places the Niagaran is found dry nearly to its base, and wells supplied from the water accumulating immediately above the impervious Maquoketa shale must be drilled a little way into the Maquoketa for reservoir. For example, the well of T. Cooper (section 20, T. 86 N., R. 2 W.) found clay to twenty feet, Niagaran dolomite to 385 feet, and was carried sixteen feet into the Maquoketa shale—a total of 421 feet.

Even on the high drift prairie of the northwest part of this area wells do not find enough water in the drift, which here ranges from ten to sixty-five feet in thickness. Where the drift is comparatively thick for this area, reaching about fifty feet, water may be found within the limestone fifteen or twenty feet below the rock surface. Where the drift is thin, and locally where it has some thickness, wells range in depth from 150 to 250 feet. Few wells of this province are less than 140 feet deep. Thus, the well of R. M. Hicks (sec. 2, T. 86 N., R. 2 W.) is 180 feet deep, rock being struck at five feet, and the well of J. F. Moore (sec. 5, T. 86 N., R. 2 W.) goes through forty feet of drift and penetrates 240 feet into the Niagaran dolomite to obtain sufficient water.

Province between Maquoketa and Wapsipinicon rivers.—The larger part of the belt of country twelve to fourteen miles wide, extending from northwest to southeast across the county between Maquoketa and Wapsipinicon rivers, is a prairie of Iowan drift, but it is traversed longitudinally and is bounded on the east side by massive ridges of Kansan drift capped with loess.

To the northeast, along a zone bordering the Maquoketa, the Niagaran dolomite stands high and is covered with a thin mantle of drift. In the northern part of Castle Grove township, as at Argand, it outcrops as high as 920 feet above sea level. In southwestern Monticello township the loess and drift of the ridges may exceed forty or fifty feet in thickness, but the rock outcrops about their bases or is found at slight depth below the surface. Southeast of Monticello the limestone also stands high, outcropping well up to the summits of the hills overlooking the Maquoketa, its height above sea level at Scotch Grove being about 900 feet. Here water is not found in the drift nor on the rock. Wells must be sunk a considerable distance in the Niagaran dolomite to find sufficient supply. Locally plenty of water is obtained within fifty feet of the surface, as at the Scotch Grove creamery well, but most wells are 100 feet or more in depth. Even on the wide river valley northwest of Monticello, where rock comes within fifteen to twenty feet of the surface, wells are about 100 feet deep, and on the adjacent hills some of them exceed 200 feet. On the high bluffs overlooking the Maquoketa, southeast of Monticello, it may be necessary to go 200 and even 300 feet to find water in the limestone.

An exceptional feature of the belt of country bordering the Maquoketa on the southwest is a buried river channel disclosed by wells in the lower valley of Kitty creek and on the Maquoketa flood plain above Monticello. Thus, in section 27, Monticello township, a well on the Kitty creek bottoms found rock seventy feet from the surface, 720 feet above sea level. The city well at Monticello on the same bottoms, enters rock at 135 feet, 665 feet above the sea, and a well in section 16 of the same township on the Maquoketa flood plain is reported as 119 feet deep, with twenty feet of alluvium at top, below which the well penetrated only sand. The rock floor at the last well must be less than 680 feet above sea level. The buried river channel thus disclosed was cut about 125 feet below the present channel of the Maquoketa. That the ancient valley does not coincide with the broad valley of the river above Monticello is seen in the numerous wells on both sides of the river which enter rock at ten to twenty feet below the surface.

From the upland along the right bank of the Maquoketa, where the Niagaran dolomite reaches an elevation of about 900 feet above sea level and where the drift is relatively thin, the rock everywhere descends to the southwest to a wide rock-cut valley now deeply filled with drift, on whose farther side the rock again ascends and again approaches the surface along a belt of country stretching along the left bank of the Wapsipinicon. The distance to which wells must be drilled to reach rock varies not only with the depth of this ancient valley and the positions of its numerous branch valleys with their divides of rock buried beneath drift, but also with the height to which the drift has been heaped over the area—whether it has been smoothed to the broad, flat plain which stretches from Castle Grove to Langworthy and Onslow or has been piled in the massive ridges which overlook this prairie from the south. The greatest depth to rock naturally occurs where the ridges directly overlie the central trough of the buried valley. In Castle Grove township (section 8) the drift is in one place 190 feet thick, the rock floor being 810 feet above sea level. In section 33 the drift is more than 200 feet thick, the rock floor not being reached at 800 feet above sea level. On the ridges from northwest of Amber to Onslow a number of wells are reported which approach and exceed 300 feet in depth, and a few successful wells are reported as less than 200 feet deep. On the bluffs near the Wapsipinicon, where rock stands high, few wells exceed 150 feet and a number of successful ridge wells from 80 to 120 feet deep are on record.

South of Newport the Wapsipinicon is bordered by flood plains one and one-half miles wide, and here driven wells are entirely adequate.

Province south of Wapsipinicon River.—On the high ridges southwest of the Wapsipinicon the depth of the wells reported ranges from 50 to 150 feet. On the prairie occupying the extreme southwestern part of the county about Morley and Martelle wells find water in the drift, and in few places exceed 130 feet, so far as reported. South of Fairview a number of successful wells are but forty or fifty feet in depth.

SPRINGS.

Springs supplied by underground courses dissolved in the Niagaran dolomite emerge in the deep gorges of the Maquoketa and the North Maquoketa. That of J. Kibury, in the NW. 1/4 NW. 1/4 sec. 30, T. 86 N., R. 2 W., feeds a small creek discharging into Maquoketa river.

To a somewhat less extent springs are found along the course of the Wapsipinicon where it leads through narrows cut in the Niagaran dolomite.

CITY AND VILLAGE SUPPLIES.

Anamosa.—The public supply of Anamosa (population, 2,983) is derived from a city well drilled by J. P. Miller & Company of Chicago in 1898. The well is situated a few yards from the bank of Wapsipinicon river, is 1,754½ feet deep and ten to six inches in diameter. It is packed with lead and rubber and carries 100 feet of casing. The head of the water is thirty feet below curb. The water comes from depths of 600, 950 and 1,200 feet. The original and present pumping capacity is 300 gallons a minute. Temperature, 52° F. Water is pumped to a reservoir and the pressures, gravity and direct, are 60 and 120 pounds, respectively. There are three miles of mains and thirteen hydrants.

The only cuttings preserved from this well come from the Saint Lawrence formation and underlying Cambrian strata. The following table presents the record:

Record of strata of city well at Anamosa.

	Depth in feet
Dolomite, gray, arenaceous; as seen by grains imbedded in dolomite chips	1,335 and 1,345
Dolomite, light yellow-gray	1,370
Marl, light pink; powder contains large residue of minute angular quartzose particles; cement dolomitic, glauconiferous	1,375
Marl, bright pink, as above	1,385
Marl, blue, dolomitic, quartzose, glauconiferous	1,435
Shale, white, calcareous, siliceous, in powder	1,440
Sandstone, green-gray, grains minute, rounded, slightly calcareous, argillaceous, glauconiferous	1,525
Sandstone, white, rounded grains; largest, 0.6 mm. in diameter	1,530
Sandstone, gray, fine	1,660
Sandstone, white, very fine	1,670
Sandstone, buff, of finest grain, glauconiferous	1,690
Sandstone, pink, of finest grain, in loosely coherent chips	1,720
Shale, green	1,735
Shale, bright green, calcareous, glauconiferous, highly siliceous; with minute quartz particles	1,750

The water supply problems of Anamosa seem to have been successfully solved by the excellent and abundant supply of water from the city well. Domestic supplies are still drawn, however, from many house wells, which on the hills are not uncommonly 100 to 160 feet in depth. The drift, which is forty feet thick, is dry, and water must be sought in limestone.

In the remote contingency that the present supply from the deep well may be overdrawn by increasing population, tests might well be made of the amount of ground water available on the low ground west of the town near the mouth of Buffalo creek, where the convergence of drainage lines points to some considerable store. Several wells of small diameter sunk about 320 feet to the horizon of the Maquoketa shale would probably yield a large supply.

The State Penitentiary well has a depth of 2,007 feet and a diameter of 10 inches (cased) to 96 feet, 8 inches (uncased) to 290 feet, 6 inches (cased) to 987 feet, 5 inches to 2,007 feet. The curb is 816 feet above sea level. The original head was 760 feet above sea level; the present head is 768 feet. The original and present pumping capacity is more than 300 gallons a minute, and the amount pumped daily in summer is 135,000 gallons. When pumped at rate of 200 gallons a minute water is lowered nineteen feet in half an hour. The water comes from 860 feet and from between 1,070 and 1,215 feet. The well was completed in 1896 by J. P. Miller & Company of Chicago at a cost of $11,000. Temperature, 53.5° F.

The well yields excellent drinking water. Since its completion no cases of typhoid fever have occurred in the penitentiary, although from 1875 to 1891, sixty-four were reported by the prison physician. The water forms much scale in boilers but is not otherwise deleterious.

Record of strata of penitentiary well (Pl. IX).

	Thickness	Depth
	Feet	Feet
Pleistocene (78 feet thick; top, 816 feet above sea level):		
Clay, yellow	30	30
Clay and sand	46	76
Quicksand	2	78
Silurian:		
Niagaran dolomite (282 feet thick; top, 738 feet above sea level)—		
Dolomite, light bluish gray, crystalline, vesicular; 5 samples, at 145 feet dark brown-gray and more compact	137	215
Dolomite, as above, cherty	20	235
Dolomite, light gray, crystalline; 2 samples	30	265
Dolomite, cream colored and buff, cherty; 4 samples	60	325
Dolomite, gray, in flaky chips, argillaceous, lustre earthy, with some chert; 2 samples	30	355
Dolomite, blue-gray, highly argillaceous	5	360
Ordovician:		
Maquoketa shale (175 feet thick; top, 456 feet above sea level)—		
Shale, green-gray, slightly calcareous; 4 samples	130	490
Dolomite, brown, somewhat bituminous, blackens in closed tube	10	500
Shale in molded masses; 2 samples	35	535
Galena dolomite and Platteville limestone (325 feet thick; top, 281 feet above sea level)—		
Dolomite, buff and gray, hard, rough, crystalline; 10 samples, at 675 feet, cherty	205	740
Limestone, magnesian, blue-gray, granular, crystalline; 2 samples	30	770
Shale, blue and dark brown, bituminous	30	800
Limestone, magnesian, or dolomite, buff-gray, fine-grained, crystalline; samples at 800 and 820 feet; in the latter sample are found fragments of magnesian limestone which may extend from that depth to 852 feet	52	852
Shale, no sample	8	860
Saint Peter sandstone (55 feet thick; top, 44 feet below sea level)—		
Sandstone; clean, white quartz sand; grains well rounded, moderately fine	55	915
Prairie du Chien stage (335 feet thick; top, 99 feet below sea level)—		
Shale, green, noncalcareous, finely laminated, containing some rounded grains of quartz	40	955
Dolomite, light yellow-gray	15	970
Shale; in large fragments, noncalcareous, green, finely laminated	20	990
Dolomite, gray and white; 5 samples	260	1,250
Cambrian:		
Jordan sandstone (95 feet thick; top, 434 feet below sea level)—		
Sandstone, light blue-gray, calciferous	55	1,305
Sandstone, clean, white; grains rounded	20	1,325
Sandstone, white, calciferous	20	1,345
Saint Lawrence formation (235 feet thick; top, 529 feet below sea level)—		
Dolomite, yellow-gray, rough	35	1,380
Dolomite, cream-yellow; rounded grains of quartz in drillings; 2 samples	35	1,415
Dolomite, ranging from white to brown	70	1,485
Sandstone, red, argillaceous and calcareous, of microscopic grain, with green grains like glauconite	5	1,490
Shale, light green-gray, slightly calcareous	50	1,540
Dolomite; fragments mottled pink and gray	40	1,580
Dresbach sandstone (180 feet thick; top, 764 feet below sea level)—		
Sandstone, cream-yellow, buff and white, fine-grained; 4 samples; softest sandstone in well by driller's log	180	1,760
Undifferentiated Cambrian strata (247 feet penetrated; top, 944 feet below sea level)—		
Shale, green, fissile	10	1,770
Sandstone, buff; very fine, glauconiferous; 3 samples	45	1,815
Sandstone, brick-red, very fine-grained, argillo-calcareous, glauconiferous	40	1,855
Sandstone, as above, but less calciferous	20	1,875
Sandstone, gray and buff, fine; argillo-calcareous at 1,890; 3 samples	20	1,895
Sandstone, coarser; with green shale	5	1,900
Sandstone, gray; moderately fine grains, angular, hard	50	1,950
Sandstone, white, rounded; unbroken grains, soft	45	1,995
Sandstone, light pink, sample of rounded grains mostly unbroken, hard, 2½ hours to drill 5 feet; sample not a quartzite	12	2,007

Center Junction.—The domestic supply of Center Junction (population, 199) is drawn from deep wells, which range from 116 to 140 feet in depth and find water in the Niagaran dolomite six or eight feet below the rock surface. Here, as at Onslow, a sand mixed with small gravel and reaching a thickness of fifty or sixty feet occurs beneath glacial stony clays, but, on account of difficulties in screening, wells are drilled through it into rock and are cased to a few feet below the rock surface.

Langworthy.—At Langworthy (population, 100) shallow wells in sand and gravel are about fifteen feet deep; drilled wells range from 50 to 200 feet. Langworthy is on low ground on the Iowan drift plain and ground water stands near the surface, heading two to ten feet below the curb in most wells, and in one or two overflowing.

Monticello.—The city supply of Monticello (population, 2,043) was originally from an artesian well drilled in 1875, which had a depth of 1,198 feet and a diameter of eight to five inches. The curb was 820 feet above sea level and the head forty feet below the curb. The tested capacity, original, was 200 gallons a minute; about 1898, with a pump cylinder set forty-five feet below the curb, it was twenty-five gallons a minute; and with air compressor working 200 feet below the curb it was 125 gallons a minute. The well was abandoned in 1900. The strata penetrated are shown in the following table:

Record of strata in Monticello well.

	Depth in feet
Pleistocene (85 feet thick; top 820 feet above sea level):	
Drift	60
Silurian:	
Niagaran dolomite (180 feet thick; top, 735 feet above sea level—	
Dolomite, light buff	85
Dolomite, lighter in color than above, porous, sub-crystalline; some chert	100
Dolomite, gray; with chert	200
Dolomite, buff, hard, porous	235
Ordovician:	
Maquoketa shale (195 feet thick; top 555 feet above sea level)—	
Shale, greenish, calcareous at 263 and 380	380
Shale, dark brown, strongly bituminous, pyritiferous, slightly calcareous	420
Shale, light greenish gray, magnesian	460
Galena dolomite and Platteville limestone (315 feet thick; top, 360 feet above sea level)—	
No sample	460-550
Dolomite, gray and buff; much shale powder and foreign coarse quartz sand	550
Dolomite and limestone, soft, white	615
Limestone, blue-gray, nonmagnesian; in flaky chips; fossiliferous, rather soft	645
Saint Peter sandstone (25 feet thick; top, 45 feet above sea level)—	
Sandstone, white, grains rounded, fine	775
Prairie du Chien stage (340 feet thick; top, 20 feet above sea level)—	
Dolomite, cream colored; some quartz sand, probably from above	800
Dolomite; as above, but darker	820
Dolomite, light gray	920
Dolomite, light yellow	975
Sandstone, calciferous, or dolomite, highly arenaceous	1,025
Dolomite, hard, siliceous, reddish buff	1,025
Sandstone, argillaceous; drillings largely coarse quartz sand, imperfectly rounded	1,040
Dolomite, gray	1,085
Cambrian:	
Jordan sandstone (58 feet penetrated; top 320 feet below sea level)	1,140-1,198

In 1893 the supply was found insufficient for the needs of the town and a well 120 feet deep was drilled a short distance away and connected with pumps. In 1895, 250 gallons (?) per minute could be pumped from the dual supply without lowering the water. A few years later the diminishing yield was increased by the use of an air lift which discharged from the deep well 125 gallons per minute from a depth of 200 feet, but this increase proved to be but temporary. The loss of capacity was thought to be largely due to defective casing, but on attempting to recase the well it was found that the bore hole was "crooked" and a four-inch pipe could not be driven below 400 feet. As the Maquoketa shale lies at about this depth it is possible that the so-called crookedness was due to creep of the thick body of shale constricting the bore and diminishing its capacity. It is reported that no casing had been placed in the well below 105 feet.

In 1902 the municipality abandoned both wells, which were situated near the Chicago, Milwaukee & St. Paul Railway station, and found an abundant supply in a well sunk in the outskirts of town on the flood plain of Kitty creek near its junction with the Maquoketa. This well, supplying 250 gallons per minute, is eight inches in diameter and 219 feet deep. The water heads but fifteen feet below the curb. The driller's log is as follows:

Log of well at Monticello.

	Thickness	Depth
	Feet	Feet
Soil	4	4
Sand, water bearing	16	20
Clay, blue, hard	105	125
Gravel of white flint with some water	10	135
Limestone (Niagaran), water bearing	84	219

The water is distributed from a reservoir under gravity pressure of sixty-five pounds. For fire protection, direct pressure of eighty pounds is available. The system comprises four and one-half miles of mains, thirty-seven fire hydrants and 536 taps.

The depth of the well, the heavy impervious blue clay, and the casing which extends to rock, give assurance that with due care in keeping the casings intact, thus excluding all water in surface sands, the well will remain entirely safe as a city supply, notwithstanding the low ground on which it is situated and the increasing settlement of the area above it.

The yield from the Niagaran is exceptionally large at other points in town; the capacity of the well of the Chicago, Milwaukee & St. Paul Railway, for example, which is sunk forty feet in the Niagaran, is 100 gallons a minute; but the supply near Kitty creek is especially large because of the broad deep sag in the rock surface which underlies the valley. In this sag the limestone is no doubt saturated with water supplied from the higher rock on either side, and perhaps from a considerable distance to the north and the south.

Olin.—Water at Olin (population, 659) is found in sands of the ancient flood plain of Wapsipinicon river on which the village is built, and in the underlying Niagaran dolomite, which is reached at different depths, in places somewhat more than 100 feet. Water rises within ten or fifteen feet of the surface.

The town is supplied from an eight-inch well 272 feet deep. Water was found in sand at twenty-five feet, and also in the Niagaran, which was entered at 117 feet. Casing shuts out water above that of the limestone. Water stands at thirteen feet from the surface, and the capacity of the well is 100 gallons a minute. On pumping at this rate water lowers nine feet. There is a pneumatic storage tank. The pressure is from forty-five to eighty pounds. There are 6,400 feet of mains and sixteen hydrants.

Onslow.—Onslow (population, 207) is supplied by deep drilled wells, some of which are sunk in the deposits filling an ancient buried valley (p. 519).

House wells find abundant water in the Niagaran just beneath the drift. Rock is found at different depths from the surface, as the Iowan plain on which the town is built here overlies the sloping side of a buried valley. At the south end of the village rock is found at eighty feet; 700 feet north the rock floor has descended to 137 feet and 300 feet north to 206 feet. In some of these wells as much as seventy feet of sand is found beneath heavy glacial stony clays.

Oxford Junction and Oxford Mills.—The level plain adjacent to Wapsipinicon river about Oxford Junction (population, 822), and Oxford Mills (population, 233) is underlain by the Niagaran dolomite, which comes to the surface within the limits of the former town, but is cut with deep ancient channels of the river. Thus in Oxford Mills rock occurs within four feet of the surface at the schoolhouse, and a block away a house well enters rock at eleven feet.

Stone.—The village of Stone (population, 700), situated on the bluffs of Wapsipinicon river, depends on drilled wells for house supply. On the highest elevations wells are 265 feet in depth and water stands 190 feet from the surface.

Wyoming.—The waterworks of Wyoming (population, 733) comprise a well 78 feet deep, a storage basin, and two miles of mains. Water is distributed by gravity and by direct pressure of 55 pounds. There are 15 hydrants. The well is located in the valley of Beaver creek and is sunk 41 feet into the Niagaran dolomite. An eight-inch casing is driven three feet into the rock, but is not packed. The material penetrated above the rock is river sand, deriving its water by percolation from the surface.

It may be necessary in the future to prevent the ingress of water liable to contamination by recasing the well to considerably greater depth and by very thorough packing. Water stands within nine feet of the curb, and is not lowered by pumping 100 gallons a minute.

Many house wells are used throughout the town. On the flat land in the northern part rock is found at about the same depth from the surface as at the city well. On the hills bordering the valley, house wells enter rock after passing through 70 feet of glacial clays and obtain water in the Niagaran at depths of 90 and 100 feet below the surface.

WELL DATA.

Information concerning typical wells in Jones county is presented in the following table:

Typical wells in Jones County.

Owner	Location	Depth	Depth to rock	Source of supply	Remarks: (Logs given in feet)
		Feet	Feet		
T. 86 N., R. 4 W. (Castle Grove).					
P. Kehoe	NW. ¼ NW. ¼ sec. 5	125	40	Limestone	Blue clay to rock.
T. Cashman	NW. ¼ sec. 8	200	190		Do.
A. W. Cramer	SW. ¼ NW. ¼ sec. 14	150	40	Limestone	
Geo. Henderson	Sec. 19	80	70		Ridge.
D. W. Cunningham	NE. ¼ SW. ¼ sec. 21	126	124		
J. Lukken	SW. ¼ SE. ¼ sec. 25	125	115		Fairly level ground.
J. M. King	SE. ¼ SW. ¼ sec. 29	150	74	Limestone	
N. Deischer	NW. ¼ NW. ¼ sec. 29	90	75	do	
C. Pheil	NW. ¼ NW. ¼ sec. 32	125	50		All blue clay.
N. Nichols	NW. ¼ NW. ¼ sec. 33	200		Sand	Blue clay to sand.
A. B. Harms	NW. ¼ SW. ¼ sec. 34	175	160		Mostly blue clay; one 10-foot stratum of of sand.
T. 86 N., R 3 W. (Monticello).					
R. A. Ryerson	SE. ¼ NE. ¼ sec. 1	95	10	Limestone	
R. M. Hicks	NW. ¼ NE. ¼ sec. 2	180	5	do	
J. McNutt	NW. ¼ NW. ¼ sec. 2	85	65		
H. Sandhouse	W. ½ SW. ¼ sec. 5	85	15	Limestone	River bottom.
P. Meyer	NE. ¼ NE. ¼ sec. 6	105	20	do	Do.
J. Joussi	NE. ¼ SW. ¼ sec. 6	220	40	do	Hilly ground back from river.
J. Mangold	SW. ¼ NW. ¼ sec. 8	85	15	do	River bottom.
C. A. Schatz	NE. ¼ NE. ¼ sec. 15	150	10	Limestone	Across road from Rolston well.
J. Voorhees	SE. ¼ NE. ¼ sec. 17	100	20	do	
Mrs. Ferring	SW. ¼ SW. ¼ sec. 16	119		Sand	Dirt, 20; sand, 99. River bottoms.
James Skelly	SW. ¼ SE. ¼ sec. 22	100	10	Limestone	
G. H. George	SE. ¼ SE. ¼ sec. 27	100	70	do	Creek bottoms.
P. Byerly	NW. ¼ NE. ¼ sec. 29	150	50	do	Rock; yellow clay, 50.
T. 86 N., R. 2 W. (Richland).					
J. F. Moore	SW. ¼ SE. ¼ sec. 5	280	40	Limestone	
Diamond Creamery	NW. ¼ NE. ¼ sec. 19	60	12	do	80 gallons per minute
Wm. Farragher	N. ½ SW. ¼ sec. 19	150	40	do	
T. Casper	SE. ¼ SE. ¼ sec. 20	401	20		Clay, 20; limestone, 365; shale, 16.
M. Allen	E. ½ SW. ¼ sec. 20	219	2		Started in a spring.
John Shover	SE. ¼ SE. ¼ sec. 30	100	25		Sand, 25.
T. 85 N., R 4 W. (Cass).					
Mrs. Mayberry	SW. ¼ SE. ¼ sec. 1	185	170		Hill.
Norman Clark	SW. ¼ NE. ¼ sec. 2	280	260		
Colton	SE. ¼ SE. ¼ sec. 3	200	190		Do.
H. C. Thompson	SE. ¼ sec 5	97	60		
P. Osborne	NW. ¼ NW. ¼ sec. 10	100	140		
L. H. Darrow	NW. ¼ NE. ¼ sec. 11	180	180		
A. C. Stickle	SE. ¼ NE. ¼ sec. 15	185	161		Much blue clay in locality.

Typical wells in Jones county.—Continued.

Owner	Location	Depth	Depth to rock	Source of supply	Remarks: (Logs given in feet)
		Feet	Feet		
J. J. Richards	SW. ¼ NW. ¼ sec. 20	54	17		
George Ketcham	SE. ¼ NE. ¼ sec. 22	144	93		
P. Berryman	N. ½ SW. ¼ sec. 25	200	167		Rather low ground.
L. Hartman	SE. ¼ SE. ¼ sec. 28	203	107		
T. Foley	NW. ¼ NE. ¼ sec. 26	257	240		Nearly 100 feet of quicksand on rock.
T. 85 N., R. 3 W. (Wayne).					
R. Batchellor	SE. ¼ NE. ¼ sec. 7	130			Heads 11 feet above curb. Blue clay, 100; sand, 30.
Langworthy Creamery.	Langworthy	120	100		Flowing well; blue clay and sand in alternate strata, 100; rock with water, 20.
H. Himebaugh	SE. ¼ SW. ¼ sec. 10	100		Sand	Yellow clay, 20; sand, 80.
S. Woster	SE. ¼ SW. ¼ sec. 18	180	170		Sand and blue clay to rock.
H. M. Dirks	NW. ¼ SW. ¼ sec. 20	320	300		From 120 to 190 feet sand; a well on same section, 306 feet to rock, has 100 feet of sand.
William Helgens	SW. ¼ NW. ¼ sec. 22	100	80		Blue clay, 50; sand, 30; rock, 20.
A. G. Zimmerman	SW. ¼ SW. ¼ sec. 22	190		Sand	Blue clay, 100; sand, 90.
A. Balster	NE. ¼ SE. ¼ sec. 24	185	184		Blue clay with sand streaks 6 and 8 feet thick, 144; gravel, hard clay, 40; rock, 1.
H. S. Hartman	NE. ¼ SW. ¼ sec. 26	245	200	Limestone	Yellow clay, 20; blue clay, 180; limestone and shale in alternate layers about 5 feet thick, 35; limestone with water, 10.
J. Cunningham	SE. ¼ SE. ¼ sec. 27	300	299	Gravel	Blue clay; sand and gravel: gravel 30 feet thick on rock.
Aug. Toenges	SW. ¼ NE. ¼ sec. 28	209	175		Drill dropped 12 inches in rock cavity.
William Rilken	NE. ¼ SW. ¼ sec. 29	430	415		Ridge. Yellow clay, 50; remainder sand and blue clay to rock.
A. B. Hungerford	NW. ¼ SE. ¼ sec. 30	328	320		Yellow clay, 30; blue clay, 160; quicksand with water, 130; limestone, 8.
G. E. Strawman	SW. ¼ sec. 32	320	310		High ground.
J. Schron	SE. ¼ NE. ¼ sec. 33	245	225		Yellow clay, 50; blue clay and streaks of sand 175.
Amker Creamery	Amker	225		Gravel	Yellow clay, 15; sand, 65; hard blue clay; gravel.

Typical wells in Jones County—Continued.

Owner	Location	Deph	Depth to rock	Source of supply	Remarks: (Logs given in feet)
T. 85 N., R. 2 W. (Scotch Grove).		Feet	Feet		
P. E. Preibilbis	SE. ¼ NW. ¼ sec. 11	50	18	White flint	River bottoms.
A. O. Preibilbis	NE. ¼ NW. ¼ sec. 11(?)	170	9	Limestone	Bluff.
David Sutherland	NW. ¼ NW. ¼ sec. 14	315	34		Do.
	NE. ¼ NE. ¼ sec. 23	280	16		Do.
	NW. ¼ NE. ¼ sec. 25	213	210		Heads 11 feet below curb.
A. G. Haukea	SW. ¼ SW. ¼ sec. 27	120	120		Blue clay to rock. Level ground.
J. Sutherland	SE. ¼ SW. ¼ sec. 28	240	235		Much sand.
P. Kahns	SE. ¼ NW. ¼ sec. 29	110	100		Blue clay to rock.
R. Williamson	SE. ¼ NE. ¼ sec. 31	250	240		Sand and blue clay: sand quicksand above growing coarser toward bottom.
R. Livingston	NW. ¼ NW. ¼ sec. 33	280	260		"Surface," 15; "hardpan," 135; sand, 98; clay, 12; rock, 20.
S. Walworth	SW. ¼ NE. ¼ sec. 36	111	100		Low ground near creek: heads 4 feet above curb. Blue clay, 40; sand and gravel, 45; clay, 15; rock, 11.
G. Overly	2 miles east of Center Junction.	398	391		
Elmer Overly	2 miles east of Center Junction.	311	311		Surface soil, hard pan, sand, old wood, 4; clay rock.
Scotch Grove Creamery.	Scotch Grove	44	10	Soft limestone	
R. Gunn	SW. ¼ SW. ¼ sec. 19	130	123		
W. H. Chatterton	SE. ¼ SW. ¼ sec. 20	226	221		100 feet "hardpan"; 121 feet sand to rock.
T. MacManus	NE. ¼ NE. ¼ sec. 21	205	2		5-foot crevice full of water with strong current.
R. Haynor	NE. ¼ SW. ¼ sec. 23	282	20		
Carstens	NW. ¼ sec. 28	156	150		
—— Oar	SW. ¼ NE. ¼ sec. 29	130	20		
Mrs. MacMasters	SW. ¼ NW. ¼ sec. 32	115	2		
T. 84 N., R. 4 W. (Fairview).					
L. J. Adair	SW. ¼ NE. ¼ sec. 1	165	139		
Wm. Bromley	SE. ¼ NE. ¼ sec. 2	124	123		Mostly sand to rock.
James Shonflin	NW. ¼ NE. ¼ sec. 3	131	80		
Robt. Lister	NW. ¼ NE. ¼ sec. 5	215	83		High ridge, nearly all yellow clay to rock.
M. Wagener	SW. ¼ sec. 9	175	116		Nearly all yellow clay to rock.
A. Alspaugh	SW. ¼ SW. ¼ sec. 15	175	91		
Edward Grimm	NW. ¼ NE. ¼ sec. 16	190	100		
J. Joslin	SW. ¼ NW. ¼ sec. 22	142	70		
J. Meeks	SW. ¼ NW. ¼ sec. 24	134	52		
Allen Stone	NE. ¼ SE. ¼ sec. 25	188	142		
T. Helberg	NE. ¼ NE. ¼ sec. 27	152	128	Limestone	60 to 90 feet clean clay, "river sand."
J. Dumont	SW. ¼ SW. ¼ sec. 29	96	40		
J. Underwood	SW. ¼ NE. ¼ sec. 33	70	51		
Daniel Joslyn	NE. ¼ SE. ¼ sec. 35	100	86		

Typical wells in Jones County—Continued.

Owner	Location	Depth	Depth to rock	Source of supply	Remarks: (Logs given in feet)
		Feet	Feet		
T. 84 N., R. 3 W. (Jackson).					
Frank McNeely	SE. ¼ SE. ¼ sec. 1	300	289		Heads 127 feet below curb, 100 feet quicksand on rock.
P. Cheshire	SW. ¼ SW. ¼ sec. 3	290	200		
W. Johnson	NE. ¼ NW. ¼ sec. 4	260	130		
Melvin Strawman	NW. ¼ NE. ¼ sec. 5	270	262		Yellow clay, 30; stony clay, 110; sand, 100; cemented sand and gravel, 22; rock, 8.
H. Mowery	NW. ¼ SW. ¼ sec. 6	170	144		Blue clay; quicksand, 30; cemented gravel, 4; rock.
J. L. Brown	NE. ¼ NE. ¼ sec. 11	143		Gravel	
Frank Barly, Sr.	Sec. 12	213	205		Top of ridge. Heads 198 feet below curb.
John McNeely	NE. ¼ NE. ¼ sec. 12	238	229		All blue clay to rock.
Creamery	Sec. 13	160	153		Heads 115 feet below curb.
Ben Johnston	NE. ¼ SE. ¼ sec. 19	112	85		
T. 84 N., R. 2 W. (Madison).					
J. F. Brown	NE. ¼ SW. ¼ sec. 6	245	240		Ridge. Heads 125 feet below curb.
Carlston Kettleson	SW. ¼ sec. 7	322		Sand and gravel	Sand at 200 feet; much sand on ridge.
M. O. Felton	SW. ¼ sec. 11	324	320		Much sand.
F. Baily	Center of sec. 13	190		Gravel	Heads 177 feet below curb.
J. V. Smith	NE. ¼ NE. ¼ sec. 13	135	132		"Surface," 15; hard blue clay, 25; sand and gravel, 10; hardpan, 50; sand, 30; clay, 2; rock, 3.
B. C. Bromwell	NE. ¼ NW. ¼ sec. 17	235	230		
	SE. ¼ SE. ¼ sec. 20	317	310		"Surface," 10; yellow clay and "hardpan"; clear sand and gravel 225. Not 50 feet above Bear creek.
J. S. Bromwell	NE. ¼ NE. ¼ sec. 22	240	230		
J. L. Finch	NE. ¼ SE. ¼ sec. 23	211	205		
J. Thompson	SW. ¼ NE. ¼ sec. 25	165	160		
—— Niles	NW. ¼ NW. ¼ sec. 27	63	20		Sand and gravel to rock. Creek bottom.
E. Anderson	NE. ¼ NW. ¼ sec. 29	280	275		
T. 84 N., R. 1 W. (Wyoming).					
J. Corbit	SE. ¼ NE. ¼ sec. 5	------	80		Mostly blue hardpan.
Israel Edwards	Sec. 11	120	30		
J. F. Allen	SW. ¼ SW. ¼ sec. 13	116	65		
J. Edward	E. ½ sec. 23	162	70		
Peter Kegly	Sec. 24	88	15		Hill.
J. W. Kegly	Sec. 24	170	50		
T. 83 N., R. 4 W. (Greenfield).					
Geo. Lamb	NW. ¼ SE. ¼ sec. 1	214	202		All clay to rock.
F. B. Hakes	SE. ¼ NW. ¼ sec. 8	98	68		Nearly all sand. Ravine.

Typical wells in Jones County—Continued.

Owner	Location	Depth	Depth to rock	Source of supply	Remarks: (Logs given in feet)
		Feet	Feet		
J. H. Armstrong	NW. ¼ NE. ¼ sec. 5	86	53		Low ground.
Wm. Breeds	NW. ¼ NW. ¼ sec. 6	86	80		Yellow clay, 20; blue clay to rock.
A. D. MacCanahy	NE. ¼ NW. ¼ sec. 10	100	99		
Peter Duncan	NE. ¼ SW. ¼ sec. 12	132	132		
T. 83 N., R. 3 W. (Rome).					
Jane Gauser	NW. ¼ SE. ¼ sec. 6	216	195		
R. J. Boots	NE. ¼ NE. ¼ sec. 7	131	95		Water heard running in vein.
H. P. Farnham	SW. ¼ NW. ¼ sec. 8	159	158		
S. Strong	SE. ¼ NW. ¼ sec. 10	210	80		Soil, 4; yellow clay, 71; no blue clay.
B. A. Jeffries	SE. ¼ SW. ¼ sec. 13	60	12		
	SW. ¼ SW. ¼ sec. 14	76	50		First rock hard gray flint underlain with soft porous limestone. Plenty of water.
—— Thrapp	NW. ¼ SW. ¼ sec. 17	61	32		
W. R. Vernon	SW. ¼ NW. ¼ sec. 25	179	70		Heads 59 feet below curb.
J. Rummel	SW. ¼ SW. ¼ sec. 36	78	36		Heads 48 feet below curb.
T. 83 N., R. 2 W. (Hall).					
Murray Brothers	SE. ¼ SW. ¼ sec. 1	200	70		
B. Sherman	NW. ¼ NW. ¼ sec. 7	45	20		
—— Baumgartner	SW. ¼ SW. ¼ sec. 13	160	70		
P. W. Mitchell	SE. ¼ SE. ¼ sec. 16	163	100		
W. & L. Glick	SW. ¼ SW. ¼ sec. 20	72	26		Heads 30 feet below curb.
B. Meyers	SW. ¼ NE. ¼ sec. 24	160	70		
G. A. Phillips	NW. ¼ NW. ¼ sec. 27	150	145		

LINN COUNTY.

BY W. H. NORTON.

TOPOGRAPHY.

The salient topographic features of Linn county are two long belts of dissected upland, consisting of loess and Kansan drift, coincident in the main with the courses of Cedar and Wapsipinicon rivers and hence traversing the county diagonally from northwest to southeast. These ridges rise 60 to 100 feet above the bordering drift plains and as much as 200 feet above the streams which cleave them. In places they close in on the rivers from either side and leave but narrow rock-bound gorges for the pathways of the streams, and for long stretches they draw back, leaving space for alluvial plains one to two miles wide. Here and there the upland disappears on one or both sides of the rivers and the Iowan drift plain comes down to the immediate valley of the stream.

The remainder of the county is occupied by the plain of Iowan drift. To the north of the Kansan upland bordering the Wapsipinicon lies a drift prairie, the only village upon it within the limits of the county being fitly named Prairieburg. To the south of the upland of Cedar river is an area of Iowan drift prairie fluted with numerous loess-capped elliptical hills, called paha, which rise in places as much as 120 feet above the adjacent streamways and whose major axes bear northwest and southeast. The surface is here further diversified by the wide and ancient channel now held by Prairie creek. Fairfax and Ely are the villages of this area.

Between the two river ridges lies a broad plain of Iowan drift, on which are built Walker, Center Point, Marion, Springville, Mount Vernon, Lisbon, and several villages. The valleys of a number of southward-flowing creeks trench the prairie to a depth of from 40 to 60 feet. Paha are generally absent from the area except about its margins. Southeast of Springville, however, the plain is divided by a belt of hilly country with pahoid crests, leaving on either side an undulating prairie three or four miles wide.

GEOLOGY.

The uplands of the county are mantled, in some places to a depth of 40 feet, with loess, a yellow silt distinguished by the driller from the yellow stony clays beneath by its freedom from pebbles and by its darker and duller tint. The Iowan drift, which covers the prairies with its brownish pebbly sands and light yellow till, is too thin to be of importance in this inquiry. The Kansan drift sheet underlies the entire county. To it belong most of the blue and yellow stony clays which the driller finds everywhere. In places the Nebraskan drift is indicated by a dark till, separated from the overlying Kansan by old soils (Aftonian).

In the eastern part of the county the drift rests on the Niagaran dolomite—a coarsely granular, crystalline, buff or blue-gray dolomite—which presents two phases. The first, the so-called "lime rock," seen at Viola and at the palisades near Mount Vernon, occurs in massive lenses 80 feet thick, almost destitute of structure planes, and also in highly tilted layers which afford easy descent for ground waters. The second phase, a buff, granular, finely laminated stone, is used extensively as a building stone; the strata are approximately horizontal and the joints and numerous bedding planes and porous layers offer ready passageways for the water.

In the central and western parts of the county (Pl. XI) the drift rests on strata of Devonian age, of which two formations have been distinguished. The upper, a yellow limestone, in places highly fossiliferous, is known as the Cedar Valley limestone. The lower is an assemblage of strata, chiefly limestones, called the Wapsipinicon limestone, which includes a number of members to which names have been given by the Iowa State Survey from places of outcrop in this or adjoining counties. At the base of the Wapsipinicon is a soft, granular magnesian limestone (Coggon beds of Iowa Survey) somewhat resembling the Niagaran on which it rests. Next in ascending order is a variable brown or drab limestone, in places flinty (Otis beds of Iowa Survey), succeeded by a series of shales and shaly limestones, normally blue but locally black with carbonaceous content, and even containing thin discontinuous seams of coal, to which the Iowa State Survey has given the name Kenwood beds but which are considered as the equivalent of the Independence shale member of Buchanan county.

In the latter beds much flint is contained in concretionary masses. Upon them lies a heavy bed of broken or brecciated limestone made up of angular fragments (the Upper Davenport and Lower Davenport beds of the Iowa Survey), which may even embrace some of the underlying beds and in places include some of the lower beds of the overlying Cedar Valley limestone. In small areas in the county the bedrock is a sandstone or coaly shale belonging to the Pennsylvanian series.

The limestones of the Devonian are exceptionally soluble because of their slight magnesian content, and contain many water passages and some crevices where the drill drops slightly and in which running water is found. As the "Kenwood beds" (Independence shale member) are more or less clayey, they serve to arrest the descent of ground water and to impound it within the overlying limestones as in a reservoir. In Otter Creek, Washington, Spring Grove, and Fayette townships drillers report beds of "soapstone" which are referable to the Independence member.

UNDERGROUND WATER.

SOURCE AND DISTRIBUTION.

On the broad flood plain of Cedar river open and driven wells 15 to 30 feet deep obtain an abundant supply of water in river-laid sands and gravels.

About the margin of the Iowan drift the loess graduates downward by interstratification into yellow sands, which furnish small supplies for house and farm wells in the areas bordering paha hills and the Kansan upland, and in some of the towns of the county bring ground water into the cellars of houses located on the flanks of loess-capped hills. The lower portion of the loess, which is in many places gray or ashen in color, may become so saturated with water as to form a quicksand in railway cuts and other excavations, and may afford a scanty and inconstant supply for shallow wells. The loess and its basal sands are poor aquifers. The loess is thick upon the summits of the uplands and of the paha hills; but these uplands are deeply dissected and water readily drains out, leaving little stored for the supply of wells; and where the land is low and comparatively level, the loess is either so thin as to be negligible, or is wholly wanting. Wells sunk in loess should, if possible, be located where the subsurface seepage follows along channels cut in the Kansan drift, as, for example, near the foot of a large ravine or where several ravines converge.

Beds of sand and gravel occur in the drift clays and may separate the upper weathered zone of yellow stony clay from the blue unweathered till beneath. The sands immediately beneath the yellow tills may yield small supplies of water, but as a rule wells are compelled to seek deeper aquifers, which may occur in sands and gravels (Aftonian) lying beneath the Kansan drift sheet, in lenses of sand in either of the older drifts, or in gravels lying on bedrock. The gravels above bedrock are in some places found oxidized and even cemented to a hardpan through the seepage of water, while the overlying till retains its normal bluish color.

On the Iowan drift plain ground water stands high wherever porous beds capable of storing and transmitting water are found near the surface, but even here impervious thick beds of stony clay may force the owners of wells to drill deep to find water in adequate amounts in interglacial and preglacial sands or in the rock. On the uplands of loess and Kansan drift in the immediate vicinity of the rivers and creeks the groundwater surface approaches the level of its outlets at the water level of the streams, and wells are necessarily deep.

In general, all these Pleistocene beds have been decreasing in value as water bearers, owing both to the progressive lowering of ground water since the settlement of the country and to the continued increase in the drafts upon them.

Old soils and accumulations of wood which affect the quality of well water are reported from some wells, but are relatively so few that they do not seem referable to any special horizon. Thus, in sections 10 and 11 of Washington township dug wells encounter at about 60 feet from the bottom deposits of driftwood with some logs said to show marks of beaver cutting. The forest bed here occurs beneath blue clay which extends upward to within a few feet of the surface, yellow till being absent.

The Niagaran dolomite is one of the chief aquifers of the county. The towns of Mount Vernon and Lisbon draw from it their town supply, and farm wells tap it over all the eastern townships of the county. The formation measures more than 300 feet in thickness and rests upon the thick and impervious Maquoketa shale which effectually prevents any leakage of ground water downward. In the central and western parts of the county the westward dip of the Niagaran carries it beneath overlying Devonian strata along a sinuous line extending south from Coggon to near Bertram, and the formation carries with it the ground water received on its broad area of outcrop. The lower argillaceous beds of the Devonian here to a large extent prevent upward leakage from the artesian pressure to which the water of the Niagaran is subjected. Wells sunk into the Niagaran in the central and western townships of the county have fair prospects of obtaining a bountiful supply of water, although in this, as in all other limestone formations, it is never certain that the drill will strike one of the water channels of the rock.

BURIED CHANNELS.

Some exceptionally deep wells in drift indicate ancient channels excavated in rock in interglacial or preglacial times and later filled with deposits of ground moraine or outwash sands. Thus a belt of "deep country" where a number of wells in drift exceed 275 and 300 feet in depth extends north from Prairieburg to the Delaware county line, embracing sections 2, 10, 11, 15, 22, and 28 of Bowlder township. This channel is probably a continuation of that of western Jones county. In several places farm wells have disclosed such buried channels which cannot be traced across the country with the little data at hand. Thus three miles west of Mount Vernon (SE. ¼ SE. ¼ sec. 12, T. 82 N., R. 6 W.) the following well section is reported. It will be noticed that the depth at which rock was reached is 110 feet below low water in the Cedar river and nearly 100 feet below its rock-cut bed.

Section of well 3 miles west of Mount Vernon.

	Thickness	Depth
	Feet	Feet
Clay, yellow	14	14
Clay, hard, blue, pebbly	48	62
Soil, dark, and wood	6	68
Clay, blue, stony	66	134
Sand and gravel	8	142
Clay, blue, stony	63	205
River sand to rock	6	211

In the northern part of the county (NW. ¼ sec. 17, T. 86, R. 6) another buried channel shows the following section:

Section of well in northern part of Linn county.

	Thickness	Depth
	Feet	Feet
Soil and clay, yellow, pebbly	19	19
Sand, yellow	4	23
Clay, blue; changeable from hard to soft every few feet	190	213
Sand, fine, white	13	226
Sand, coarser, with wood	12	238
Gravel, coarse	3	241

In towns, house wells are so closely spaced that even narrow gorges cut in rock can be discovered and traced. At Lisbon, where the rock outcrops or is found within 6 to 24 feet of the surface, a gorge half a mile long, 115 feet deep, and about 18 rods wide extends through the town. The drift, which completely fills this ancient channel, leaving no surface indication of it, consists of yellow and blue clays with some beds of gravel. At Central City an old channel of Wapsipinicon river is disclosed by wells on the east side of the village. It is separated from the present channel by a rocky elevation that comes within a very few feet of the surface of the low plain on which the village stands. The channel, which is filled with yellow sand, is 96 feet deep, or 60 feet below water in the river.

In Cedar Rapids, on the west side of the river, a buried channel 60 feet deep extends parallel to the river and separated from the present rock-cut bed of the stream by limestone rising nearly to the level of the low, broad flood plain on which this portion of the city is built.

SPRINGS.

No marked spring horizons are found in Linn county, for in it there are no outcropping planes of contact of limestones with underlying thick and persistent shales. The most important springs are those which form the main supply of the town of Marion. (Pp. 125, 543.) Other springs rise from the Devonian along its outcrops on the valley sides of Cedar river north of Cedar Rapids, and still others along the Wapsipinicon from Central City to Troy Mills, but few, if any, are strong enough to yield a stream of any size.

Springs from the Niagaran are found in many localities over the outcrop of that formation. Thus the springs in Spring Hollow, at the summer resort of the Palisades of Cedar river, rise from the base of cliffs of the Niagaran. A large spring from the same formation is that of Granger, on Wapsipinicon river, two miles northwest of Central City. The large spring which supplies Lisbon may in part draw its waters from the Niagaran.

Small springs and seepages occur in large numbers where the valleys transect the porous sands and gravels of the drift.

CITY AND VILLAGE SUPPLIES.

Cedar Rapids.—The public supply of Cedar Rapids (population, 32,811) is drawn from Cedar river and from three artesian wells located 100 to 200 feet apart at the apices of a triangle. (See Pl. XI.) The total capacity of the works is 10,000,000 gallons daily and the consumption is 2,500,000 gallons. The domestic pressure is 60 pounds and the fire pressure 130 pounds. There are 53 miles of mains, 4,200 taps, and 310 fire hydrants. The wells are described as follows:

The waterworks well No. 1 has a depth of 2,225 feet and a diameter of five inches. The curb is 733 feet above sea level. The original head was 28 feet above the curb and the original discharge 250 gallons a minute; the present head is two feet above the curb and the present discharge 150 gallons a minute. First water was from 85 feet and first flow from 1,050 feet; water was also found at 1,300 to 1,450 feet and at 2,000 feet. The well was completed in 1888 at a cost of $6,065 by J. P. Miller & Company, of Chicago. Corroded casing was drawn in 1893. In 1894 the well was reamed to eight inches to a depth of 1,450 feet and plugged there to shut off a lower salty and corrosive water; no increase in flow resulted.

The following record of strata is based on only 25 samples, and its accuracy is, therefore, open to question:

Record of strata of waterworks well No. 1, at Cedar Rapids (Pl. XI.)

	Thickness	Depth
	Feet	Feet
Alluvium	10	10
Limestone, light buff, rather soft, magnesian; and gray, very hard, nonmagnesian, compact; somewhat fragmental in structure	40	50
Limestone, gray, sparry, subcrystalline	85	135
Limestone, moderately hard, light buff, magnesian	40	175
Dolomite, pink, minutely vesicular, subcrystalline	65	240
Dolomite, bright buff, porous	60	300
Dolomite, hard, light gray, porous	80	330
Dolomite, light yellow; coarser grained than that above	20	350
Dolomite, hard, light gray, subcrystalline; some white chert	25	375
Dolomite, yellowish; like above but softer	45	420
Shale, fine, bluish green, calcareous, magnesian	200	620
Limestone, magnesian and nonmagnesian	295	915
Shale	5	920
Sandstone, slightly bluish or greenish gray; grains of quartz rounded; considerable calcareous powder; some gray shale	65	985
Shale, dark colored	1	986
Sandstone; clean, white grains, rounded and somewhat uniform in size	50	1,036
Dolomite, light gray, rather hard, arenaceous, fine-textured; much finely laminated green shale	114	1,150
Dolomite, gray; with chert, white, and quartzose sand	270	1,420
Sandstone; fine, white, rounded grains with much finely comminuted quartz and many smaller angular fragments of white dolomite	88	1,508
Sandstone, fine, yellowish, water bearing	42	1,550
Sandstone, with slight admixture of calcareous powder	140	1,690
Shale, tough and hard; small amount of very fine siliceous particles and some dolomite	100	1,790
Sandstone; light, reddish grains largely angular; some with crystalline facets	160	1,950
Sandstone, cream colored, very fine-grained	200	2,150
Quartzite, reddish brown; grains angular; rock drilled with great difficulty	75	2,225

The waterworks well No. 2 has a depth of 1,450 feet and a diameter of five inches; cased to 85 feet. The curb is 733 feet above sea level. The original head was 28 feet above the curb; present head, two feet above the curb. The original discharge was 250 gallons a minute; present discharge, 150 gallons a minute. Water comes from depths of 485 feet, 1,050 feet, and 1,300 to 1,450 feet. Temperature, 62° F. The well was completed in 1888, at a cost of $3,205, by J. P. Miller & Company, of Chicago.

Waterworks well No. 3 is of the same dimensions as well No. 2. It is not now used.

The Young Men's Christian Association well has a depth of 1,462 feet and a diameter of five inches. The curb is 733 feet above sea level and the original head is 2½ feet above the curb. It was at first cased to a depth of 1,372 feet, but as a large part of the flow was thus shut off the casing was drawn and the well left cased to 85 feet. The well was completed in 1894 by A. K. Wallen, of Ottawa, Illinois.

The following record of strata is based on a large number of drillings taken at frequent intervals. Unfortunately, samples were not saved for the first 90 feet, within which space the drill must have passed through the lowest beds of the Devonian system.

Record of strata of Young Men's Christian Association well at Cedar Rapids.

	Thickness	Depth
	Feet	Feet
Devonian (95 feet thick; top, 733 feet above sea level):		
No samples	90	90
Nonmagnesian limestone, dark, slate-colored, in chips, argillaceous, hard, compact, subconchoidal fracture, pyritiferous, showing junction surfaces with green clay; smaller chips of light buff magnesian limestone, not porous, earthy luster; green clay	5	95
Silurian:		
Niagaran dolomite (349 feet thick; top, 638 feet above sea level)—		
Magnesian limestone, or dolomite, light buff; slightly vesicular, earthy luster; samples at 95, 105, 115 feet	25	120
Dolomites, buff, pinkish and gray; mostly vesicular, subcrystalline and subtranslucent; 17 samples	324	444
Ordovician:		
Maquoketa shale (276 feet thick; top, 289 feet above sea level)—		
Dolomite, hard, gray, argillaceous; with argillaceous powder	6	450
Shale, bluish; intercalated limestones at 525, 565 and 595 feet; 7 samples	270	720
Galena dolomite to Platteville limestone (305 feet thick; top, 13 feet above sea level)—		
Dolomites, rough, hard; 6 samples	65	785
Limestones, magnesian, some cherty; 8 samples	135	920
Limestones; briskly effervescent, earthy; in flaky chips; bluish gray	15	935
Shale and limestone, brown, petroliferous	15	950
Shale, blue	40	990
Limestone, bluish gray; in flaky chips; briskly effervescent; samples at 990 and 1,000 feet	35	1,025
Saint Peter sandstone (20 feet thick; top, 292 feet below sea level)—		
Sandstone; of clean, white quartz sand; grains rounded and ground	20	1,045
Prairie du Chien stage (355 feet thick; top, 312 feet below sea level)—		
Shakopee dolomite (125 feet thick)—		
Dolomite, gray, cherty; samples at 1,045, 1,080, 1,100 and 1,115 feet	85	1,130
Dolomite, arenaceous; in fine buff dolomite powder with some quartzose grains	40	1,170
New Richmond sandstone (55 feet thick)—		
Sandstone; in fine, light yellow quartz sand of angular grains; some dolomite; 3 samples	55	1,225
Oneota dolomite—		
Dolomite, gray; 12 samples; at 1,240 and 1,380 feet, arenaceous		1,400
Cambrian:		
Jordan sandstone (62 feet penetrated; top, 667 feet below sea level)—		
Sandstone, clean white quartz sand similar to the Saint Peter, but coarser; 4 samples; at 1,435 feet, slightly calciferous		1,462

This section indicates that the lower strata of water-works well No. 1 may be correlated as follows:

Saint Lawrence formation, 1,462 (?) to 1,790 feet; earlier Cambrian, 1,790 to 2,150 feet; Algonkian (?) quartzite, 2,150 to 2,225 feet.

A number of moderately deep wells, such as those of the gas company, the starch works, and the Montrose Hotel, draw an excellent supply of water from the Niagaran. The well at Montrose Hotel is eight inches in diameter and 235 feet deep. Water heads 11 feet below the curb and can be lowered but seven feet by pumping. The well is cased to rock about 30 feet below the level of the street. An older well, 95 feet deep, yielded a wholly insufficient supply.

Central City.—At Central City (population, 558) the Saint Peter sandstone will be found at about 75 feet above sea level or 912 feet below the surface. Possibly this sandstone, together with the water of such veins as might be struck in the Niagaran and Galena, would furnish a supply ample for the town at present. Otherwise the well should be sunk about 400 feet deeper, or to a total depth of about 1,300 feet.

Coggon.—Water is supplied to Coggon (population, 471) by a well and pumped to an elevated tank affording a gravity pressure of 43 pounds. There are 3,000 feet of mains and nine hydrants.

Lisbon.—At Lisbon (population, 848) a spring whose water issues from Niagaran dolomite, near the head of a ravine in the northwestern part of town, is pumped to a standpipe. The domestic pressure is 45 pounds and the fire pressure 100 pounds. There are 16 hydrants and 1½ miles of mains.

Marion.—Water for Marion (population, 4,400) is obtained from four large springs, supplemented for fire protection by water from Indian creek. Four springs—the Bowman, Lower Bowman, Davis, and Riley—are inclosed in stone reservoirs with roofed superstructures and screened openings. They flow 3,000,000 gallons a day from near the base of the Wapsipinicon limestone. The pressure is direct, the domestic being 60 pounds and the fire pressure from 80 to 120 pounds. There are 15 miles of mains, 73 hydrants, and 1,000 taps. The supply from the springs far exceeds the maximum daily consumption.

The records of the Cedar Rapids deep wells indicate approximately the prospects for such wells at Marion . Allowing for the difference in elevation and the dip of the strata, a well about 1,500 feet deep would obtain water which would not flow, but which should rise nearly to the surface.

Mount Vernon.—The water supply of Mount Vernon (population, 1,532) is drawn from a well 328 feet deep, ending near the base of the Niagaran dolomite. (See Pl. XI.) The yield is augmented from surface gravels whose waters are admitted to the well, so that pumping draws the water down in adjacent shallow wells.

The well entered rock at 10 feet and the principal supply is said to have been found at 160 feet. Water rises within six feet of the curb. The water is distributed under direct pressure and from a standpipe; the pressure varies, according to location, from 45 to 80 pounds. There are 2¾ miles of mains, 42 hydrants, and 275 taps. The consumption is estimated at 25,000 gallons daily.

A statement of the artesian conditions at Mount Vernon was prepared by W. H. Norton several years ago, when the city waterworks were built, but was not acted on, as the supply obtained by the city well was considered sufficient. The advisability of a deep well has been again raised, however, as a supply for Cornell College and especially for a swimming pool for the new gymnasium.

At Mount Vernon (elevation, 843 feet) the drill will find below the country rock (Niagaran) 250 feet or more of a dry shale —the Maquoketa. This shale rests on a series of dolomites and limestones with some shales, aggregating 300 feet or more in thickness and known as the Galena dolomite, Decorah shale, and Platteville limestone. The Saint Peter sandstone will be struck somewhere between 100 and 250 feet below sea level, the exact position being doubtful because of the strong upwarp of the strata whose axis probably lies east of the town. (Pl. XI.) It is probable that the effect of the uplift extends as far west as Mount Vernon, and the Saint Peter is expected to occur nearer the first-mentioned than the last-mentioned depth.

The water from the Saint Peter and such as may be found in the superior limestones may be found adequate for the college needs. The water will be of good quality and should rise within 50 to 100 feet of the level of the surface at the railway station.

A deep well for city supply should be drilled to a depth of 400 or 500 feet below the Saint Peter sandstone to obtain the much greater yields of the water-bearing strata underlying that terrane. To tap the Prairie du Chien and Jordan aquifers, a well need not exceed 1,600 feet in depth, and a depth of 1,400 feet would probably suffice if the Saint Peter lies as high as there is some reason to suppose. The well should be so located as to avoid all ground-water drainage lines passing through the town through surface sands and gravels, and should be so cased as to absolutely exclude such waters.

Springville.—The water supply of Springville (population, 588) is drawn from a well of which no report has been obtained. The gravity pressure from standpipe is 62 pounds and the direct fire pressure is 120 pounds. There are nine hydrants and one mile of mains.

Walker.—Artesian wells at Walker (population, 517) should find the Saint Peter sandstone about 965 feet below the surface or 75 feet below sea level. From 540 to 310 feet above sea level (350 to 580 feet below the surface) the drill would pass through dry shales (Maquoketa) which should be cased. Water would probably be found in small quantities in the Devonian and Silurian limestones, which overlie these shales, and in the Galena and Platteville limestones which underlie them. Probably sufficient water could be found in the Saint Peter for the present needs of the town, but if not, the well should be carried to about 1,400 feet below the surface to tap the large stores of the Prairie du Chien stage and the Jordan sandstone.

The water will not flow at the surface, as the head in the Saint Peter sandstone can hardly be higher than 100 feet below the surface. The upper limestone waters will probably rise higher.

Minor supplies.—Details of water supplies of minor towns and villages are given in the following table:

Village supplies in Linn County.

Town	Nature of Supply	Depth	Depth to water bed	Head below curb
		Feet	Feet	Feet
Alburnett	Drilled wells	55-100		
Bertram	Drilled and driven wells	23-124		12-75
Center Point	Drilled wells	15-175	15-130	30- 50
Ely	Open, drilled and driven wells	17- 48	20	10+
Fairfax	No report			
Norway	Drilled wells	150-400		
Paralta	Wells and cisterns	25- 50	100	10-95
Prairieburg	Drilled wells	13-140		3-100
Palo	Driven wells	18- 24	20	
Springville	No report			
Viola	Drilled wells and cisterns	30- 85		20

WELL DATA.

The following table gives data, largely gathered by the late Dr. Martin J. Iorns, of the Department of Agriculture, of typical wells in Linn county:

Wells in Linn County.

Owner	Location	Depth	Depth to rock	Depth to water supply	Source of supply	Head above or below curb	Remarks: (Logs given in feet)
T. 86 N., R. 5 W. (Bowlder).							
		Feet	Feet	Feet		Feet	
T. Cushman	SE. ¼ SE. ¼ sec. 1	160	160	155	Sand on rock.		
A. McDonald	SE. ¼ sec. 4	160	160				
L. McEvoy	SE. ¼ NW. ¼ sec. 4.	160	159		Limestone	—60	All yellow and blue clay; no sand.
E. C. Bebb	SE. ¼ SE. ¼ sec. 8	45	20				
D. Carr	NE. ¼ NE. ¼ sec. 9.	170	150		Limestone		All clay; 10 feet red sticky clay (geest) on rock.
D. Hennessy	SE. ¼ SE. ¼ sec. 10.	160	160				
S. McAleer	SW. ¼ SW. ¼ sec. 12.	160		125	Sandstone		
D. Hennessy Creamery.	NW. ¼ sec. 11		305				
W. McAleer	NE. ¼ NE. ¼ sec. 13.	130	130				
C. LeClaire	NW. ¼ sec. 14	160	160				
W. G. Zimmerman	SE. ¼ NW. ¼ sec. 15.	160	160				
W. McEvoy	NW. ¼ NE. sec. 17.	60	40		Limestone	—40	Trace of red geest on rock.
J. W. Braselton	SE. ¼ SW. ¼ sec. 17.	95	95		Sand	—15	Quicksand 35 feet deep to rock.
P. McMurtin	NW. ¼ NE. ¼ sec. 20.		145				
E. Berlingham	SW. ¼ SW. ¼ sec. 21.		100		Gravel		All gravel to rock.
G. Cowan	NW. ¼ sec. 23	303		276	Sand	—103	3-foot sand bed, at depth of 25 feet; considerable water from 276 to 303. Sand and gravel with water.
P. H. Ryan	SE. ¼ NE. ¼ sec. 23.	180	180		On rock		
M. A. Leonard	SE. ¼ SE. ¼ sec. 23.	313	313				
O. Rundall	SW. ¼ SW. ¼ sec. 23.	240	240				From 220 to 230, "soluble" blue clay.
J. I. Henderson	SW. ¼ sec. 24	150	150		On rock		
T. Shaffer	NE. ¼ NE. ¼ sec 25.	80	80		On rock		
J. Plower	SW. ¼ SW. ¼ sec. 25.	195	185	195	Limestone		
A. Kula	NW. ¼ NW. ¼ sec. 26.	165			Sand and gravel.		Yellow and blue clays, 150; sand and gravel, 15.
F. Valanta	SW. ¼ NW. ¼ sec. 27.	50	50		On rock		

Wells in Linn County.—Continued.

Owner	Location	Depth	Depth to rock	Depth to water supply	Source of supply	Head above or below curb	Remarks (Logs given in feet)
		Feet	Feet	Feet		Feet	
J. Kula	SW. ¼ SW. ¼ sec. 27.	50	20		Limestone		
Prairieburg	NW. ¼ NW. ¼ sec. 28.	120	120		On limestone.		All blue clay.
J. Walker	SE. ¼ sec. 28	50	50		On rock		
A. Burnside	SW. ¼ NE. ¼ sec. 30.	120	120				Yellow and blue clays to rock.
G. Borsky	SW. ¼ SE. ¼ sec. 30.	120	120				
A. E. Butler*	NW. ¼ SW. ¼ sec. 34.	188	88	188	Limestone		Loess, 45; blue clay, 15; sand, 10; blue clay, 18; limestone, 100.
M. C. Walker	SW. ¼ NW. ¼ sec 34.	92	40		Limestone		All gravel above rock.
A. Lawrence	SE. ¼ NE. ¼ sec. 35.		198			—14	
J. B. Holub	NE. ¼ NE. ¼ sec. 36.		149				Yellow clay, 30; solid blue clay, 119.
F. Stack	SW. ¼ sec. 36		185				
T. 86 N., R. 6 W. (Jackson).							
Lawton Estate	NW. ¼ NW. ¼ sec. 1.	180	40	180	Limestone	—40	
W. H. Sherman	NW. ¼ NW. ¼ sec. 2.	180	40				
T. L. Main	NE. ¼ NW. ¼ sec. 3.	160	8				
J. H. Ashby	NW. ¼ NE. ¼ sec. 3.	125	25			—25	
L. H. Webb	NW. ¼ NE. ¼ sec. 5.	52			Gravel	—10	
S. N. Joslyn	SW. ¼ SE. ¼ sec. 5.		270				
F. M. Philips	NW. ¼ NW. ¼ sec. 5.	180	180		On rock		Yellow clay, 15; blue clay to rock.
D. L. Castle	SW. ¼ sec. 6	140	40	140			
C. Ellis	NE. ¼ SE. ¼ sec. 6.	100	100		Limestone		
L. Dix	SW. ¼ SE. ¼ sec. 6.	242	242				
S. M. Dennis	NW. ¼ NW. ¼ sec. 7.	75	50	75	Spongy limestone	—50	
C. Boone	NW. ¼ sec. 7	100	40	100			
H. Henderson	SE. ¼ NE. ¼ sec. 9.	186			On rock	—126	Yellow clay, 20; sand and gravel, 20; blue clay to limestone rock.
G. Joslyn	NE. ¼ SW. ¼ sec. 9.	232	230	180	Sand	—50	Yellow clay, 20; blue clay, 160; clear sand, 50; limestone, 2.
W. McTavish	SW. ¼ SW. ¼ sec. 9.	240	240				Yellow and blue clay with layers of quicksand.
H. Henderson	SE. ¼ sec. 10		171		Sand		Yellow and blue clay, 166 feet; sand, 5 feet.
W. J. Woods	SW. ¼ SE. ¼ sec. 10.	122	116		Rock	—116	All yellow and blue clay.
C. B. Chesmore	NW. ¼ NE. ¼ sec. 15.	180	180		On rock		
O. Woods	NE. ¼ sec. 15	202	202			—102	Sandbeds.
C. Forest	NE. ¼ SE. ¼ sec. 16.	140	130				Blue clay to rock.

* Approximate.

Wells in Linn County.—Continued.

Owner	Location	Depth	Depth to rock	Depth to water supply	Source of supply	Head above or below curb	Remarks: (Logs given in feet)
		Feet	Feet	Feet		Feet	
T. Long	SE. ¼ SE. ¼ sec. 17.	142	140		"Shell-rock."	—60	Blue clay to rock.
C. J. Avis	NW. ¼ NE. ¼ sec. 18.	185	85	185			
P. I. Henderson	SE. ¼ NE. ¼ sec. 21.	35					At 32 feet old soil: 8 more layers 3 feet thick.
J. Slife	SW. ¼ NE. ¼ sec. 25.		145				Yellow clay with streaks of gravel; blue clay to rock.
S. N. Kruetzer	NW. ¼ SE. ¼ sec. 26.	126	126		On rock		
B. T. Hall	SW. ¼ SE. ¼ sec. 30.	70	40	70			
J. D. Moles	NW. ¼ sec. 32	140	120	140	Limestone		
B. W. Long	SW. ¼ SW. ¼ sec. 32.	140					Yellow clay, 25; blue clay with sandy layers, 75; yellow sand changing to gravel, 6.
J. Blodgett	SW. ¼ SW. ¼ sec. 35.	70	70				
J. R. Stone	NE. ¼ NE. ¼ sec. 36.	100	80	100	Limestone.		
O. Gilchrist	NE. ¼ SE. ¼ sec. 29.	47	9				Yellow clay; limestone; blue sandstone; shale; a little coal.
T. 86 N., R. 7 W. (Spring Grove).							
J. Peyton	SE. ¼ SE. ¼ sec. 3.	200	20			—25	
James McKnight	SE. ¼ NE. ¼ sec. 8.	180					Rock from near surface.
G. C. Gardner	NW. ¼ NE. ¼ sec. 13.	185	35				
S. B. Mills	NW. ¼ SE. ¼ sec. 23.	40			Gravel		
E. C. Cook	SW. ¼ NE. ¼ sec. 20.	252	62				Yellow clay, blue clay to rock, small vein.
W. D. Bucklon	NE. ¼ NE. ¼ sec. 22.	140	20				Dark shale (Independence) at bottom.
F. A. Wilson	SE. ¼ SE. ¼ sec. 22.	109	20				
W. Forest	NE. ¼ NE. ¼ sec. 25.	140	120	138			Yellow clay, 20; blue clay with bowlders, 100; very hard blue limestone, 18; yellow limestone 2.
E. D. Powers	NW. ¼ SW. ¼ sec. 25.		245				
J. F. Robinson	NE. ¼ SE. ¼ sec. 26.	140	65				
C. Robinson	SE. ¼ SE. ¼ sec. 32.	54	54		On rock	—20	Yellow clay, 16; blue clay, 38, to rock.
A. G. McBurney	NE. ¼ sec. 34	150	75	150		—60	Rock, very porous.
Sisler Estate	NE. ¼ sec. 36	105	80				Yellow clay, 20; blue clay, 60; black shale, 25.

Wells in Linn County.—Continued.

Owner	Location	Depth	Depth to rock	Depth to water supply	Source of supply	Head above or below curb	Remarks: (Logs given in feet)
		Feet	Feet	Feet		Feet	
P. W. Mix	SE. ¼ NE. ¼ sec. 22.	140	20				At 140 feet thin layer of dark shale (Independence).
T. 86 N., R. 8 W. (Grant).							
J. Wachal	NE. ¼ NW. ¼ sec. 21.	33	30		On rock	—18	Dug well. Loam, 5; yellow clay, stony, 5; blue clay, 20; rock, 3.
M. Darrow	NE. ¼ SE. ¼ sec. 21	62	18	62			
W. H. Newland	NE. ¼ SW. ¼ sec. 28.	80	35			—40	
M. Hazeltine	NE. ¼ sec. 32	137	40	137	"Sandstone."	—17	Yellow clay, 15; solid blue clay, 25.
C. Cox	NW. ¼ NE. ¼ sec. 34.	130			Gravel		Yellow clay; blue clay; sand, blue clay at 130 feet; gravel.
C. H. Nietert	NW. ¼ SE. ¼ sec. 25.	117	30				Yellow and blue clay to rock.
M. L. Kerly	NW. ¼ sec. 21	203	130		"Sandstone."	—20	Drift, 130; limestone, 40; blue "marble," 16; "sandstone," 17.
M. A. Hamlin	SE. ¼ SW. ¼ sec. 33.	100	52	100	"Sandstone."	—40	Yellow clay; blue clay with layers of sand; "sandstone," water bearing, at 100 feet.
T. 85 N., R. 5 W. (Buffalo; part of Maine).							
F. Fousek	NW. ¼ NW. ¼ sec. 1.	240	240				Yellow clay, 25; blue clay to rock.
J. Bouchtela	SW. ¼ NE. ¼ sec. 1.	140	140		On rock		Northern blue clay.
M. Holub	NE. ¼ SW. ¼ sec. 1.	120	120		do		Northern blue clay, some sand and gravel.
W. Johanek (Two wells.)	SW. ¼ NW. ¼ sec. 2.	213 108	213 108		On rock Gravel		All gravel.
J. McNamera	NE. ¼ SE. ¼ sec 3.	108			Gravel		Do.
Story Estate	NW. ¼ SW. ¼ sec. 3.	80	80				All gravel and sand.
H. Story	SE. ¼ NE. ¼ sec. 4.	80	80			— 6	
J. Peet	SE. ¼ SE. ¼ sec. 3.	125	125		Gravel		All gravel to rock.
T. Neilly	NE. ¼ SE. ¼ sec. 11.	140	140				Mostly blue clay
W. Jackson	SE. ¼ SE. ¼ sec. 13.	30	30		Gravel		Creek bottom; all gravel.
M. Green	SE. ¼ SW. ¼ sec. 13.	80	50		Limestone		Mostly yellow clay.
J. Anderson	SE. ¼ NE. ¼ sec. 14	100	100		Gravel		Mostly sand and gravel.
W. Ross	SE. ¼ SW. ¼ sec. 15.	140	140				Yellow clay, 30; blue clay to rock.
G. Minehart	SE. ¼ SE. ¼ sec. 15.		156				Ridge. Yellow clay, 30; blue clay to rock.

Wells in Linn County.—Continued.

Owner	Location	Depth	Depth to rock	Depth to water supply	Source of supply	Head above or below curb	Remarks: (Logs given in feet)
		Feet	Feet	Feet		Feet	
J. G. Denny	NW. ¼ NW. ¼ sec. 19.	105	30				
J. C. Kennedy	NW. ¼ sec. 20	60	20	60	Showing water in crevice.		
F. Richards	SE. ¼ NW. ¼ sec. 23.		160		On rock		Ridge. Yellow clay, 30; blue clay to rock.
D. C. Peet	NE. ¼ NE. ¼ sec. 25.	180	80	180	Shelly limestone.		
S. L. Bowdish	NE. ¼ SW. ¼ sec. 29.		185				Mostly blue clay.
S. F. Bowdish	NW. ¼ NW. ¼ sec. 32.		292				Yellow clay, 30; sand with some water at 40; blue clay with streaks from 60 and to rock.
T. Wilkinson	NW. ¼ NW. ¼ sec. 31.	297	289			—89	Yellow clay, 35; blue clay, 100; white sand, 20; blue clay, 134; shell rock, 8.
A. Shanklin	NW. ¼ NE. ¼ sec. 33.	120	120				First 40 feet dug; blue clay from 40 feet to bottom.
T. 85 N., R. 6 W. (Part of Maine).							
H. Smith	SE. ¼ NE. ¼ sec. 2.	100	1	75		—30	Pockets of very sticky, waxy, yellow clay.
I. Floss	SE. ¼ SE. ¼ sec. 4.	+240	240				
G. Nightingale	SW. ¼ sec. 5	185	172				Yellow and blue clay to rock.
C. J. Church	NE. ¼ SE. ¼ sec. 6.	135	135		On rock	—95	Do.
G. M. Rogers	NE. ¼ NE. ¼ sec. 7.	240	232			—70	Yellow clay, 30; blue clay, 170; shell rock and gravel, 32; rock, 8.
Creamery	NE. ¼ NE. ¼ sec. 7.		245			—70	No sand; nearly all blue clay.
Martha Taylor	SE. ¼ NE. ¼ sec. 7.	233	233				Yellow clay, 30; blue clay, 200; sand, 3.
W. Butters	SE. ¼ SE. ¼ sec. 7.	230	190				
M. A. Benton	NE. ¼ SW. ¼ sec. 8.		180				Blue clay from 25 to 160; yellow clay, 25; overlying rock.
Goldsberry and Haskell.	NW. ¼ SW. ¼ sec. 10.		75				
C. Jordan	SE. ¼ SE. ¼ sec. 14.		112				
E. Finsen	NW. ¼ SW. ¼ sec. 15.	80			Sand and gravel.		All sand and gravel.
L. J. Reed	NE. ¼ SE. ¼ sec. 15.	90	50	90			
J. McLead	SE. ¼ NW. ¼ sec. 15.	100	100		Sand and gravel.		Do.
A. T. Crosby	NW. ¼ SE. ¼ sec. 16.		100				

Wells in Linn County.—Continued.

Owner	Location	Depth	Depth to rock	Depth to water supply	Source of supply	Head above or below curb	Remarks: (Logs given in feet)
		Feet	Feet	Feet		Feet	
C. Nightingale	SW. ¼ SW. ¼ sec. 17		118				Yellow clay, 30; blue clay, 75; yellow clay, 13.
E. Brewer	NE. ¼ NE. ¼ sec. 19.	100	100				
S. O. Scott	NE. ¼ NW. ¼ sec. 21.		137				Yellow clay, 30; bowldery blue clay to rock.
M. Stickney	SE. ¼ SE. ¼ sec. 21.	160	150				Yellow clay, 40; blue clay, 80; yellow clay, very stony, 30; yellow rotten limestone, 10.
F. Stickney	SE. ¼ SW. ¼ sec. 22.	160	150				Mostly sandy blue clay.
A. M. Noah	SW. ¼ NW. ¼ sec. 23.	230					Quicksand; no water.
G. L. Jordan	SW. ¼ NW. ¼ sec. 25.		229		Sand		Yellow clay, 70; blue clay to sand on rock.
A. M. Kennedy	NE. ¼ SE. ¼ sec. 25.	270	270		On rock		Yellow clay, 30; blue clay, 90; sticky blue clay, 5; blue clay to thin sand layer on rock.
A. Maag	NE. ¼ SE. ¼ sec. 26.	225					Driftwood on rock.
N. Jordan	NE. ¼ NE. ¼ sec. 26.		170				Yellow clay, 20; blue clay, 15; sand and gravel, 15; blue clay, 50; quicksand, 20.
L. C. Clarup	NW. ¼ SW. ¼ sec. 27.	203			Gravel	—63	Drift, 73; gravel, 15; blue clay, 79; sand and gravel, 36.
I. Miller	SE. ¼ sec. 28		100				Thin sand streak between yellow and blue clay.
F. K. Balderson	NE. ¼ SW. ¼ sec. 29.		70				Yellow and blue clay to rock.
E. J. Craft	NE. ¼ NE. ¼ sec. 33.		100				Thin sand layer with a little water between yellow and blue clay.
G. W. Anderson	NW. ¼ NW. ¼ sec. 36.	135			Gravel		Sand and gravel from 100 feet down.
W. McTanst	NE. ¼ NW. ¼ sec. 36.		165				Sand and gravel throughout; rotten wood at 150 feet.
T. 85 N., R. 7 W. (Otter Creek).							
B. Norris	SE. ¼ SE. ¼ sec. 1.		150				Solid blue clay, 90; soft blue clay, solid blue clay to rock.
C. Lyman	SE. ¼ NE. ¼ sec. 5.	75	64				
P. Bowman	SE. ¼ NE. ¼ sec. 12.	160	100				

Wells in Linn County.—Continued.

Owner	Location	Depth	Depth to rock	Depth to water supply	Source of supply	Head above or below curb	Remarks: Logs given in feet)
		Feet	Feet	Feet		Feet	
G. Dolderer	SW. ¼ SW. ¼ sec. 14.	82	71		"Sandstone."	—66	Sandy yellow clay, 20; blue clay, 40; sand giving off strong currents of gas, 5; gray clay, 5; yellow "sandstone" to 82.
J. B. Fishel	NW. ¼ NE. ¼ sec. 32.	80			"Sandstone."		
J. Maier	NW. ¼ NE. ¼ sec. 33.	92	3	92	do	—22	Soil, 3; limestone, 71; soapstone (Independence), 15; "sandstone," 8.
M. Karch	Sec. 34	70	68		In upper layers of rock.	—58	Yellow clay, free from stones, 18; tough blue clay, 50.
T. 85 N., R. 8 W. (Washington; part of Fayette).							
J. R. Elliott	NE. ¼ sec. 1	24				— 4	Much wood at [illegible] feet.
H. H. Martin	SW. ¼ SW. ¼ sec. 2.	248	131				Yellow pebbly clay 20; blue clay with bowlders, 111. At 220 shell rock and mud seams; poor supply of water.
W. H. Stewart	NE. ¼ SW. ¼ sec. 4.	95	95		On rock	—26	Yellow clay, 30; blue clay, 65.
J. Roger	NE. ¼ NW. ¼ sec. 5.	76				—26	Clay and sand, 35; black muck, 3; sand and gravel.
Cemetery, Center Point.		160				—60	Limestone, streaks of shale, thickest being 10 feet.
D. W. Esget	NE. ¼ SE. ¼ sec. 10.	110	110				Yellow stony clay, 20; blue clay, 90; soft limestone.
M. Wilson	SW. ¼ SW. ¼ sec. 14.	130	130		Gravel and rock.	—60	
H. D. Newland	SW. ¼ sec. 17	60			Sand and gravel.		
J. Pifer	SW. ¼ NE. ¼ sec. 15.	133			Vein in clay.		Blue clay, strong water vein; blue clay.
P. McGuff	SW. ¼ NW. ¼ sec. 13.	80	60	80	Limestone		
Thompson S. Yakle	SE. ¼ NE. ¼ sec. 21.	120	120		On rock		Yellow clay, 20; blue clay, 90; hardpan of cemented pebbles. 10.
F. P. Kratzer	NW. ¼ sec. 21	128					Soapstone, 3 or [illegible] feet thick at 120 feet.
J. Ashlock	SW. ¼ sec. 26	74	14	74	Limestone		Gravel to rock.
T. Newman	SW. ¼ NW. ¼ sec. 27.	45			Gravel		Yellow clay without pebbles, 15; light blue clay to gravel, 30.
M. Schmickle	NE. ¼ sec. 24	34	18				Drift, 18; limestone and shale, 8; dirty coal, [illegible] to 8.

Wells in Linn County.—Continued.

Owner	Location	Depth	Depth to rock	Depth to water supply	Source of supply	Head above or below curb	Remarks: (Logs given in feet)
		Feet	Feet	Feet		Feet	
F. Mobey	NE. ¼ sec. 4	75	40				
E. T. Pickerel	SE. ¼ SE. ¼ sec. 31.	178	40				Some shale near bottom.
T. 84 N., R. 8 W. (Parts of Fayette and Monroe).							
S. McClintock	SW. ¼ SW. ¼ sec. 4.	225			Sand		Yellow clay, 15; solid blue clay, 180; sand, 30.
A. Elsen	NE. ¼ SE. ¼ sec. 5.	238	180				No sand.
	NE. ¼ SE. ¼ sec. 5.	213	190				Mostly clay and rock.
J. C. Adair	SE. ¼ SW. ¼ sec. 5.	100	75				
S. B. Mather	NE. ¼ SE. ¼ sec. 6.	200	130				
F. Shurtliff	Ne. ¼ sec. 7	164	80				Yellow clay, 10; blue clay to rock; rock sandstone; no limestone.
J. Railsbock	SE. ¼ sec. 7	53	45				Peat and black clays, 20; quicksand to rock; on an old lake bed.
L. D. Lewis	NE. ¼ sec. 5	262	140	160			Yellow clay, 40; blue clay, 100; rock.
A. McManus	SE. ¼ Ne. ¼ sec. 8.	138	138				Almost entirely sand to rock.
W. H. Rahde	SE. ¼ sec. 8	53	30				A little quicksand on rock.
J. H. Ray	SW. ¼ NE. ¼ sec. 9	97	70				
L. F. Wright	NE. ¼ sec. 19	80	20		Limestone	—40	On high elevation.
C. Beatty	Sec. 29	32	32				
C. Rake	NW. ¼ SW. ¼ sec. 29.	174	50	174	Crevice in Independence shale member.	—10*	Soil, 10; sand, 23; thin bed of yellow clay; blue clay, 30; limestone, 20; shale, 15; rock; coal layer; hard pyritiferous stone; sulphur-bearing rock at 165; water sulphurous.
P. E. Wilsc	NE. ¼ SW. ¼ sec. 33.	135	40				
C. Rabe	SE. ¼ SW. ¼ sec. 30.	47	30		In crevice in rock.		A little yellow clay mixed with soil; blue clay to rock: on coal or shale.
Robert J. Hoff	SW. ¼ SE. ¼ sec. 12.	140	25	140		—4	On hillside, tapped with pipe and flowing.
D. Roy	SW. ¼ NE. ¼ sec. 12.	48	40		"Sandstone."		Yellow clay without pebbles, 16; sand, 4; blue clay, 20; "sandstone," 8.

* More or less.

Wells in Linn County.—Continued.

Owner	Location	Depth	Depth to rock	Depth to water supply	Source of supply	Head above or below curb	Remarks: (Logs given in feet)
T. 82 N., R. 7 W. (College).							
		Feet	Feet	Feet		Feet	
M. Buresh	SE. ¼ NE. ¼ sec. 23.	116			Sand		Reddish clay; blue clay, 55; black soil, 2; layer of light gray soil; sand to bottom.
J. Buresh	SE. ¼ NE. ¼ sec. 35.	40			do		All sand.
T. 82 N., R. 6 W. (Putnam; part of Bertram).							
J. Cack	SW. ¼ NW. ¼ sec. 14.	100	60				
F. Havlicek	SE. ¼ SE. ¼ sec. 16.	170	75				
F. Bohak	NW. ¼ SE. ¼ sec 22.	196	30		Limestone		Rock bedded at this point.
J. Bartosh	SW. ¼ NE. ¼ sec. 26.	182	100				
J. Rousar	NE. ¼ NE. ¼ sec. 31.	50			Sand		Yellow clay, 15; sand, 35.
M. Pisarck	SE.¼ NE.¼ sec. 32	125	123				
T. 84 N., R. 6 W. (Part of Marion).							
E. R. Mason	NE.¼ NW.¼ sec. 4	170			Sand and gravel.	+4	Dark sand, 100; clean sand growing coarser to bottom, 70.
T. 84 N., R. 7 W. (Parts of Marion and Monroe).							
J. Pahms	SW.¼ NW.¼ sec. 1	50	40	50	"Sandstone."	—20	Yellow clay, 15; blue clay, 20; sand and "rock" layers to rock.
F. Walser	SE.¼ SE.¼ sec. 15	59	18				
T. C. Marton	SW. ¼ SW.¼ sec. 23	168	40	160*	"Sandstone."	—108	Yellow clay, 40; hard gray fossiliferous flinty limestone, 80; soapstone (Independence) to near bottom; "sandstone."
W. Howe	SE.¼ NE.¼ sec. 24	62	(?)				Sand, 2; very porous rock and abundant water with little head.
J. Stockey	SE.¼ NE.¼ sec. 27	117	17		Fissure in limestone	— 60	Loess, 15; blue clay; red rock, 10 feet thick at 50; limestone, 40; very hard limestone, 17; limestone full of seams and crevices.
M. J. Certain	NW. ¼ SW.¼ sec. 26	120	17				
R. Stinson	NW.¼ NW.¼ sec. 35	87	15		Limestone		Yellow and white limestone from 15 to 87.
G. Leidigh	SE.¼ SW.¼ sec. 9	165	20		"Sandstone."		
R. Hagerman	NW.¼ NE.¼ sec. 14	+200	170		Shelly rock		Yellow clay, 6; blue clay to rock.

*More or less.

Wells in Linn County.—Continued.

Owner	Location	Depth	Depth to rock	Depth to water supply	Source of supply	Head above or below curb	Remarks: (Logs given in feet)
		Feet	Feet	Feet		Feet	
D. Miller	SW.¼ SW.¼ sec. 16	67	15		In crevice	— 20	
O. A. Coleman	NW.¼ SW.¼ sec. 33	48	20		Crevice in rock.		Sand, 20, to rock.
W. McCreary	SE.¼ sec. 4	60	20	60	"Sandstone."		Sand, 20; limestone, 30; "sandstone," 10.
E. Quass	Sec. 31	168	140		Crevice in rock.		
A. Senger	NW.¼ SW.¼ sec. 28	106	20	106	do		Blue, gray, and white limestone.
T, 83 N., R. 5 W. (Linn).							
J. Drips	NW.¼ NW.¼ sec. 2	113	35				
F. Martin	SW.¼ SW.¼ sec. 2	100	30				
S. Johnson	NW.¼ SW.¼ sec. 14	100			Gravel		Log in gravel bed at 100 underneath blue clay.
J. Napier	NE.¼ NE.¼ sec. 19	75	50		Limestone	— 50	Yellow and blue clay to rock.
J. Beechley	SE.¼ SE.¼ sec. 26	80			Gravel		
W. Walm	SW.¼ NE.¼ sec. 31	50					Mostly blue clay to 40; log and black soil in gravel bed at 40.
J. Bovey	NW.¼ NE.¼ sec. 36	200	55				
F. W. Frederick	SW.¼ SW.¼ sec. 36	80	30			120*	Sand 3 feet thick on rock.
R. Smith	NW.¼ sec. 36	65			Sand		Ridge; yellow clay, 15; yellow sand, 49; black sand, coarse, with much wood, 1.
T. 82 N., R. 8 W. (Fairfax).							
M. Kilberger	NW.¼ NE.¼ sec. 34	106	100		Limestone	— 76	Yellow clay, 20; blue clay, 80; blue, hard limestone, 6.
F. Bys	SE.¼ SW.¼ sec. 27	130	125	130	do	— 90	Yellow clay, 20; blue clay, 105; limestone, 5; no gravel beds.
O. Farrell	NW.¼ NW.¼ sec. 6	30			Sand		Driven well.
E. J. Farrell	SE.¼ NW.¼ sec. 6	70			Gravel		All sand and gravel.
H. Mordorst	NW.¼ SW.¼ sec. 5	117	100				Yellow clay; blue clay; quicksand, 10 feet thick, 50; blue clay; thin yellow clay on rock; rock, 17; below it bed of sand full of water.
T. M. Hunter	NE.¼ SE.¼ sec. 6	117	100				
A. Delancy	NE.¼ SW.¼ sec. 16	180	180				

*Approximate.

Wells in Linn County.—Continued.

Owner	Location	Depth	Depth to rock	Depth to water supply	Source of supply	Head above or below curb	Remarks: (Logs given in feet)
		Feet	Feet	Feet		Feet	
C. C. Dye	NW.¼ SE.¼ sec. 20	91	91	91	Sand on rock.		Stony yellow clay, 15; blue clay full of bowlders to thin sand layer on rock.
	NW.¼ SE.¼ sec. 30	91	25		"Sandstone."		
T. 83 N., R. 8 W. (Clinton).							
L. Lafter	NW.¼ SE.¼ sec. 2	180	60		Limestone	— 25	Near Cedar river. Sand, 2; blue clay with some bowlders, 58.
P. Lang	NE.¼ SW.¼ sec. 4	238	238				
A. Sisam	NW.¼ NW.¼ sec. 9	213	213				30 feet of quicksand; quicksand rare in vicinity.
G. H. Phelps	SE.¼ NW.¼ sec. 9	277	277		Sand	—100	Mostly blue clay with layers of sand; sandy from 192 to 242; blue clay, 33; sand with water 2.
E. L. Lang	SW.¼ NE.¼ sec. 15	248	40				Clay full of bowlders.
J. E. Rawson	SE.¼ SE.¼ sec. 15	73	1				
J. Young	NW.¼ sec. 9	102			Gravel		Drift clays; gravel, 2 feet at bottom resting on clay; clay above gravel very full of bowlders.
T. 83 N., R. 6 W. (Bertram; part of Marion).							
W. C. Litts	SW.¼ SE.¼ sec. 1	175	172				
S. Harmon	NW.¼ SE.¼ sec. 2	206			Gravel	—100	Streaks of sand and gravel at 13 and -65; bed of gravel at 206.
J. R. White	NE.¼ SE.¼ sec. 2	150	100				
J. Hunter	NE.¼ NE.¼ sec. 3	125	90		Limestone		Mostly blue clay to rock, no gravel.
F. M. Elrod	NW.¼ NW.¼ sec. 4	42	42				All quicksand and gravel.
A. P. Knapp	SE.¼ SE.¼ sec. 8	61	61				
V. Zoback	SE.¼ sec. 10	45	8				
S. H. Berry	SE.¼ NW.¼ sec. 11	142				— 26	Blue clay throughout.
R. Berry	SW.¼ NW.¼ sec. 11	106	33				Mostly sand, gravel, and small bowlders.
J. Moore	SE.¼ NE.¼ sec. 11	168	168				
J. W. Smythe	SE.¼ SW.¼ sec. 12	100	40		Limestone		Sand and gravel to rock.

Wells in Linn County.—Concluded.

Owner	Location	Depth	Depth to rock	Depth to water supply	Source of supply	Head above or below curb	Remarks: (Logs given in feet)
		Feet	Feet	Feet		Feet	
G. Smythe	NE.¼ NE.¼ sec. 12	203	203				Mostly blue clay.
R. Calhoun	NW.¼ SE.¼ sec. 24	52	27		Limestone		Thin vein of shale (Independence?) in limestone.
J. R. Grove	SW.¼ SE.¼ sec. 21	134	134				
S. Stambaugh	SE.¼ NW.¼ sec. 21	48	40	41	Limestone		Blue clay to rock.
J Paul	NE.¼ NW.¼ sec. 22	204			Gravel	—104	Few feet yellow clay; blue clay to gravel at bottom.
B. F. Parker	NW.¼ SE.¼ sec. 22	85			do	— 65	
J. Berry	SE.¼ NW.¼ sec. 23	49	19			— 30	Drift, 19; hard stone, 5; shale, 20; hard stone, 5.
F. M. Ham	Sec. 24	124	90			— 64	Blue clay from soil to rock.
J. S. Caraway	NW.¼ SE.¼ sec. 25	45	7				
M. Brown	¼ NE. ¼ sec. 27	86	75	86	Limestone		Dry gravel at 40 feet.
G. Berry	NW.¼ NW.¼ sec. 27	137	137				Blue clay, 16 to 137.
R. Berry	NW.¼ NW.¼ sec. 28	129	129				
W. L. Weller	NE.¼ NW.¼ sec. 30	98	45		In crevices		Sand and yellow clay to rock.
T. 82 N., R. 5 W. (Franklin).							
Lester R. Cook	SW.¼ NW.¼ sec. 6	135	135	100	Sand		Water at 35; "river" sand below; yellow and a little blue clay.
D. M. West	SE.¼ SE.¼ sec. 7	60	40		Limestone	— 30	
Dr. Kate Mason	Sec. 16	145	80		do	—100	All blue clay except a little yellow clay at surface.
Elmer Neal	NE.¼ NW.¼ sec. 17	170	170		Sand		Water on rock in a little sand.
Charles Platner	NE.¼ NE.¼ sec. 17	150	80		Limestone	— 70	
Ely West	NE.¼ SE.¼ sec. 20	196	177		do	— 46	Yellow clay, 25; sand, 15; blue clay to rock.
James Milhallen	SE.¼ sec. 18	181	181		do		Yellow clay, 30; blue clay to rock.

MUSCATINE COUNTY.

BY W. H. NORTON.

TOPOGRAPHY.

The larger topographic features of Muscatine county are two uplands and two river plains. Of the plains the more extensive is that of Cedar river, a flat fluviatile or lacustrine floor, aggraded largely in Pleistocene time to its present level, extending across the county from northeast to southwest with a width of six or seven miles. The towns of Wilton, Moscow, and Nichols are situated upon it. This strip of lowland separates the small triangular upland of Kansan drift which occupies the northwest corner of the county from an extensive upland of Illinoian drift which covers the eastern and larger portion of the area.

The second lowland is that of the Mississippi flood plain. Up valley from Muscatine the river approaches the Iowa bluffs, leaving to this county an inconsiderable flood plain hardly more than one-fourth mile wide. South of Muscatine the valley widens. The great river turns sharply southward from its westward course, leaving the crescent of its ancient river-cut bluffs far to the west and separated from the channel by alluvial plains five to six miles wide. Both lowlands are poorly drained and in both ground water stands near the surface. The uplands, while well dissected near their margins, preserve in their central portions flat initial surfaces but slightly etched with erosion channels.

GEOLOGY.

Over most of the county bedrock is deeply buried by deposits laid down by successive ice sheets and their outflowing drainage. The two lowest of these deposits, the Nebraskan and the Kansan drift sheets, are both dark bluish stony clays, hardly to be distinguished in wells except when parted by the deposits of the Aftonian interglacial stage. The Aftonian deposits consist of peaty beds and old soils and of beds of sand and gravel, which occur quite extensively in some townships.

The Kansan drift where weathered is oxidized and reddened, and can scarcely be distinguished by the driller from the yellow stony clay of the overlying Illinoian drift, the uppermost of the drift sheets of the area. The Illinoian and Kansan drifts are not uncommonly separated by ancient soil or peat beds or by seams of sand and gravel. The upper surface of the Illinoian is in many places leached and bleached by long weathering and the reducing action of ancient soils, and is separated from the overlying loess by peaty soils or thin layers of yellow sand.

Outside of small areas negligible in connection with groundwater supplies, the rocks of Muscatine county belong to two geologic systems. (See Pl. XV.) The lower, the Devonian, consists in part of hard gray limestones of numerous types, some fine-grained and brittle, made up of angular fragments (Lower Davenport beds of Iowa State Survey), some gray and tough (Upper Davenport beds of Iowa State Survey), some of shelly limestone, more or less clayey (Cedar Valley limestone); and in small part of green-gray or dark drab shale (Sweetland Creek shale). The upper and later series belongs to the Carboniferous system (Pennsylvanian series or Coal Measures), and is variable both horizontally and vertically, consisting of rapidly changing beds of limestone, sandstone, pebble stone, shale, and coal. It is found only in the southern townships of the eastern half of the county (except in scattered patches) and is evidently an outlier cut off by the trench of the Mississippi from the northern margin of the Illinoian coal field.

UNDERGROUND WATER.

SOURCE AND DISTRIBUTION.

Because of the large areas underlain by river deposits the waters in the alluvial sands and gravels are of exceptional importance in Muscatine county. Muscatine Island and extensive portions of the Mississippi bottoms bounded on the west by

Muscatine slough are supplied by driven wells from 20 to 30 feet in depth. The supply is copious, easily raised to the surface by steam pumps for purposes of irrigation, and the water is so slightly mineralized that it is not injurious to crops. The area is thus rendered independent of rainfall in dry seasons, and this fact, together with the warmth of its light soil, has made Muscatine Island and Fruitland township one of the garden areas of the state and of the upper Mississippi valley.

The wide plain adjacent to Cedar river draws its ground-water supply from driven and dug wells 20 to 40 feet deep, the water bed being a sand underlying the surface loess. Wells deeper than 30 or 40 feet reach horizons where the water is apt to be pretty highly mineralized with iron salts. On some low tracts temporary flowing wells have been obtained by boring through the impervious cover of hardpan. A few deep borings show that the rock floor of the plain lies more than 250 feet below the surface, but the records are not definite enough to show the character of the materials with which this ancient and wide valley has been so deeply filled. From the records of a single well in section 26, Pike township, it may be inferred that beneath the water-bearing sand, which here extends to 30 feet from the surface, is a clay 10 feet thick, beneath which occurs a water-bearing gravel. It is not known whether this gravel is a sheet deposit formed along a delta front encroaching on a lake, or was deposited by a stream the width of the present plain, or was laid down in long narrow strips in the channels of an aggrading stream perhaps no larger than the Cedar of today. At and near Wilton drillers report 90 feet of sand succeeded by 100 feet of blue clay underlain by 10 feet of sand and gravel, the rock floor here not exceeding 470 feet above sea level.

On the eastern upland of the county water occurs in sands covered with a cap of loess, forming certain low long ridges directed generally at right angles to the western margin of the upland. Wells on such ridges may obtain adequate supplies at very moderate depths though wells on the lower ground adjacent would need to go down more than 100 feet before finding water.

On both the eastern and western upland the Aftonian gravel is the chief aquifer. In Lake township these sands and gravels are tapped at about 100 feet below the surface. A general section in the southwestern part of this township is as follows:

Section of Pleistocene deposits in Lake Township.

	Thickness	Depth
	Feet	Feet
Loess and sand	20	20
Clay, blue (Illinoian and Kansan)	100	120
Water sand (Aftonian)	10	130
Clay, blue (Nebraskan)	120	250

The Aftonian is particularly valuable because of the great depth at which bedrock and rock aquifers lie over much of the eastern upland. Here the great bedrock trough which underlies the Cedar river lowlands extends for four or five miles east of the river and the deepest wells go down 250 and even 400 feet without striking rock. Fortunately water is usually found in the Aftonian or, much less commonly, in glacial sands interbedded with or underlying stony clays of the Nebraskan.

The Devonian and Silurian (Niagaran) limestones are important aquifers in the northeastern townships and on the western upland, on which latter bedrock is not reported at less than 200 feet below the surface. Most wells find water in glacial gravels, but a few have been drilled into the country rock. In one well a white limestone is reported to extend from 220 to 350 feet, below which lies 17 feet of brown porous rock, which may be assigned to the Niagaran.

In the four eastern townships drift seldom exceeds 100 feet and numerous wells draw water from the country rock. Where the bedrock is Devonian limestone, water is usually found at a moderate depth from the surface, the deepest wells being those in which the drift is underlain by heavy Carboniferous shales. In Sweetland township two wells found the Coal Measures to be 97 and 120 feet thick, and after piercing these were compelled to go 100 and 185 feet into the subjacent limestones before obtaining adequate supplies.

SPRINGS.

The important springs of the county rise from the Aftonian gravel and the Devonian limestone.

The outcrop of the Aftonian gives rise to numerous and often copious springs. These are well marked near the base of the bluffs bordering Mississippi river south and west of Muscatine in Fruitland and Seventy-six townships. Below the bluffs east of Cedar river, in Moscow township, many springs flow from the drift. Several of these, with a July temperature of 55° F., south and west of Muscatine, are near farmsteads located along the road leading under the foot of the bluffs, and their excellent water is therefore available for house and dairy and all farm purposes. Almost every farm is thus supplied. In some places, where the spring issues from 20 feet or less above the base of the bluffs, sufficient power is developed to run a milk and cream separator. The spring of Edwin Wills is estimated to have 1½ horsepower. Its temperature at outflow is 51° F. Two large springs emerge near Atalissa—one on the farm of David McClure and one on that of Mrs. C. E. Kephart. The latter was leased for several years by the Chicago, Rock Island & Pacific Railway for the supply of its locomotives before the artesian well was drilled at West Liberty.

CITY AND VILLAGE SUPPLIES.

Muscatine.—The city of Muscatine (population, 16,178) has had a public supply since 1875, the plant being owned by the Muscatine Waterworks Company. For about 20 years the raw water of Mississippi river was used, being pumped through a conduit extending 700 feet out into the river. This extremely unsatisfactory supply has recently been completely changed, new works begun in 1904 having been completed and put in use in 1906. The pumping station and wells are situated on the flood plain of the Mississippi, at the south line of the corporation area, three-quarters of a mile from the settled portions of the town. The new supply is drawn from a gang of 13 driven six-inch wells about 50 feet deep and 150 feet apart, located on a line parallel with the bank of Mississippi river and 500 feet distant from it. These wells are pumped through a 20-inch horizontal suction pipe connecting with vertical pipes, extending in each well practically to the bottom. The capacity of the wells is 2,000,000 gallons a day, twice the amount of the present consumption. The pumps are installed in a building 48 feet square, built of reinforced concrete. The cost of the new installation was $100,000, including $40,000 spent for the extension of mains in the south parts of the city. The water is pumped to a reservoir with a capacity of 2,000,000 gallons, situated on West Hill, the bottom of the reservoir being 185 feet above low-water level in the Mississippi. Domestic gravity pressure ranges in different parts of the town from 20 to 90 pounds. Fire direct pressure is from 100 to 150 pounds. There are 16 miles of mains, 185 hydrants, and 1,500 taps.

This very satisfactory supply was chosen at the recommendation of Mr. W. Kiersted, of Kansas City, after an exceptionally thorough investigation of local conditions. Some of the results as given in Mr. Kiersted's report to the council, November, 1903, are of such general interest and wide application that they may be given here in some detail.

The two sources under consideration were (1) Mississippi river, with proper equipment for settling and filtration, and (2) the ground water in gravels underlying Muscatine Island. The preference naturally lay with the latter, provided that the supply should be found of suitable quality and quantity. The physical conditions of this large area of flood plain pointed to an abundant and excellent supply. The land is nearly level and lies but sightly above the maximum high-water line of the river. The soil is sandy, light, and porous. These conditions make the run-off of storm water slight and dispose of a very large percentage of the rainfall by absorption and underflow as ground water. The permanent ground-water surface, determined by the level of low water in the river, lies within 15 or 20 feet of the surface of the ground. Moreover, since the surface of the island lies somewhat above the ground-water level, the porous soil permits rapid alternate circulation of air and water and hence affords an efficient natural filtration.

These indications were fully confirmed by a series of tests:

Nine wells about 65 feet deep were sunk upon the island along a line 3,000 feet in length at right angles to the river and beginning 300 feet from the river bank. The following succession of deposits was found, the thickness of the strata given being that found in the well nearest the river:

Section near Muscatine.

	Thickness	Depth
	Feet	Feet
Soil, sandy, black	3	3
Clay, red, tough, hard; not uniformly distributed or continuous on island	5	8
Sand, red, and fine gravel	10	18
Gravel, coarse	10	28
Sand, coarse, and gravel	15	43
Sand, gravelly	6	49
Sand and coarse gravel	2	51
Blue clay; when dry nearly white; without sand	5	56
Shaly clay or soapstone, hard, laminated, light pink	3	59
Sandstone	6	65

The geologic conditions were thus found to be extremely favorable for a large yield of ground water. A bed of porous sand and gravel 50 feet in depth, resting on an impervious floor and water-logged to a depth of 30 feet, was found to underlie the area.

The question still remained as to the permeability of the gravels and whether they could deliver a supply adequate to emergencies as well as to the ordinary demands of city consumption. To aid in solving this problem a series of observations extending from September 6 to October 26, 1903, were made on the static level of the water in the test wells and in the river, in order to obtain data as to the ground-water slope and the effect of fluctuations of the water level in the river on the ground-water surface of Muscatine Island.

Up to September 13 the river fluctuations of level were small and the ground-water surface was comparatively stable for a distance of 3,300 feet west of the river. The pronounced slope of the ground-water surface toward the river (0.8 foot in 1,000 feet) demonstrated the underflow of the absorbed rainfall toward the Mississippi. Between September 13 and 21 the river rose a little more than two feet, causing a rise of 2.1 feet in well No. 1, 300 feet distant from the river, and a rise in the other wells, decreasing in amount with increasing distance from the river, until at well No. 9 the increase was but 0.3 foot. The slope of the ground-water surface toward the river was still well defined. Obviously the rise of the river dammed the underflow in its riverward movement. From these data it was computed that the water in the saturated gravels to a depth of about 43.5 feet flowed toward the river at a rate of at least 2½ feet a day.

About September 23 the river rose a little more than four feet. The slope of the ground-water surface was now reversed, and with continued high water so remained until October 9. The average slope inland of the ground-water surface was 0.84 foot in 1,000 feet, and from this there was computed an average rate of movement of river water inland of 2.3 feet a day. Using the velocity per day and the inclination of the ground-water surface, the average factor of porosity of the medium was obtained by Dupuit's formula. This factor was found to be 5,000 a foot, indicating a very porous subsoil formation compared with similar experiments and observations made elsewhere. Continuous pumping tests were made of well No. 1 for 125.5 hours, and simultaneous observations of the water level in the other test wells, in order to procure information as to the porosity and continuity of the gravel deposits. The delivery of the pump was computed at 1,500,000 gallons a day. During the test the water in the river rose over three feet, and notwithstanding the large amount of water pumped from the ground, the water of all the wells showed a corresponding rise. The zone affected by the pumping extended 700 feet.

The data secured by these tests settled most satisfactorily the questions as to the capacity of the supply and there only remained the question of the purity of the water. The geologic conditions pointed to a rapid and effective natural filtration of surface water, with a consequent destruction of pathogenic bacteria. A series of tests of the water of the test wells with sanitary and bacteriological analyses fully confirmed this inference. Although the chemical analyses showed a high per cent of fully decomposed organic compounds, and of chlorine and nitrates in all the samples, owing to the fact that much fertilizer is used on the cultivated fields of the area, the percentage of undecomposed or partly decomposed organic compounds—ammonia, albuminoid ammonia, and the nitrates—was small, showing an effective purification of the surface waters by the natural filtration of the sandy soil. The bacterial analyses confirmed the chemical, showing but few bacteria and these of harmless varieties.

The question was also considered of the effect which the depression of the ground-water surface by a continuous draft in the area of supply would have upon the underflow of the contaminated ground water of South Muscatine. It was found that even in years of minimum rainfall the natural movement of the ground water of South Muscatine to the river could not be so diverted down valley as to reach the intake area of the city wells.

The recent installation of the shallow wells described makes artesian forecasts unnecessary so far as the municipality is concerned. But in a city as large as Muscatine and with extending industries, it may be taken for granted that sooner or later information as to artesian possibilities will be useful to manufacturers and other large consumers who for various reasons may have under advisement an individual water supply.

At Muscatine (elevation, 552 feet) the drill will penetrate first the Devonian and Silurian (Niagaran) limestones, reaching the Maquoketa shale (Ordovician) at about 500 feet and may find small flows in either limestone terrane. These flows will be under low head and should be cased out so as to prevent the lateral escape of the deeper waters through their channels. The Maquoketa strata, which are weak and caving, should be cased. Good flows under moderate pressure should occur in the Galena and Platteville limestones which immediately underlie the Maquoketa, from about 725 to 1,025 feet from the surface, and it is possible that the yield will be sufficient for some industrial plants. To carry these waters a bore of four or at most five inches will be ample. For larger drafts the Saint Peter sandstone and the loose-textured sandstones and creviced and vesicular limestones which underlie it must be utilized, and in these an inexhaustible supply of water of fine quality should be found.

To tap them the well should be sunk to 1,500 or 1.600 feet. To tap the underlying Cambrian beds drilling should continue about 400 feet deeper still, but it is not apprehended that this will be needed. The pressure should considerably exceed 20 pounds.

West Liberty.—The town of West Liberty (population, 1,666) has drawn its water supply from artesian wells since 1888. (See Pl. XV, p. 812.) Water is pumped directly through the mains, and also to an elevated tank holding 60,000 gallons, giving a domestic pressure of 40 pounds and a fire pressure of 100 pounds. There are 7 miles of mains, 27 fire hydrants, and 472 taps. The consumption is 45,000 gallons daily, and the water is said to be used by 90 per cent of the population.

The extension of the waterworks in 1899, involving the sinking of a new artesian well, was financed in an ingenious way, worthy of record. Owing to the change in the State assessment laws which went into effect in 1897, the valuation of property in the town was reduced many thousands of dollars. The municipal indebtedness, which had been increased by the building of the water works and an electric lighting system, was thus brought to near the legal limit. Another bond issue for the extension of the waterworks was thus out of the question. In this emergency thirty public-spirited citizens advanced the money for the extension and were paid out of the revenues of the waterworks. The city council entered into contract for an artesian well to be drilled upon the city's lot, the well to remain the property of the driller and contractor until the annual rentals received by him equaled the cost of the well, when its ownership was to be transferred to the city. The annual rental was fixed at $600 and 6 per cent interest on the cost of the well. When the well was tested and accepted, the driller's lease was purchased by the thirty citizens. The total cost of the well, $3,600, was raised by six promissory notes, drawing 6 per cent interest and due in six years, each note being signed by five persons drawn by lot from among the thirty. All payments, rentals and interest were indorsed pro rata on each note, thus keeping them equal in amount until their final liquidation. With the extension of the water system the revenues increased, all payments were promptly met, and at the end of six years the notes had all been paid and, under the terms of the lease, the well passed into the full ownership of the municipality.

City well No. 1 has a depth of 1,768 feet and a diameter of 6 to 4 3-16 inches; casing to 128 feet. The curb is 696 feet above sea level. The head was originally 9 feet above curb; in 1896, at curb or below. The original discharge was 120 gallons a minute. Temperature, 65° F. Date of completion, 1888. Driller, A. K. Wallen.

During the drilling the water stood at 40 feet below the curb for more than 1,000 feet. At 1,040 feet, the horizon of the Saint Peter, it rose 20 feet. Rising a little higher each day, it overflowed when the drill reached a depth of 1,354 feet and the flow increased as the drill went still deeper. A tube sunk to 1,100 feet and packed at base decreased the flow and was taken out. In 1900 the head had fallen to 12 feet below the surface and the pumping capacity to 75 gallons a minute.

Record of strata in well No. 1, at West Liberty.

	Depth of sample in feet
Silurian:	
Niagaran dolomite—	
Dolomite, light bluish gray	400
Ordovician:	
Saint Peter sandstone—	
Sandstone, very fine white particles, angular	1,000
Sandstone, coarser, larger grains rounded, "from 1,040 to 1,080"	1,050
Prairie du Chien stage—	
Shakopee dolomite—	
Sandstone, moderately coarse, white; unusually sharp to the touch; under microscope many grains are seen to be faceted with secondary crystalline enlargements	1,160
Dolomite, gray; considerable arenaceous admixture in drillings	1,250
"Flint" 12 inches thick; no sample	1,260
Dolomite, white; considerable admixture of finest particles of quartz	1,290
New Richmond sandstone—	
Dolomite, highly arenaceous	1,310
Oneota dolomite—	
Dolomite, white, porous	1,380
Sandstone, larger grains rounded; mostly angular particles with some dolomite	1,400
Sandstone; matrix calciferous	1,450
Cambrian:	
Jordan sandstone—	
Sandstone, in fine powder of particles of quartz and a little dolomite	1,500
Sandstone, saccharoidal, rather coarse, white; grains usually rounded, some faceted	1,600
Saint Lawrence formation—	
Dolomite, hard, pinkish	1,765

City well No. 2 has a depth of 1,594 feet and a diameter of 12 inches to 202 feet, 8 inches to 1,016, and 6 inches to bottom; casing 96 feet to rock. The curb is 671 feet above sea level; the head was not tested. The original discharge was 225 gallons a minute. Temperature, 66° F. The well was completed in 1900 by W. H. Gray & Brother, of Chicago.

Water stood 20 feet below the curb until the Saint Peter sandstone was reached at 1,015 feet, with a thickness of 40 feet, when it overflowed with a discharge of 20 gallons a minute. At 1,411 feet a pumping test developed a capacity of 240 gallons a minute, with the cylinder at 100 feet below curb, and 300 gallons with the cylinder at 135 feet, the natural flow being estimated at 75 gallons. At 1,435 feet the flow had increased to 100 gallons a minute. No perceptible increase occurred during the next 100 feet, but at 1,583 feet, in sandstone, a sudden increase was noted. At 1,584 feet a crevice was encountered and the flow suddenly rose to 225 gallons a minute at the base of the sandstone. Since 1902 or 1903 a gradual decrease in the head and flow of the well has been observed, the water now barely overflowing. Under continued pumping, the suction pipe extending to 26 feet below the curb, the water is lowered to 20 feet below the surface.

The only record extant is that of three water-bearing sandstones; the first, from 1,015 to 1,055 feet (344 to 384 feet below sea level), the Saint Peter; the second, from 1,300 to 1,435 feet (628 to 764 feet below sea level); the third, from 1,535 to 1,584 feet (864 to 913 feet below sea level), occupying the horizon of the Jordan.

The Iowa Condensed Milk Company well has a depth of 1,721 feet and a diameter of 12 inches to 150 feet, 7 inches to 1,000 feet, and 6 inches to bottom; cased to 120 feet; bedrock at 90 feet. The curb is 669 feet above sea level and the head, above curb. The tested capacity is 300 gallons at 1,600 feet. The first flow was at about 1,000 or 1,025 feet and increased to the bottom. The well was completed in 1904 by Gray Brothers, of Chicago.

Wilton.—At Wilton (population 1,157) the water supply is pumped from a deep well to a tank whose capacity is 50,000 gallons. Domestic pressure from the full tank is 54 pounds and the direct pressure for fires is 110 pounds. The daily consumption ranges between 15,000 and 25,000 gallons daily. There are 2 miles of mains, 23 fire hydrants, and 180 taps.

The well (Pl. XV.) has a depth of 1,360 feet and a diameter of 8 to 6 inches; casing to 900 feet. The curb is 683 feet above sea level. The original head, as reported, was 18 inches above the curb; the present head is 20 feet below. The original discharge was 300 gallons a minute; the present pumping capacity is 120 gallons a minute. The first flow was at 900 feet. Date of completion, 1891. The well was reamed to an unreported depth in 1900 without effect on supply.

Driller's log of city well at Wilton.

	Thickness	Depth
	Feet	Feet
Drift	220	220
Limestone (Niagaran)	280	500
Shale (Maquoketa)	180	680
Limestone (Galena and Platteville)	300	980
Sandstone (Saint Peter)	120	1,100

Minor supplies.—Water supplies at minor villages are set forth in the following table:

Village wells in Muscatine county.

Town	Nature of supply	Depth	Depth to water bed	Head below curb: Shallow wells	Head below curb: Deep wells	Depth to rock
		Feet	Feet	Feet	Feet	Feet
Atalissa	Bored and drilled wells	30-180				
Conesville	Driven wells	10-20		10		
Cranston	do	120-125	120		100	
Fairport	Wells and river	12-217	12	9	30	25
Fruitland	Driven wells	12- 30		8		
Moscow	do	20- 50	32	20		
Stockton	Drilled and dug wells	40-180				
Sweetland	Wells	16-300		10	60	
Nichols	Driven wells	16-20				

WELL DATA.

The following table gives data of typical wells in Muscatine county.

Wells of Muscatine County.

Owner	Location	Depth	Depth to rock	Source of supply	Remarks: (Logs given in feet)
T. 78 N., R. 4 W. (Part of Wapsinonoe).		Feet	Feet		
Joseph Mountain	6 miles southwest of West Liberty	266	206	Sand	Yellow clay underlain by dry sand, 60; blue clay, 42; gray sand with a little water, 6; blue clay to rock. Well weak, closed. Another 30 feet away found plenty of water in yellow sand 8 feet thick at 95, under blue clay.
T. W. Stoops	Sec. 8	220	220		Loess, 6; yellow clay, 20; sand, 2; blue clay, 160; sand, 28; cream-colored rock at 220.
R. Wagner	Sec. 15	175			Mostly drift.
John Gibson	Sec. 18	284	284		
Pliny Nichols	Sec. 20	367			White limestone from 220 to 350; below this a porous brownish rock.
Frank Hunter	Sec. 23	120		Sand	
Christian Wolf	Sec. 28	246		do	Unknown, 40; blue clay, 60; sand, 6; yellow clay, 25; blue clay with muck, wood and sand, 107; sand, 8.
F. Kirchner	Sec. 32	398	200		Rock; hard and white above; reddish and porous below.
T. 78 N., R. 3 W. (Goshen; part of Wapsinonoe).					
Louis Watson	Sec. 7	138	95	Limestone	Loess, 15; blue clay, 50; yellow bowlder clay, 30; soft brown limestone, 43.
Frank Barnes	Sec. 1	156	50	Devonian limestone	Drift, 50; Coal Measures, 100; limestone, 6.
W. A. Howell	Sec. 5	58		Sand	Yellow clay, 15; blue clay, 35; sand, 8.
John Venatta	Sec. 8	245	100	Limestone	Drift, 100; limestone, 145.
George Venatta	Sec. 9	220	95		Yellow stony clay, 20; blue clay, 60; brown stony clay, 15; blue limestone, 80; soft brown material, 8; hard limestone, 29; soft limestone, 8.
Isaac Dickenson	do	78	64	Carboniferous sandstone	Yellow clay, 15; blue clay, 25; sand, 4; hardpan, 20; soft yellow sandstone, 14.
—— Overman	Atalissa	136	86		Yellow clay and sand, 42; blue clay, 44; blue limestone (Devonian), 44; brown porous limestone, 6.
Mrs. Morris	3 miles east and 2 miles north of West Liberty.	226	94		Yellow clay, 40; dry sand, 2; blue clay, 50; sand with water, 2; blue limestone, 110; shale, 8; white porous rock with water, 14.
	Sec. 26	200	198		

Wells of Muscatine County—Continued.

Owner	Location	Depth	Depth to rock	Source of supply	Remarks: (Logs given in feet)
T. 78 N., R. 1 W. (Wilton; part of Sweetland).		Feet	Feet		
E. Reimers	Sec. 2	312		Sand	Yellow clay, sand, and gravel, 60; blue dirt, 80; quicksand, 60; blue clay, 90; coarse sand, 22.
William Boot	Sec. 9	200		Sand and gravel.	Sand, 90; blue clay, 100; sand and gravel, 10.
Hans Kai	Sec. 10	101	90		
W. Felthorn	Sec. 13	100		Sand	Yellow and blue dirt, 14; brown sand, 7; blue clay, 68; sand, 10.
C. W. Collins	Sec. 14	113		Gravel	Yellow clay, 8; blue clay, 32; black "hardpan" (till?), 68; gravel, 5.
—— Smith	Sec. 15	135	100		Sand, 10; blue clay, 20; sand, 30; blue clay, 40; rock, 35.
M. A. Roy	Sec. 27	135	134		Yellow clay and sand, 20; blue clay, 108; sand, 6; rock, 1.
S. Wintermirte	Sec. 36	67+		Sand	Clay, 48; gravel, 4; blue and yellow pebbly clay, 10; ashen clay, 5; sand.
T. 78 N., R. 1 E. (Fulton).					
J. H. Broders	Sec. 3	106	78		Yellow and blue clay, 70; sand, 8; limestone, 28.
H. Stoltenburg	Sec. 12	105	70		Drift, 70; soft white limestone, 35.
C. Wolfe	Sec. 23	75	70*		
	Sec. 31	121	116		Drift, 116; rock, 5.
	Sec. 33	144	115		Yellow clay, 30; blue clay, 40; quicksand, 7; blue dirt (probably in part shale), 38; rock, 29.
T. 77 N., R. 1 E. (Montpelier).					
C. Howard	Sec. 9	101	20		Drift, 20; sandrock, 80; limestone, 1.
T. 77 N., R. 1 W. (Sweetland).					
Frank Nettlebush	Sec. 27	322	40	Limestone	Drift, 40; soft sandstone, 40; soapstone, 57; limestone, 185.
Daniel Roberts	Sec. 18	80		Sand	Yellow clay, 3; sand and clay, 77.
J. Newman	Sec. 4	60		do	Yellow clay, 5; blue pebbly clay, 25; forest bed, 10; ashen clay changing to sand, 20.
P. Brosart	Sec. 26	200	130		Drift, 130; sandstone and shale, 65; limestone, 5.
J. Monsen	Sec. 20	304	90	Limestone	Drift, 90; Coal Measures, 120; limestone, 94.

*More or less.

Wells of Muscatine County—Continued.

Owner	Location	Depth	Depth to rock	Source of supply	Remarks (Logs given)
		Feet	Feet		
T. 77 N., R. 2 W. (Bloomington; part of Lake).					
G. Parks	Sec. 5	115		Sand	Loess and blue clay, 105; sand, 10.
County Farm	Sec. 33	208	180		Clay, 100; sand, 20; clay, 60; limestone, 28.
T. 77 N., R. 3 W. (Parts of Lake and Pike).					
F. P. Wood	Sec. 27	265		Sand	
C. Humphries	Sec. 13	100		do	
I. Sager	Sec. 25	150		do	
T. 77 N., R. 4 W. (Part of Pike).					
	Nichols	250		Gravel	No rock; all clay, sand and gravel; well tubed 250 feet.
G. N. Aylesworth	Sec. 26	59		do	Sand, 30; clay, 10; gravel, 19.
T. 76 N., R. 4 W. (Orona and Cedar).					
William Verink	Sec. 14	80		Sand	Loess, 15; yellow sand, 40; blue clay without pebbles, 10; white sand with gas, 15.
A. Cone	Sec. 24	200+			Soft till, 130; hard blue till, 60.
C. Carpenter	Sec. 33	125		Sand	Loess and yellow sand, blue clay, sand below.
T. 76 N., R. 3 W. (Seventy-six; part of Fruitland).					
J. Venatta	Sec. 2	150		do	
	Sec. 10	115			Bluff. Loess, 12; old soil, 3; mainly blue till, 100.
A. Migim	Sec. 10	170			Ridge. Loess, 12; yellow till, 38; gravelly sand, 25; blue till, 25; yellow cemented gravel, 10; hard blue till, 60.
Daniel McCabe	Sec. 11	80		Gravel	Sand, blue clay, and gravel. Base of bluff.
Patrick O'Brien	Sec. 17	175		Sand	
H. J. Jeffries	Sec. 22	94			Yellow clay above; red sand, 60; white sand and gravel.
T. 76 N., R. 2 W. (Part of Fruitland).					
I. W. Kincaid	Sec. 5	160	160		Base of bluff.

POWESHIEK COUNTY

BY HOWARD E. SIMPSON AND W. H. NORTON.

TOPOGRAPHY.

Poweshiek county is situated slightly southeast of the central portion of Iowa. As it has scarcely a stream large enough to bear the name of river, save perhaps the North Skunk, which crosses the southwest corner, its drift plain is a broad rolling prairie of decided upland type. The county is, however, divisible into two distinct topographic areas, coincident in a general way with the surface areas occupied by two drift sheets, the Iowan and the Kansan.

Iowan drift covers about 75 square miles in the northwestern part of the county, its eastern edge being not far east of Sheridan and Westfield. Here the plain is gently undulating, broken only by a few swells and by slight sags, in which grassy sloughs may be found. The stream channels are neither numerous nor well defined, and, in fact, this area bears all the characteristics of topographic youth; it remains very much as it was molded by the overriding ice.

The much larger, south and east portion of the county belongs to the Kansan drift area and presents evidences of early maturity. The stream valleys are comparatively deep and broad, and the uplands, though still broad, are almost completely drained through a multitude of small V-shaped valleys.

The drainage is southeastward through characteristic prairie creeks tributary to Iowa, English, and Skunk rivers. The largest streams, especially the North Skunk, have well-developed flood plains. Only in the northwest corner is the imperfection of drainage shown by small sloughs and ponds, remnants of old and larger glacial lakes occupying depressions in the drift. Even these are almost extinct, for man is aiding nature in the work of drainage, both by open ditches and by tile.

GEOLOGY.

The country rock of Poweshiek county (Pls. VIII, XV) belongs to the Carboniferous system, the Osage stage and Saint Louis limestone of the Mississippian series and the Des Moines stage of the Pennsylvanian series being represented. The Mississippian rocks consist of limestones and some shales, so similar as not to be distinguished in ordinary well borings. They form the country rock over about three-fourths of the county, lying north and east of a line passing near Newberg, Grinnell, Jacobs, Montezuma, and Tilton. The Des Moines stage (Pennsylvanian) consists chiefly of shales, together with some sandstones and limestones, and is the productive coal division. It unconformably overlies the Mississippian west and south of the line mentioned above, except where North Skunk river has cut through and the alluvium rests directly upon the Saint Louis limestone.

The older Kansan drift rests upon the country rock and is overlain in the northeast corner by the younger Iowan drift and elsewhere by a thin veneer of loess. In places there seem to be traces of a drift older than the Kansan, but these have not yet been well made out.

UNDERGROUND WATER.

SOURCES.

In Poweshiek county water is obtained from the alluvium, including some outwash gravels, the drift, the Des Moines stage, the Mississippian limestones, and deeper strata. Only the drift and the Mississippian limestone are of importance.

The alluvium in the stream valleys is comparatively unimportant, owing not only to its small areas, but to its slight depth. However, in the valleys of North Skunk and a few of the larger creeks sufficient gravel, probably of Buchanan age, underlies the silt in such a way as to permit a strong underflow, which is utilized in shallow driven and open wells, chiefly in pasture wells for stock.

The water beds of the drift are several in number, but are not generally differentiated. In the loess-Kansan area shallow wells secure a meager, variable, and insufficient supply in the sandy phase at the base of the loess. In the Iowan area a gravel corresponding to the Buchanan gravel is not uncommon between the Iowan and Kansan drifts, but is not easily distinguished on the uplands and is variable and uncertain as a source of supply. In the valleys it is more important, but can not there be distinguished from the alluvial sands, and has therefore been classed with them.

The persistence and abundance of their waters makes the extensive gravel deposits which lie deep below the surface of the Kansan drift, the most valuable of all the Pleistocene sources. In many places these gravels are double, one bed occurring well up within the drift and another at the base. The former is probably of Aftonian age while the latter is probably residual rock material or rubble from the surface of the bedrock. Whatever their origin, they form excellent waterways and reservoirs. In Poweshiek county these gravels are all deeply buried, lying at depths of 50 to 200 or even 400 feet.

Small veins and seeps are found at intervals throughout the drift, and from these by far the greater number of the wells in Poweshiek county draw a somewhat variable supply of good, wholesome water. Only when larger supplies for town or stock-farm use are desired is it necessary to resort to rock wells.

The Des Moines stage consists chiefly of shales, too impervious and too strongly impregnated with mineral matter to be of value as a water bearer. A few local sandstone beds furnish good water but these are not common in the thin margin of the formation found in Poweshiek county.

The Mississippian limestones have sufficient sandy and porous layers to form a good water bed, which is persistent throughout Poweshiek county. Though deeply buried by drift, this bed may well be sought where a moderately large and constant supply is desired. Though hard, it is generally free from obnoxious minerals and is an almost ideal stock water. Wells of 180 to 200 feet are most common, but some of 400 and 500 feet are reported.

Deeper sources are reached by the city wells at Grinnell (p. 578) and by a well on the "Farwell ranch," near Montezuma; this last is reported to be about 2,500 feet in depth, but no record of it is obtainable.

BELLE PLAINE BASIN.

About four square miles of the extreme northeast corner of Poweshiek county is included within the Belle Plaine artesian basin (pp. 426-429). Within this area wells ranging from 200 to 250 feet in depth yield a strong flow. In other near-by wells the water rises close to the curb but does not flow.

SPRINGS.

A number of strong springs are found in Poweshiek county, especially in the southern and eastern parts. The spring near Montezuma (p. 583) and one on the farm of W. H. Taylor, south of the town, are among the more important.

CITY AND VILLAGE SUPPLIES.

Brooklyn.—The public supply of Brooklyn (population, 1,233) is from a 208-foot well, the water bed being a sand and gravel layer, probably Aftonian, overlying blue clay near the bottom of the well. A higher water bed was found at 80 feet, but the flow was insufficient. This is the fourth well put down to this water bed, the others being abandoned chiefly on account of difficulty with sand. The present well was sunk in 1903, is used without a screen, and no trouble is experienced.

The water is pumped by a gasoline engine into an elevated tank that holds 16,920 gallons. The gravity pressure is 76 pounds in the business district and in case of fire may be raised to 220 pounds by direct pressure. A large reservoir, having a capacity of 1,000 barrels, is used to supplement the tank and hold the reserve; 2½ miles of mains supply 22 hydrants and 180 taps. Only about 500 or 600 barrels are used daily.

An excellent water supply is that of John F. Scott, on Jackson Street, whose well probably reaches at 230 feet the same gravel bed that supplies the city well. The water is pumped by windmill to an elevated tank and supplies some of the neighboring houses. The Chicago, Rock Island & Pacific Railroad uses the water of a small creek in preference to a shallow well.

In the vicinity of Brooklyn drift wells are ordinarily dug to about 40 feet, though they range from 15 to 65, and some on the higher lands reach 90 feet. An abundance of good water is ordinarily obtained at this depth in gravel probably of Aftonian age. For larger supplies the gravels and sands at the base of the drift, in places at depths of 200 to 230 feet, are sought. The great depth of the drift and the abundance of water in its lower gravel beds is such that rock is rarely reached. The depth of the limestone is variously reported from 150 feet to the very unusual depth of 400 feet. Water from limestone is hard but very constant in supply.

The elevation at Brooklyn is 848 feet above sea level. The drill will probably leave the Kinderhook about 500 feet above sea level, will find the Silurian limestones from 275 above to 75 feet below sea level, the Maquoketa shale to 300 feet below, and the Galena and Platteville limestones to 600 feet below sea level, at which depth the water bed of the Saint Peter sandstone should be discovered. Drilling should be carried at least 300 feet deeper, or to 900 feet below sea level (1,750 feet from the surface), in order to secure the flows from the creviced limestones and the sandstones underlying the Saint Peter. Water will probably be found in the Galena and surely in an adequate amount in the Saint Peter and adjacent terranes. The Silurian is probably here somewhat gypseous, and absolutely water-tight casing should be carried down to the Galena and securely bedded there with the best of packing.

Deep River.—The village of Deep River (population, 467) owns a waterworks system in which a deep well is pumped by gasoline, compressed air being used to force the water from the storage tank through a mile of mains to 11 fire hydrants and several private taps under a normal pressure of 25 pounds, which is increased in case of fire to 65 pounds.

Most wells are in drift and are 30 to 40 feet in depth. Heavy beds of sand are reached at about 135 to 175 feet, and of limestone between 200 and 250 feet. All ground water is hard, but the limestone water is harder than the drift water.

Grinnell.—The public water supply of Grinell (population, 5,036) is obtained from deep wells (Pls. VIII, XV) by an air lift and is emptied into a covered reservoir (capacity, 188,000 gallons) at a rate of 7,500 gallons per hour. From this reservoir the water is forced into the main standpipe by a direct-pressure pump having a capacity of 1,000 gallons a minute. A pressure of 50 pounds is ordinarily maintained, but this may be increased to 125 pounds in case of fire after cutting off the standpipe. A battery of two boilers of 50 horsepower each furnishes the steam for the station plant. From the standpipe 5½ miles of mains distribute the water to 55 fire hydrants and many private taps.

A second supply suitable for boiler purposes is obtained from Crescent lake, formed by impounding the waters of a small branch of Sugar creek. From this it is pumped into an elevated tank, located at the city station, which has a capacity of 40,000 gallons. Two miles of mains distribute about 40,000 gallons daily, under 25 pounds pressure, to the city waterworks and the electric light plant, and to practically all the manufacturing plants of the town using steam power. It makes a very satisfactory boiler supply. The amount available is limited only by the capacity of the pump, approximately 10,000 gallons an hour.

City well No. 1 has a depth of 2,003 feet and a diameter of 10 inches to 208 feet, 6 inches to 408 feet, 5 inches to 1,185 feet, and 4 inches to 2,003 feet; 10-inch casing is used to 208 feet, 5-inch from 408 to 958 feet, and 4-inch from 1,145 to 1,185 feet. The curb is 1,028 feet above sea level and the head 230 feet below the curb. The tested capacity is 105 gallons a minute. Strongly mineral water, almost yellow in color, rises from the depth of 212 feet to 90 feet below the curb; water also occurs at 1,530 feet, at 1,700 feet and lower. The well was completed in 1893 by J. P. Miller & Company, of Chicago.

Record of strata in city well No. 1 at Grinnell.

	Thickness	Depth
	Feet	Feet
Quaternary:		
Soil, loess, and drift	212	212
Carboniferous (Mississippian):		
Saint Louis limestone and Osage stage—		
Limestone, rather soft, buff; in chips mixed with sand and small pebbles of northern drift	8	220
Shale, dark gray, fissile; fragments of impure chert; in light drab argillo-calcareous powder	20	240
Limestone, cherty, arenaceous, argillaceous; after washing is seen to contain many minute crystals of selenite	30	270
Limestone, gray; as fine sand in argillo-calcareous powder	45	315
Limestone, cherty, and shale; as chips in argillo-calcareous powder	50	365
Shale and limestone; soft, fissile, dark drab; in powder; with a few minute fragments of limestone and considerable chert	35	400
Kinderhook stage—		
Shale, blue, calcareous; in powder, concreted into readily friable masses containing microscopic particles of quartz	15	415
Shale, hard, green-gray; with compact, light yellow, calcareous, siliceous, angular grains of transparent quartz, the largest 0.09 mm. in diameter	20	435
Shale, fine-grained, calcareous, greenish	5	440
Shale, brownish drab	10	450
Shale, light blue-gray, somewhat calcareous; 2 samples	100	550
Shale, brownish drab	20	570
Devonian:		
Limestone, fine-grained	-------	570
Shale, light blue-gray, seleniferous, calcareous; a few particles of limestone	30	600
Shale, light drab and bluish, somewhat calcareous; a little finely divided quartzose residue after washing; 5 samples	200	800
Silurian:		
Limestone, light yellow-gray, granular, subcrystalline; brisk effervescence; much shale	10	810
Shale and limestone; in light blue-gray argillaceous powder containing a few fragments of limestone	15	825
Shale, light blue and green-gray; somewhat calcareous; 7 samples, last at 900	115	940
Limestone, magnesian, medium dark gray, earthy, argillaceous	9	949
Limestone, magnesian or dolomite; considerable hard, finely arenaceous, greenish shale	20	969
Shale, light gray, argillo-calcareous	21	990
Limestone, highly cherty	22	1,012
Limestone, white, soft	53	1,065
Limestone, highly cherty; 2 samples	65	1,130
Limestone, cherty	45	1,175
Dolomite or magnesian limestone, light buff; in fine sand	25	1,200
Ordovician:		
Maquoketa shale—		
Shale, light drab, calcareous	60	1,260
Shale, light brown, pyritiferous; 2 samples, last at 1,280	60	1,320
Magnesian limestone or dolomite, buff; residue cherty and microscopically arenaceous	60	1,380
Shale, brown	20	1,400
Galena dolomite—		
Magnesian limestone or dolomite, ferruginous; in dark buff powder; residuary quartzose particles 0.018 to 0.18 millimeter in diameter; 4 samples	75	1,475
No samples	135	1,610
Limestone, magnesian, cherty, light yellow; in powder	20	1,630
Limestone, light gray, fossiliferous; in flaky chips	10	1,640
Decorah shale—		
Shale, green, noncalcareous, "fossiliferous"	15	1,655
Platteville limestone—		
Limestone, magnesian; in buff powder	45	1,700
Saint Peter sandstone—		
Sandstone, calciferous; quartzose particles from 0.018 to 0.18 millimeter in drillings	6	1,706
Sandstone, white; grains rounded and smooth; usual size about 0.55 millimeter, largest 0.92 millimeter in diameter	34	1,740
Sandstone, light reddish buff; fine grains, mostly broken; many stained with film of ferric oxide; largest 0.28 millimeter in diameter	-------	1,740
Prairie du Chien stage—		
Shakopee dolomite and New Richmond sandstone—		
No samples	262	2,002
Sandstone, highly calciferous, or limestone, arenaceous; sand grains angular, some rounded; largest 1 millimeter in diameter, matrix of dolomite, white, at	-------	2,003

Record of strata in city well No. 2 at Grinnell (Pl. VIII, p. 420).

	Thickness	Depth
	Feet	Feet
Pleistocene (209 feet thick; top, 1,028 feet above sea level):		
No sample	41	41
Till, greenish yellow	49	90
Till, blue	85	175
Till, blue; darker than above	5	180
Till, blue; lighter	29	209
Carboniferous (Mississippian):		
Saint Louis limestone and Osage stage (191 feet thick; top, 819 feet above sea level)—		
Limestone, buff, dense, hard; brisk effervescence; in small cuttings and concreted powder	5	214
Sandstone, highly calcareous; grains of clear quartz, coarse, diverse in size, imperfectly rounded	26	240
No record	6	246
Limestone, light blue-gray; dull luster; slow effervescence; some cuttings of sandstone, dark blue, fine-grained	2	248
No record	8	256
Limestone, blue, highly cherty, argillaceous, pyritiferous; effervescence slow, also shale	12	268
Limestone, light gray, fossiliferous, encrinital; brisk effervescence	32	300
Chert: in large chips, some limestone	25	325
Limestone, blue-gray and whitish; cherty and with microscopic angular particles of quartz; brisk effervescence	25	350
Limestone, light gray, cherty, arenaceous; rapid effervescence	25	375
Shale, light blue-gray; in powder; chert, blue; and limestone, gray	25	400
Kinderhook stage (167 feet thick; top, 628 feet above sea level)—		
Shale, blue-gray; in friable concreted powder; largely composed of microscopic angular particles of quartz	15	415
Shale, green-gray; in hard concreted masses, quartzose	5	420
No record	5	425
Shale, blue-gray and olive-gray, calcareous; in tough concreted masses; 7 samples	142	567
Devonian (216 feet thick; top, 461 feet above sea level):		
Limestone, gray; rapid effervescence; crystalline; some chips pyritiferous; much shale from above	25	592
Shale, light blue, calcareous; in tough concreted masses	8	600
Limestone, blue-gray; rapid effervescence; also shale, blue	33	633
Shale; in tough, blue, concreted masses; 2 samples	67	700
Limestone, drab, hard; rapid effervescence; and shale, blue, in concreted masses	23	723
Limestone, light yellow-gray, argillaceous, or shale, highly calcareous; in concreted powder	27	750
Limestone, light yellow-gray, lithographic; brisk effervescence	26	776
Shale, blue, somewhat calcareous	7	783
Silurian (414 feet thick; top, 245 feet above sea level):		
Limestone, brown, crystalline; rapid effervescence; in angular sand; also gypsum, in white cuttings	77	860
Limestone, light gray, hard, compact, subcrystalline	10	870
No record	5	875
Limestone, light yellow-gray and dark drab; moderately rapid effervescence; much white gypsum	14	889
Shale, calcareous, light blue; chert, white; and light gray limestone of slow effervescence	26	915
Dolomite, light gray, crystalline; slow effervescence	35	950
Dolomite, light brown, macrocrystalline; in large chips; a little white gypsum	40	990
Dolomite, light gray, crystalline; in small chips	10	1,000
Gypsum, white, with shale, hard, dark green, calcareous, and highly arenaceous; fairly large rounded grains and minute angular particles	25	1,025
Gypsum and shale; in whitish concreted powder	5	1,030
Chert, white, gray, yellow and black; with limestone, light gray, of rapid effervescence	10	1,040
Limestone, light yellow-gray, macrocrystalline; rapid effervescence; chert, white; and hard, green, arenaceous shale; cuttings chiefly chert	40	1,080
Limestone, light gray, earthy; rapid effervescence; much white chert	30	1,110
Limestone, whitish and light yellow; rapid effervescence; shale, reddish and green; calcareous in molded masses; flint, brown and gray	10	1,120
Limestone, whitish, pink, and yellow, with much gray flint; shale, dark green and a little dark reddish; all concreted in greenish argillaceous powder	30	1,150
Limestone, whitish and yellow; rapid effervescence; much chert	20	1,170
Limestone, magnesian or dolomite, crystalline, light yellow	27	1,197
Ordovician:		
Maquoketa shale (211 feet thick; top, 169 feet below sea level)—		
Shale, green, slightly calcareous	23	1,220
Shale, green and brown	3	1,223

Record of strata in city well No. 2 at Grinnell—Continued.

	Thickness	Depth
	Feet	Feet
No samples	40	1.263
Shale, dark brown, bituminous, burning freely; and rather hard, blue shale, pyritiferous	2	1,265
Shale, brown; in calcareous concreted masses	19	1,284
Shale, blue, in concreted powder; and limestone, dolomitic, in crystalline sand; some dark-brown siliceous cuttings	6	1,290
Shale, blue	50	1,340
Shale, light brown, calcareous; 3 samples	35	1,375
Shale, drab	33	1,408
Galena dolomite to Platteville limestone (291 feet thick; top, 380 feet below sea level)—		
Dolomite, light buff and brown, crystalline, porous; in chips	42	1,450
Dolomite, as above; cherty; in sand	25	1,475
Dolomite, as above; with greenish, argillaceous and microscopically arenaceous powder, 3 samples	75	1,550
Limestone, gray; brisk effervescence; in sand	10	1,560
Dolomite, buff and brown; in crystalline sand; 2 samples	65	1,625
Limestone, dark drab and light gray; rapid effervescence	25	1,650
Shale, green, hard, laminated, slightly calcareous	4	1,654
Limestone, yellow-gray, crystalline; rapid effervescence; some rounded grains of quartz sand	37	1,691
Shale, green, laminated, hard; practically noncalcareous	8	1,699
Saint Peter sandstone (32 feet thick; top, 671 feet below sea level)—		
Sandstone, white; grains rounded; largest 0.8 millimeter in diameter	32	1,731
Prairie du Chien stage—		
Shakopee dolomite (169 feet thick; top, 703 feet below sea level)—		
Dolomite, dark brown and gray, hard; much quartz sand in drillings; dolomite cuttings very sparingly arenaceous	39	1,770
Dolomite, buff, arenaceous; with grains seen to be embedded; in sand and large chips of vesicular dolomite	34	1,804
Sandstone and dolomite; in buff sand; quartz sand in excess	9	1,813
Dolomite; in buff sand, cherty, oolitic, arenaceous, as inferred from quartz sand in drillings	27	1,840
Dolomite, gray, vesicular, crystalline; in large chips	20	1,860
Sandstone, white; largest grains 1 millimeter in diameter, showing some secondary enlargements; with chips of finer-grained sandstone, with calcareous cement	6	1,866
Dolomite, gray; in large chips	34	1,900
New Richmond sandstone (79 feet thick; top, 872 feet below sea level)—		
Sandstone and dolomite; in buff, fine sand; quartz sand in excess; grains of quartz sand and cuttings of dolomite of about same size	33	1,933
Sandstone, white, rather coarse; grains with secondary enlargements; some chips showing calcareous cement	17	1,950
Sandstone, buff; finer than above; in chips showing calcareous matrix	29	1,979
Oneota dolomite (8 feet penetrated; top, 951 feet below sea level)—		
Dolomite, white; in chips	4	1,983
Dolomite, cherty, bright buff; in sand	4	1,987
Dolomite, buff; in sand.		

Malcom.—The town of Malcom (population, 377) is provided with a water supply from two wells. An elevated tank furnishes 65 pounds pressure for a mile of mains, supplying nine hydrants and a few private consumers.

Montezuma.—The public supply of Montezuma (population 1,172) is from a 300-foot well. The water is pumped by gasoline engines into a 20 by 24 foot tank, elevated on a 100-foot steel tower. Distribution is entirely by gravity, through 2 miles of mains to 17 fire hydrants and 35 taps. Only about 200 barrels are used per day in summer. A pressure of about 45 pounds is maintained throughout the town. The water is hard and deposits a red precipitate on the pipes, showing that, though some of it may be drawn from the limestone, a large part of it comes from the overlying Pleistocene gravels, which in many places carry much iron.

Two miles northeast of Montezuma is a spring which is said to flow in a 2-inch stream from a sand bed into a 12 by 12 foot brick reservoir, from which arrangement is made for pumping by a gasoline engine. This spring is being considered as a source of public supply.

In the vicinity of Montezuma plenty of water may usually be found in drift sand at depths of 50 to 60 feet or perhaps 80 feet on the uplands. Fine sand has caused some difficulty in pumping and on that account a few wells have been abandoned or extended to limestone at depths of 200 to 300 feet. The limestone water is hard and stands about 100 feet below the surface; the supply, however, is certain and very constant.

Montezuma is 948 feet above sea level, but an accurate estimate of the depths of the different water beds is difficult because of a hypothetical east-west sag bounded on the south by the upwarp of the lower Paleozoic formations of southeastern Iowa. If the dip of the strata from Belle Plaine to Pella is uniform the Saint Peter should be found at Montezuma about 649 feet below tide, a depth nearly coincident with that given on a section from Grinnell to Sigourney. But the sag may carry the Saint Peter down to 675 or 700 feet below sea level or at most 1,650 feet below the surface. A deep well should be drilled at least 300 or 400 feet below the Saint Peter into the subjacent limestones and sandstones, where an abundant supply will probably be secured. The well should be sunk to a depth of 1,950 to 2,050 feet.

The upper waters from the Mississippian and probably also any water found in the Silurian will be heavily mineralized and should be shut out. The quality of the lower and main waters is a matter of prime importance which regrettably can not be definitely predicted. In general, it is believed that these waters are of a fair quality, but there are some indications to the contrary for this locality. The experience of Sigourney, where casing carried to the Galena, as reported, still left an unpotable water, is distinctly discouraging although the probabilities are that at the latter place either the casing leaked or the Galena water was heavily mineralized. On this last supposition a water-tight casing bedded a short distance above the shales of the lower Platteville should have remedied the difficulty. At Pella the upper waters were found unpotable, but when cased out, the lower or Ordovician waters were insufficient in quantity. The Pella well, however, reaches only to the Saint Peter; had it been sunk a few hundred feet deeper fair waters of good yield would have probably been secured. The experience of the second city well at Grinnell, which succeeded in casing out the injurious sulphated waters of the first well and still had an abundant supply, would probably be duplicated at Montezuma with due care in the construction of the well. The water will probably head at about 175 feet from the surface.

WELL DATA.

The following table gives data of typical wells in Poweshiek county:

Typical wells of Poweshiek County.

Owner	Location	Depth	Depth to rock	Source of supply	Head below curb	Remarks: (Logs given in feet)
T. 78 N., R. 14 W. (Part of Jackson).		Feet	Feet		Feet	
W. H. Taylor	SW. ¼ sec. 34	217	177	Limestone	— 90	Yield, 10 gallons per minute; pumped by gas and wind engines. "Iron and sulphur" taste. First water bed at 180.
City of Montezuma		300	200	do	— 65	Pumped by 10-horsepower gas engine. Hard. Iron taste. Used but little.
T. 80 N., R. 16 W. (Grinnell).						
J. W. Folwer	Grinnell	434	200	Limestone and shale	—130	Pure. Water beds at 216 and 300. Pumps 9 gallons a minute without lowering.
M. A. Sears	do	183	(a)	Fine sand	— 83	Plenty of soft water.

Typical wells of Poweshiek County—Continued.

Owner	Location	Depth	Depth to rock	Source of supply	Head below curb	Remarks: (Logs given in feet)
T. 80 N., R. 14 W. (Bear Creek).		Feet	Feet		Feet	
Talbot and Thompson.	Sec. 12	605	325	Red sandstone.	—125	Pumps 12 gallons a minute. Black soil, 3; red clay, 75; blue clay, 246; sand (dry), 1; blue and gray shale, 225; white clay, 7; limestone, 46; red sandstone, 2.
City of Brooklyn		208		Sand and gravel		
John F. Scott	Brooklyn	233		do	—100	Abundant soft water. Soil and yellow clay, 30; blue clay, 200; fine sand and gravel, 3.
James Calderwood	SE. ¼ sec. 2	575	400	Limestone	— 50	Very constant. Red clay, 50; blue clay, 350; limestone, 175.
Luther Triplet	SE. ¼ sec. 4	201	(*a*)	Gravel	— 65	
Jos. F. Coulter	S. ½ sec. 15	170	169	Limestone (?)	— 50	Fine well; probably from gravel.
S. E. Brush	do	172	170	Limestone	— 10	Probably from gravel.
J. N. Newkirk	NE. ¼ sec. 16	578	325	do	— 75	Strong well. Soil and yellow clay, 60; blue clay, 262; gravel and sand (dry), 3; shale (?) slaty color, 247; limestone, hard, gray, 6. Hard and strongly mineral. Pumped by gasoline engine to tanks of farm; also of neighbor.
T. 81 N., R. 14 W. (Madison).						
John W. Jones	W. ½ sec. 20	400	(*a*)	Sand	— 65	
T. 78 N., R. 13 W. (Deep River).						
W. L. Buxton	NE. ¼ sec. 5			Limestone	— 75	Can not pump down.
John Doonan	1½ miles north of Deep River.	194	180	do	— 94	First water at 165 feet in sand and clay; yield 8 gallons a minute. Hard.
T. 79 N., R. 14 W. (Scott).						
R. F. Hutchinson	SE. ¼ sec. 28	202	152	do	—100	First water bed at 50. Sand and gravel. Hard. Drift, 152; slate, 16; coal and fire clay, 2; shale; limestone, water-bearing.
John Hutchinson	SW. ¼ sec. 27	181	171	do	— 68	Strong well. Drift, 168; sand, partly cemented, 3; limestone, 9; limestone, very hard, 1. White and milky after storm; hard.
Wm. T. Hutchinson.	NE. ¼ sec. 34	184	181	do		Black water at first, bad odor; later cleared.
John R. Johnson	NE. ¼ sec. 35	412	131	do	—100	Red clay, 75; blue clay, 50; sand (scant water), 6; limestone, hard, gray, 281. Pumped 8 gallons per minute at test without lowering.
Do.	NE. ¼ sec. 22	118	(*a*)	Gravel	— 35	Strong well.
Maggie R. Johnson	NW. ¼ sec. 6	324		Sandstone	— 40	Very strong well.
T. 79 N., R. 13 W. (Lincoln).						
J. A. Dougherty	SE. ¼ sec. 3	180	(*a*)	Gravel	—100	Never pumps lower.

a No rock.

SCOTT COUNTY

BY W. H. NORTON.

TOPOGRAPHY.

Scott county is an area of faint relief. The larger part is an upland of well-nigh level Illinoian drift, sharply dissected along its margins, but elsewhere drained by shallow though broad waterways. The extreme northwestern part is occupied by a maturely dissected area of Kansan drift. Along the right bank of the Wapsipinicon valley in Butler and Princeton townships rises a narrow and high ridge composed largely of loess and sand. The recently cut channel of the Mississippi from Princeton south gives room for a narrow alluvial lowland south of Valley City and one somewhat wider below Davenport. That part of the wide flood plain of Wapsipinicon river which lies south of the channel, an area of about 35 square miles, falls to Scott county. Across the western part of the county stretches a broad marshy sag once occupied as a temporary channel by the Mississippi and now held by an insignificant stream called Mud creek.

GEOLOGY.

Buff and bluish dolomitic limestone quarried at Le Claire and belonging to the Niagaran underlies the northern part of the county; higher and younger limestones of Devonian age, of which the Davenport quarries furnish examples, underlie the drift in Davenport and Blue Grass townships; and shales and sandstones belonging to the Pennsylvanian series occupy the extreme southern part of the county. (See Pl. XV.)

UNDERGROUND WATER.

Underground Water Provinces.

Wapsipinicon Flood Plain.—Wapsipinicon river, which forms the northern boundary of the county, flows over a flood plain whose width on the right bank of the stream ranges from half a mile near Dixon to three miles at McCausland. On this plain alluvial sands and gravels supply abundant water to shallow dug and driven wells.

Mud Creek Channel.—The little stream of Mud creek drains the northern portion of an ancient channel held by several geologists to have been cut in glacial time by the diverted waters of Mississippi river. The channel floor is about a mile wide, increasing at the mouths of the valleys of tributary creeks. Ground water stands high. Much of the area is ill drained and ponds and marshes occur, especially at the col which crosses the flat valley floor at the head of Mud creek, separating it from the headwaters of another creek, Elkhorn, whose course is in the opposite direction. Along this channel ground water is easily reached by shallow wells.

Cleona Buried Channel.—In the western part of the county a distinct ground-water province exists in the ancient and deeply buried river valley called Cleona Channel, from a township through which it passes. The depth and width, which considerably exceed that of the present Mississippi channel contiguous to the county, lead to the inference that it was cut in rock by a stream of large size. Apparently the rock-cut valley is wide-floored and bounded by steep bluffs now buried deep from sight. In the village of Plainview wells a few rods apart show sharp descents of the rock surface of about 150 feet, and in Cleona township the rock surface declines more than 260 feet within a mile.

The Cleona Channel joins the valley of the Wapsipinicon north of Allen Grove and Donahue, and probably continues down that valley to join the deep preglacial channel of the Mississippi north of Princeton. From Allen Grove southwest to Plainview it coincides in part with the broad flat-floored valley of Mud creek, but from Plainview to Durant it lies mostly on the east side of Mud creek valley.

North of Durant, in section 19, Cleona township, the channel attains a depth of more than 300 feet below the surface of the ground. The rock floor is not reached here at an elevation of 399 feet above sea level. This elevation is but 20 feet above extreme low water in the Mississippi at St. Louis, and the fall thence to the Gulf of Mexico is but three inches to the mile. The rock floor here is more than 160 feet lower than the present bed of the Mississippi at Le Claire.

In this province water occurs in river or glacial-outwash sands with which the channel has been heavily aggraded, and which have been deeply buried beneath stony clays deposited by ancient ice sheets. The formations to be met with by the driller vary considerably, as the following well logs show:

Figure 5.—Map of western Scott county, showing the ancient channel now occupied by Mud creek (shown by shading) and the buried Cleona Channel (bounded by broken lines). Figures at deep wells (●) indicate the elevation of the rock surface above sea level. Figures prefixed with minus signs are used with wells which did not reach rock and indicate that the rock surface is *less* than the elevation given, that of the bottom of the well.

Log of well of H. Goettsch, NW ¼ sec. 9, Cleona Township.

	Thickness	Depth
	Feet	Feet
Clay, yellow and blue, Kansan	102	102
Clay, black, ill-smelling, Aftonian	45	147
Clay, blue, hard, Nebraskan	50	197
Quicksand, mostly fine	134	331

Log of well of Henry Roh, NE. ¼ sec. 26, Allen Grove Township.

	Thickness	Depth
	Feet	Feet
Clay, yellow and blue	100	100
Quicksand	25	125
Clay, blue, stony, underlain by 70 feet of river sand resting on blue till	150	275
Gravel	25	300

Log of well of J. Rathjen, SW. ¼ sec. 12, Cleona Township.

	Thickness	Depth
	Feet	Feet
Clay, yellow	35	35
Clay, blue	205	240
Sand	2	242

Log of well of Lena Mumm, NE. ¼ sec. 21, Cleona Township.

	Thickness	Depth
	Feet	Feet
Clay, yellow	12	12
Clay, blue	236	248
Sand and gravel	30	278

These and other wells show that in places beds of sand covered with stony clays occur at a depth from the surface of about 100 feet. These sands are apt to be too fine to be available for wells with the methods now in use in well construction. At depths of 200 to 275 feet a body of sand is encountered, which probably rests on bedrock, although, as it has not been drilled through, this is not altogether certain. The thickness of this bed may reach 130 feet. Because of the fineness of grain over much of this depth, it may be expected to give much trouble to the driller, but there are coarser layers and gravel beds in which a good supply can be obtained.

Niagaran Province.—The Niagaran province embraces the two northern tiers of townships, where most of the wells are compelled to pass through the drift and find water either in the Niagaran dolomite within a short distance from its surface or in overlying gravels.

In Liberty township rock outcrops in the northern sections, as about Big Rock and Dixon, but in the southern half it is covered with 50 to 140 feet of drift. The depth to water varies widely in wells but a short distance apart; throughout the township water is found in rock within 50 to 150 feet of the surface.

In Hickory Grove township, except along the buried channels of Cleona river and of another preglacial stream which passes through the eastern tier of sections, rock occurs within 30 and 50 feet between Plainview and Maysville and within 80 and 150 feet elsewhere, water being commonly found a few feet below the rock surface.

In Winfield, Butler, and Princeton townships, outside of the Wapsipinicon valley, water is found but a short distance below the rock surface, which lies within 60 to 170 feet of the surface of the ground on the upland back of the bluffs of Mississippi river, at whose base rock outcrops. Northwestern Winfield township, however, lies in Cleona Channel, and a series of wells from 190 to 225 feet deep to rock in sections 15, 26, and 35 indicate a buried channel somewhat less deep and wide than the Cleona, with an approximately south-north course.

In Sheridan and Lincoln townships and the western parts of Le Claire and Pleasant Valley townships rock is generally found at 60 and 70 to 150 feet, some wells reaching it, however, at 170 feet or even more. In the eastern sections of Le Claire and Pleasant Valley townships rock occurs at or near the surface, and wells passing through 30 to 60 feet of drift find water within 75 to 150 feet of the surface of the ground.

Devonian Province.—In Davenport township rock is generally entered at 80 to 170 feet, and water is found 10 to 50 feet below rock surface. Along the Mississippi rock outcrops in the side of the bluffs, but is covered with heavy drift and loess. A buried deep channel is suggested by wells in section 12 which strike rock at 212 to 230 feet, and a well in Davenport, on Gains Street, said to be 200 feet to rock. These wells are aligned with the channel traced near Leroy Grove, in Winfield township, but there are no well reports from the eastern sections of Sheridan township, through which the channel connecting the two "deep countries" would run.

In Blue Grass township, Devonian limestones lie 40 to 50 feet below the surface about Walcott, and from 80 to 100 feet below elsewhere. In sections 1 and 12, however, two wells, one 230 feet to rock, and the other 275 feet deep, ending in sand, probaby mark the southward extension of the buried channel which stretches across the eastern tier of sections of Hickory Grove township. No data are at hand to trace the channel south of section 12.

Carboniferous Province.—The Carboniferous province includes the larger part of Buffalo township and parts of Rockingham, together with outliers in Le Claire and Sheridan townships. Here beneath the drift the drill strikes the shales and sandstones of the Pennsylvanian series or Coal Measures. As the water contained in these beds is meager in quantity and is, as a rule, highly mineralized, wells are generally drilled to the underlying limestones, where water of excellent quality is found in ample amounts and with a head which lifts it high in the well.

Outside of Buffalo township the outliers of the Pennsylvanian are small in area, but as they occupy very ancient channels cut in Niagaran dolomite, may reach 200 feet in depth. The following are typical wells in the Pennsylvanian province:

Log of well in Buffalo Township, SE. ¼ SE. ¼, sec. 16.

	Thickness	Depth
	Feet	Feet
Clay, yellow	20	20
Soapstone	25	45
Slate	2½	47½
Coal	½	48
Fire clay	2	50
Shale	20	70
Coal	2½	72½
Fire clay	1	73½
Limestone (Devonian)	66½	140

Log of well of LeClaire Brick & Tile Company, Island City.

	Thickness	Depth
	Feet	Feet
Shale, dark	90	90
Sandstone, white	6	96
Shale, blue	70	166
Sandstone	9	175
Shale, blue	25	200
Limestone (Niagaran) with water vein beneath the shale, water heads 4 feet from surface	26	226

The White Sulphur Springs well is located in the NW. ¼ sec. 24, Buffalo township. Its depth is 800 feet. It has a flow of strongly sulphureted water. The well was completed prior to 1870.

CITY AND VILLAGE SUPPLIES.

Bettendorf.—At Bettendorf (population, 909) the well of the Bettendorf Improvement Company has a depth of 1,650 feet and a diameter of 12 inches at top and 9 inches at bottom; casing, 12-inch to 80 feet. The principal water bed is from 500 to 650 feet; flow, about 1,000 gallons a minute. Temperature, 65° F. Driller, John D. Shaw, of Davenport.

The Bettendorf Metal Wheel Company's well No. 1 has a depth of 400 feet and a diameter of eight inches; cased to rock, 20 feet. The curb is 585 feet above sea level and the head 15 feet below the curb. Tested capacity, about 30 gallons a minute. Water somewhat sulphureted.

The Bettendorf Metal Wheel Company's well No. 2 has a depth of 1,539 feet and a diameter of 10 inches to 60 feet, 8 inches to bottom; cased to 60 feet. The curb is 585 feet above sea level; head not reported. The flow is 200 gallons a minute. The well was completed in 1909 at a cost of $2,300 by J. D. Shaw, of Sioux City.

Davenport.—Davenport (population, 39,797) is supplied with water drawn from Mississippi river and filtered. It is distributed by gravity pressure, 65 pounds, and direct pressure, 125 pounds. There are 72 miles of mains and 650 hydrants. The works are owned by the Davenport Water Company.

The 30-inch cast-iron intake pipe opens 1,000 feet off shore, the joints being all thoroughly calked with lead. The water flows from the intake pipe into a forebay, which is screened to prevent fish or floating debris from entering, and thence into the well, from which the suction is taken. Well and forebay are cleaned from 20 to 40 times a year. The water is then pumped into a settling basin with a capacity of 5,000,000 gallons, where it remains for 24 hours. This basin is cleaned once a year, the sediment collected during this time amounting to about three feet at the end of the basin at which the water is delivered, and one foot at the end where it is taken out.

From the settling basin the water flows through a flume over a weir into the coagulating basin with a capacity of 300,000 gallons, at whose entrance it is met by the coagulant solution. From two to five grains of sulphate of alumina to the gallon is used, the amount depending on the condition of the raw water. The alkalinity is tested daily. The filter alum is dissolved in tanks into which air is blown under pressure through pipes at bottom. The solution flows by gravity to a lead-lined centrifugal pump, by which it is lifted to an upper tank, which overflows into the bottom tanks, from which it is fed by gravity into the water in the coagulating basin. This method is believed to keep the solution at uniform strength and insure a uniform head. The water in the coagulating basin is given three hours for the completion of the process, and is then pumped under pressure through the filters into the main distribution. Each of the ten horizontal filter shells is 32 feet long and 7½ feet in diameter. Each shell is divided into two compartments, in each of which are five feet of sand. The filter shells are capable of sustaining a pressure of 200 pounds to the square inch.

The bacterial efficiency is reported to range from 96 to 99.06, the percentage increasing with the number of bacteria in the raw water.

An upper and lower distributing service is employed. The lower service is supplied from the river station, which is designated station No. 1, and serves, under direct pressure, the business section of the town and that along the flood plain of the river. At station No. 2 the filtered water is pumped into a reservoir and the mains are so arranged that the pumps can be brought into commission at time of fire on the lower service to aid the pumps of station No. 1. When fire occurs on the upper service the pumps of station No. 2 supply direct pressure.

The Davenport waterworks supply the Iowa Soldiers' Orphans' Home, whose daily consumption is about 15,000 gallons, at a cost of 10 cents for 1,000 gallons. The supply had previously been drawn from a well on the grounds of the institution, but the capacity proved insufficient..

The sequence of formations at Davenport has been fully treated by Udden[1] and by the writer,[2] and the correlations specified in the papers cited have been confirmed, on the whole, by the records of wells drilled since their publication.[3] (See Pls. XII, p. 618, XV, p. 812.)

The surface rock at Davenport is the Wapsipinicon limestone of the Devonian system, the type outcrops of the Upper and Lower Davenport limestones of the Iowa State Survey being within the city limits near the water level of Mississippi river. The Devonian includes shales (as shown by the Kim-

[1]Water resources of Illinois: Seventeenth Ann. Rept. U. S. Geol. Survey, pt. 2, 1896, pp. 829-849.
[2]Artesian wells of Iowa: Rept. Iowa Geol. Survey, vol. 6, pp. 272-280.
[3]Many of the data as to the newer wells were collected by Udden.

ball House samples, and by the record of "caving material" of the Malt & Grain Company's well No. 2) which may be assigned to the Independence shale member of the Wapsipinicon. The base of the Devonian may be placed at 475 feet above sea level.

The samples from the Kimball House well, confirmed by other well records, define the lower limit of the Niagaran and summit of the Maquoketa at about 130 feet above and the base of the Maquoketa at about 100 feet below sea level.

The Galena dolomite extends at least to 250 and perhaps to 300 feet below sea level. The undolomitized limestones and accompanying shales of the Platteville limestone meet the Saint Peter sandstone at about 448 feet below sea level. according to Udden. The records as to the summit of the Saint Peter are singularly conflicting, however, varying from 376 to 511 feet below sea level. The base of the Saint Peter sandstone is also variously reported, and Udden's estimate of 524 feet below sea level may be accepted as an approximation to its average place.

The Prairie du Chien stage, on which the Saint Peter rests, consists in its upper beds of shales and interbedded dolomites which reach a thickness of more than 100 feet. In several wells red marl is reported from this horizon.

The Jordan sandstone, which succeeds the Prairie du Chien at about 800 feet below sea level, is at least 150 feet thick and is continued downward into sandy limestones and limy sandstones of the Saint Lawrence formation, from which its parting is ill-defined in the driller's logs. The shale from 1,268 to 1,308 feet below sea level may be taken as the basal portion of the Saint Lawrence, the latter depth marking the summit of the Dresbach sandstone. The deepest wells show that the Dresbach is underlain by heavy shales, succeeded below by another sandstone.

The first water obtained at Davenport comes from the Devonian at 440 to 480 feet above sea level. It may represent the natural springs which rise from the Independence shale member of the Wapsipinicon limestone along its outcrops. The water is insignificant in quantity, but is noteworthy because of its corrosive qualities, which eat the casing from the outside, where the drill hole passes through water channels.

A second flow is obtained in the Galena dolomite at depths of 108 to 242 feet below sea level. This is the so-called "upper water" and is noticeably impregnated with sulphureted hydrogen. Aeration and relief from pressure insure a rapid and complete escape of the gas. The water is frequently separated from lower flows. The yield has been generous, amounting in the Witts well to 300 gallons a minute.

A third flow comes from the Saint Peter sandstone, which has so far furnished the larger part of the discharge of the Davenport basin and is the main water bed supplying wells from 1,050 to 1,200 feet in depth.

The analogy of other localities, where observations as to discharge seem to have been more carefully made, testifies that the Prairie du Chien stage, especially its middle and lower portions, will also contribute largely to the flow of wells.

The Jordan sandstone at 745 to 945 feet below sea level may be depended on to yield generously with a head at present more than 20 feet higher than that of the Saint Peter.

The Saint Lawrence may be expected to yield little, if any, water, but the underlying Cambrian strata contain a well-filled reservoir 1,300 to 1,500 feet below sea level.

As is commonly the case when numerous artesian wells are drilled in a small area, the Davenport artesian field has shown from the beginning a progressive loss of pressure, lowering of static level, and diminution of discharge. This has been specially marked in wells 1,200 feet and less in depth, in which the main supply comes from the Saint Peter. The initial head of these wells seems to have reached 651 feet above sea level, as shown by the woolen mills well drilled in 1890. In 1891 an initial head of 612 feet was reported, in 1892 initial heads of 606 and 631 feet, in 1893 of 610 feet, and in 1905 the initial head (at the Malt & Grain Company's well) of the Saint Peter was less than 592 feet above sea level; all these heads are those of new wells and are therefore affected by no causes other than overdraft.

The head of the Jordan and lower waters remains higher than that of the Saint Peter. Thus the head of the Park well, drilled in 1888, was initially 682 feet above sea level and in 1895 had declined to 670 feet. It should be noted, however, that this well is situated on high ground and is nonflowing. The initial head of the Malt & Grain Company's well for the Jordan, drilled in 1905, was 612 feet and that of the well of the Bettendorf Metal Wheel Company, drilled in 1909, is 606 feet above sea level.

In recent years the static level has been lowered by the use of compressed air in pumping a number of the wells, and though the discharge of the wells pumped has been increased to even more than the initial flows the head of other wells has been so reduced that they no longer flow. Thus the initial flow of the four wells of the Corn Products Refining Company is reported at 1,413 gallons a minute. In 1908 the natural flow had declined to 842 gallons, but with compressed air a discharge is obtained of 1,635 gallons a minute. The well at the woolen mills yields at present but 25 gallons a minute under its natural pressure, but with compressed air gives 225 gallons. The two wells of the Independent Malting Company, which yielded in 1905 but 350 gallons, now pump 800 gallons. The well of the Crystal Ice Company, which flowed 250 gallons, pumps 240 gallons a minute.

The flow from the deeper aquifers still remains fair in new wells. Thus the new well of the Malt & Grain Company flows 150 gallons, that of the Davenport Malting Company, and that of the Bettendorf Metal Wheel Company, each 200 gallons a minute.

As the static level of Saint Peter waters is now below the surface and the supply overtaxed, it is advised that new wells be sunk to the Jordan sandstone and to the sandstones underlying the Saint Lawrence formation from 1,550 to 2,100 feet from the surface, although wells of 1,000 and 1,200 feet in depth will still yield largely under the pump.

The glucose factory has four wells. Well No. 1 has a depth of 1,500 feet and a diameter of five inches. The curb is 562 feet above sea level, and the head in 1896 was 58 feet above curb. The flow in 1896 was 230 gallons a minute; in 1908 it was 60 gallons a minute; tested capacity, under compressed air, in 1908, 160 gallons a minute. The temperature of the water is 61° F. Date of completion, 1876.

Well No. 2 has a depth of 2,101 feet and a diameter of six inches. The curb is 562 feet above sea level. The head in 1896 was 81 feet above curb; in 1905 it was 24 feet above curb. The original flow was 380 gallons a minute; the present flow is 228 gallons a minute; tested capacity, under compressed air, 380 gallons a minute. Temperature, 64° F. The well was completed in 1889 by J. P. Miller & Company, of Chicago.

Well No. 3 has a depth of 2,105 feet and a diameter of 6 inches. The curb is 562 feet above sea level. The original flow was 400 gallons a minute; present flow, 264 gallons a minute; tested capacity, under compressed air, 530 gallons a minute. Temperature, 64° F. The well was drilled in 1889-1892 by J. P. Miller & Company of Chicago.

Well No. 4 has a depth of 2,107 feet and a diameter of 8 inches. The curb is 562 feet above sea level. The original flow was 400 gallons a minute; present flow, 290 gallons a minute; tested capacity, under compressed air, 565 gallons a minute. The temperature of the water is 64° F. The well was completed in 1892 by J. P. Miller & Company of Chicago.

Repairs have been made only on well No. 4, new casing to 650 feet having been inserted in 1906, slightly increasing the flow. In 1905 these four wells discharged into the basin from which the water is pumped. The wells are situated not more than 240 feet apart, but no interference has been noticed.

Driller's log of glucose factory wells.

	Thickness	Depth
	Feet	Feet
Surface material	52	52
Limestone, bluish, sample at		410
Shale		635
Limestone		970
Shale	30	1,000
Sandstone (Saint Peter)	42	1,042
Limestone, sandy	530	1,572
No record	258	1,830
Shale	40	1,870
Limestone, sandy	20	1,890
Sandy rock	160	2,050
Shale	50	2,100

The Park well has a depth of 1,797 feet. The curb is 704 feet above sea level. The original head was 22 feet below curb; head in 1896, 34 feet below curb. The tested capacity is 125 gallons a minute. The well was completed in 1888 by J. P. Miller & Company, of Chicago.

Record of strata in Park well at Davenport.[1]

	Thickness	Depth
	Feet	Feet
"Loess," no sample	40	40
"Bowlder clay," no sample	60	100
Shale; dark, no sample	30	130
Limestone, pure, hard, gray, compact, fine-textured, nonmagnesian	220	350
Dolomite; hard, highly vesicular, light pinkish buff, with casts of crinoid stems and casts of apex of Platystoma niagarense Hall	30	380
Dolomite, subcrystalline, cream-colored, highly vesicular, with obscure cast of bryozoans	20	400
Dolomite, hard, bluish gray, subcrystalline	90	490
Shale, lead colored, argillaceous, very slightly calcareo-magnesian, fossiliferous; blackens in closed tube B. B.; turns white	30	520
Dolomite, white, arenaceous	80	600
Dolomite, hard, gray, subcrystalline	50	650
Dolomite, hard, rough, brownish, white; some fine gray shale	75	725
Dolomite, lighter in color, with obscure casts of fossils referred to Zygospira	50	775
Dolomite, light brownish	125	900
Dolomite, as above, with white chert	50	950
Dolomite, magnesian limestone, white	75	1,025
Limestone, light bluish gray, nonmagnesian, argillaceous; in thin, flaky chips	50	1,075
Shale, green, pyritiferous	10	1,085
Sandstone, grains rather coarse, rounded, white and pinkish	75	1,160
Shale, indurated, slightly arenaceous, fine-grained, gray, green and purplish	30	1,190
Dolomite, light gray, arenaceous	60	1,250
Dolomite, light buff, arenaceous	50	1,300
Dolomite, buff, arenaceous	100	1,400
No record	25	1,425
"Sandstone"	10	1,435
"Limestone"	100	1,535
Dolomite, in minute fragments, with large admixture of siliceous sand		1,797

[1]From drillings preserved by A. S. Tiffany, Davenport, Iowa.

The Kimball House well has a depth of 1,560 feet and a diameter of eight inches to 710 feet and four inches to bottom. The curb is 579 feet above sea level. The original head (of lower water) was 58 feet above curb; in 1896, 20 feet above curb; in 1908, below curb. A flow of sulphur water, 120 gallons a minute from a depth of about 700 feet, was cased out. The well was completed in 1890 (?) by A. K. Wallen. Between 1896 and 1905 the casing became corroded and the upper and lower waters mingled.

Record of strata in Kimball House well.[1]

	Thickness	Depth
	Feet	Feet
"Modified drift"	13	13
Limestone, magnesian, compact, fine-textured, hard, light and dark gray	67	80
Limestone, softer, lighter colored; similar in composition and texture to that above	48	128
Dolomite, hard, pure, subcrystalline, vesicular, light greenish gray; casts and molds of fossils	47	175
Dolomite; as above, but darker	130	305
Dolomite; as at 128 to 175 feet	120	425
Dolomite, light bluish gray; with white chert	23	448
Shale, black, pyritiferous, noncarbonaceous	27	475

Record of strata in Kimball House well—Continued.

	Thickness	Depth
Shale, blue	90	565
Limestone, blue, argillaceous, fossiliferous	125	690
Dolomite, hard, rough, subcrystalline, medium dark buff	40	730
Sand, fine, buff, largely dolomitic, with rounded grains of quartz; also many grains of pyrite in minute, agglomerated crystals; water bearing	45	775
"Limestone, soft, yellow, magnesian;" no sample	75	850
"Limestone, hard, buff, nonmagnesian;" no sample	50	900
"Limestone, argillaceous, ferruginous;" no sample	90	990

[1]From samples supplied by A. S. Tiffany.

The woolen mills well has a depth of 1,053 feet and a diameter of 3½ inches. The curb is 564 feet above sea level. The original head was 87 feet above the curb; head in 1905, at curb. The water at 85 or 120 feet, at 700 feet, and near bottom, was corrosive, cutting the casing from the outside. The original flow is unknown; flow in 1908, 25 gallons a minute; tested capacity in 1908, 225 gallons a minute. The well was completed in 1890 by A. K. Wallen. New casing was inserted in 1895, in 1901, and in 1906, to 200 and to 280 feet below the curb and each time a higher pressure was obtained.

The Witts's Bottling Works well has a depth of 780 feet and a diameter of six and three inches. The curb is 575 feet above sea level. The original head was 82 feet above curb; head in 1896, 59 feet above the curb. The original and present flow is 300 gallons a minute, but is said to diminish when the well of Crystal Ice Company is used. Date of completion, 1891. Drillers, J. P. Miller & Company, of Chicago.

The gas works wells Nos. 1 and 2 have depths of 1,200 feet and a diameter of five to four inches; five-inch casing nearly to bottom. The curb is 564 feet above sea level. The head of lower water, original, was 48 feet above the curb; head in 1896, 48 feet above the curb; head in 1905, four feet above the curb. Temperature, 65° F. The wells were completed in 1891 by A. K. Wallen.

The Schmidt building well has a depth of 1,200 feet and a diameter of four inches. The curb is 576 feet above sea level and the original head was about 30 feet above the curb. Head in 1905, less than the original. The original flow was about 45 gallons a minute. Date of completion, 1892; driller, A. K. Wallen.

Driller's log of Davenport Malt & Grain Company's well No. 2.

The Malt & Grain Company well No. 1 has a depth of 1,076 feet and a diameter of 5 inches. The curb is 592 feet above sea level. The original head was 39 feet above the curb; the head in 1896, 15 feet above the curb; in 1909, 14 feet below curb. The water comes from depths of 700 feet and 1,055 to 1,076 feet. Temperature, 62° F. The well was completed in 1892 by A. K. Wallen.

The Malt & Grain Company well No. 2 has a depth of 1,653 feet and a diameter of 12 to 5 inches; cased from 100 to 120 feet, to shut out caving material, and from 1,100 to 1,135 feet. The curb is 592 feet above sea level and the flow 150 gallons a minute, the water rising 20 feet above the curb. The first flow was from Jordan sandstone at depths of 1,385 to 1,535 feet. Temperature, 64° F. The well was completed in 1905 by L. Wilson, of Chicago. During the drilling of the second well the flow of the first was permanently increased. The two wells are 100 feet apart.

	Thickness	Depth
	Feet	Feet
Sand	35	35
Hardpan and gravel	31	66
Shale, sandy	15	81
Gravel	10	91
Loose limestone	1½	92½
Limestone	6½	99
Caving sand and gravel	3	102
Limestone, sandy	9	111
Shale	11	122
Limestone, white	161	283
Shale, sandy	15	298
Limestone, sandy	123	421
Limestone, brown	11	432
Shale, blue	74	506
Limestone	90	596
Limestone and blue shale	40	636
Shale, sandy	25	661
Shale, gray	100	761
Limestone	168	929
Limestone, flinty	2	931
Limestone, brown	65	996
Limestone, caving	7	1,003
Shale, blue and gray	22	1,025
Sandstone	62	1,087
Shale and caving rock	30	1,117
Limestone	39	1,156
Limestone and blue shale	6	1,162
Limestone and shale, caving	22	1,184
Limestone and shale	17	1,201
Marl, red, and limestone	49	1,250
Limestone, sandy	40	1,290
Sandstone	60	1,350
Limestone, gray	100	1,450
Limestone, brown	125	1,575
Limestone, sandy	78	1,653

The Crystal Ice Company's well has a depth of 1,067 feet and a diameter of six to four inches; cased to 1,067 feet. The curb is 590 feet above sea level and the original head 15 feet above the curb. The original flow was 250 gallons a minute; tested capacity in 1908, 240 gallons a minute. The first flow was at about 600 feet. Temperature, 60° F. The well was completed in 1893 by A. K. Wallen.

The Tri-City Packing & Provision Company's well has a depth of 1,100 feet and a diameter of eight to five inches; cased to 800 feet. The curb is 564 feet above sea level. The original head was 46 feet above the curb; head in 1896, 46 feet above the curb; head in 1905, seven feet above the curb. The original flow was 250 gallons a minute. The water comes from 800 and 1,100 feet. Date of completion, 1893. Driller, J. P. Miller & Company, of Chicago.

The Independent Malting Company's well No. 1 has a depth of 1,285 feet and a diameter of four inches. The curb is 573 feet above sea level (aneroid). The original head is unknown; the head in 1905 was 20 feet above the curb; in 1909, nine feet above the curb. The flow in 1905 was 150 gallons a minute; tested capacity in 1909, 400 gallons a minute. Sulphureted water comes from a depth of a little more than 700 feet; other water from a sandstone near the bottom; waters separated. Date of completion, 1896.

The Independent Malting Company's well No. 2 has a depth of 1,285 feet and diameter of six inches. It is 175 feet distant from well No. 1. The head in 1905 was 12 feet above the curb and the flow 200 gallons a minute. The tested capacity in 1909 was 400 gallons a minute. Date of completion, 1904.

The well of the Martin Woods Company has a depth of 415 feet and a diameter of 12 and 8 inches; casing, 12 inches for 48 feet, 8 inches for 98 feet; space between casings filled with concrete. The curb is 559 feet above sea level and the head is one foot above the curb. The pumping capacity is 33 gallons a minute; temperature, 53° F. The principal water bed is at 415 feet. Date of completion, 1910; driller, J. E. Shaw. On completing the well the head was found to be four feet below the curb, but in a few days the water had risen within a few inches of the surface. The use of a centrifugal pump has increased the natural flow.

The Davenport Malting Company's well has a depth of 1,998 feet (also reported as 1,880 feet) and a diameter of eight inches. The curb is 560 feet above sea level (aneroid) and the head 45 feet above curb. The original flow was 200 gallons a minute; present flow, 150 gallons a minute. The first flow was of sulphureted water at 800 feet; second flow at 1,750 feet. Temperature, 62° F. The well was completed in 1900 by Wilson & Company, of Chicago.

The Independent Baking Company's well has a depth of 900 feet and a diameter of 10 inches. Water from depth of 100 feet rises within 20 feet of surface; the flow comes from a depth 873 feet. Temperature, 56° F. Driller, J. D. Shaw.

To better define the place of the chief water beds there may be added the lower portions of the logs of two wells across Mississippi river from Davenport.

Log of lower part of Moline Paper Company's well at Moline, Illinois.

(Curb, 564 feet above sea level).

	Thickness	Depth
	Feet	Feet
Sandstone (Saint Peter)	65	1,141
Marl, red, and limestone	16	1,457
Sandstone	101	1,578
Limestone	50	1,628

Log of lower part of Mitchell & Lynde Building well at Rock Island, Illinois.

(Curb, 558 feet above sea level).

	Thickness	Depth
	Feet	Feet
Sandstone (Saint Peter)	145	1,104
Limestone	811	1,915
Sandstone, compact	30	1,945
Limestone	35	1,980
Sandstone	130	2,110
Limestone, shaly, and shale	75	2,185
Sandstone	97	2,282

Donahue.—At Donahue (population, 62) a small water-supply system is owned by two citizens. Water from wells is pumped to a tank with a capacity of 600 barrels. The number of taps is reported as 50. Drilled wells 100 to 300 feet deep find rock from 10 to 300 feet below the surface. Water from 150 feet has a head of 20 feet below the curb.

Eldridge.—The waterworks owned by the town of Eldridge (population, 217) consist of a well 180 feet deep, a tank, about a mile of mains, 16 fire hydrants, and 50 taps. The consumption is 800 gallons daily. The domestic and fire pressure is 45 pounds. Eldridge also uses cisterns and dug and drilled wells. The wells are from 103 to 201 feet deep, averaging 130 feet. They find rock at 100 feet. The water heads 90 feet below the curb.

Le Claire.—Le Claire (population, 690) draws its supplies from cisterns, drilled wells, and Mississippi river. The wells are from 30 to 150 feet deep with an average of 60 feet. They tap Niagaran dolomite at about 60 feet, and are in rock from 20 feet down. There are some small springs in the neighborhood.

Le Claire is 580 feet above sea level. An artesian well was recommended for it in 1899 by W. H. Norton,[1] on account of the steeply inclined layers of the country rock which apparently afford open waterways by which surface water may reach the common wells now in use in the town. A deep well will find the Saint Peter 900 to 950 feet from the surface and this together with the supplies found in the Galena and Platteville should be adequate.

Walcott.—The waterworks in Walcott (population, 416) are owned by the town. They include a well 85 feet deep, from which water is pumped to a tank with a capacity of 2,000 barrels, affording a pressure of 42 pounds. There are a mile of mains, 16 fire hydrants, and 128 taps. House wells in the village range in depth from 20 to 42 feet. The shallower wells find water in gravel and the deeper in limestone, which is entered at 55 feet.

[1]Report on the geology of Scott County: Iowa Geological Survey, vol. 9, 1899, p. 505.

Minor supplies.—The following table gives data concerning the supplies of minor villages:

Village supplies in Scott County.

Town	Nature of supply	Depth: From	Depth: To	Depth: Common	Depth of water bed	Source of supply	Depth to rock	Head below curb: Shallow wells	Head below curb: Deep wells	Springs
		Ft	Ft	Feet	Feet		Feet	Feet	Feet	
Big Rock	Dug and drilled wells.	14	130	30	60	Limestone	8–14	—14		
Blue Grass	Drilled wells	35	90	50				—25	—50	None
Buffalo	Open and drilled wells	16	270	24		Limestone	4–10	—16		Medium
Dixon	Wells and cisterns	50	160	75				—30		
Long Grove	Drilled wells and cisterns	135	180		135–170	Limestone	120	—40		
McCausland	Wells	16	60					—10		Small
Noel	do			30				—25		Small
New Liberty	do	80	165	90–125	100	Sand		—20 to —50	—10 to —40	None.
Princeton *a*										

a No report.

WELL DATA.

The following table gives data of typical wells in Scott county.

Typical wells in Scott County.

Owner	Locality	Depth	Depth to rock	Depth in rock	Rock surface above sea level	Remarks: (Logs given in feet)
		Feet	Feet	Feet	Feet	
T. 80 N., R. 1 E. (Liberty).						
Z. Parker	NE. ¼ NW. ¼ sec. 7	113	93			Yellow clay, 18; blue clay, 75.
J. Stoltenberg	SE. ¼ sec. 7	90	60	30		
J. L. Andre	NE. ¼ NE. ¼ sec. 8		150			Yellow clay, 35; yellow sand; blue and yellow clay to bottom.
—— Klahn	NW. ¼ sec. 8	118	60	58		
G. Parker	SE. ¼ SE. ¼ sec. 8	143	143			Yellow clay, 40; sand; remainder blue clay.
Dixon City Hotel	SE. ¼ SE. ¼ sec. 12	73	23	50	657	Nearly all fine, blue, silty quicksand.
J. Holt	SE. ¼ SE. ¼ sec. 13	108	60			Yellow clay, 25; black muck, 35.
J. Flinker	NW. ¼ sec. 15	135	60	75		
P. Mohr	NE. ¼ NW. ¼ sec. 17		60		740	
A. Paustian	NW. ¼ NE. ¼ sec. 9		18		782	

Typical wells in Scott County—Continued.

Owner	Locality	Depth	Depth to rock	Depth in rock	Rock surface above sea level	Remarks: (Logs given in feet)
		Feet	Feet	Feet	Feet	
Town of New Liberty.	SW. ¼ sec. 20		108		692	Yellow clay, 16; yellow sand, 3; blue clay, 89.
A. Weise	NW. ¼ NE. ¼ sec. 20		100			Yellow clay, 16; quicksand, 10; blue clay, 74.
W. N. Lensch	SE. ¼ SW. ¼ sec. 20		90			Yellow clay, 20; sand, 3; blue clay, 67.
Do	SE. ¼ SW. ¼ sec. 20	90	60	30		Little blue clay.
H. Schmidt	SW. ¼ SE. ¼ sec. 22	115	50	65		Yellow clay, 25; red clay, 25; bowlders on rock.
M. Smallfield	SW. ¼ NW. ¼ sec. 24	165	105			
H. Meinert	Sec. 26	48	36			
E. Moeller	SW. ¼ SW. ¼ sec. 32	72	60			Yellow clay, 20; sand, 2; blue clay, 38.
T. Ketelson	NE. ¼ NW. ¼ sec. 35	150	128	22	672	
T. Killian	SE. ¼ SE. ¼ sec. 16	64	8			
J. Killian	Sec. 16	125	120			
J. Ketelson	SE. ¼ NE. ¼ sec. 26	74	70			Thick yellow clay throughout.
T. 79 N., R. 1 E. (Cleona).						
C. Ginn	NW. ¼ NE. ¼ sec. 4	72	42			
W. Rheims	SW. ¼ sec. 4	163	162			
J. Schroder	SW. ¼ SE. ¼ sec. 7	108	80			
H. Kroeger	SW. ¼ SW. ¼ sec. 9	113	45		595	All yellow clay.
J. Rathjen	SW. ¼ SW. ¼ sec. 12					Yellow clay, 35; blue clay, 205; sand, 2.
H. Speth	NW. ¼ sec. 13					Yellow clay, 10; blue clay, 116; quicksand, 150; ends in gravel.
A. Franz	SE. ¼ NE. ¼ sec. 13		193			All slushy blue mud to rock, below a little yellow clay.
G. Paustian	NE. ¼ NE. ¼ sec. 14					Yellow clay, 10; blue clay, 268; sand and gravel 2.
P. Paulson	NE. ¼ NW. ¼ sec. 16	122	58			
Do	NW. ¼ SW. ¼ sec. 16	137	111			
Lena Mumm	NE. ¼ NE. ¼ sec. 21					Yellow clay, 12; blue clay, 236; sand and gravel, 30.
J. Theil	NE. ¼ NE. ¼ sec. 22					Yellow clay, 15; blue clay, 129; sand and gravel, 2.
H. Wessel	NW. ¼ SE. ¼ sec. 23					Yellow clay, 20; sand, 10; blue clay, 100; gravel, 3.
W. Rheims	SW. ¼ sec. 4	161	146			
J. Tesrow	NW. ¼ sec. 24					Yellow clay. 7; red sand, 7; sand, 21; gravel, 25.
Durant						Yellow clay, 25; sand, 5; blue clay, 109.
T. 80 N., R. 2 E. (Allens Grove).						
D. Yale	NW. ¼ SW. ¼ sec. 29	111	99			Yellow clay. 20; blue clay, stony, 70; hardpan, 9.
M. King	SE. ¼ NW. ¼ sec. 20	75				Yellow clay, 20; blue clay 50; hardpan, dry, 5. No water.
E. Richardson	SE. ¼ SE. ¼ sec. 20	118	100			Blue clay, 70; sand, 30.
O. H. Walton	Sec. 24					Yellow clay; blue sticky clay; quicksand; stopped in 50 feet of river sand.
Wm. Blythe	SE. ¼ NW. ¼ sec. 25		246			
Gilmore	SE. ¼ SE. ¼ sec. 27		228		472	

Typical wells in Scott County—Continued.

Owner	Locality	Depth	Depth to rock	Depth in rock	Rock surface above sea level	Remarks: (Logs given in feet)
		Feet	Feet	Feet	Feet	
E. O'Neil	SE. ¼ NE. ¼ sec. 28	323	312		448	Yellow clay, 50; sand, 50; mostly blue clay; coarse gravel.
H. Schultz	SW. ¼ SE. ¼ sec. 33		113			Yellow clay, 16; quicksand; blue stony clay to 50; sand and gravel 2; blue clay, 61.
H. Stahft	NE. ¼ SW. ¼ sec. 33	250	240		440	Mostly quicksand; 100 feet of sand in one bed.
H. Latrode	NW. ¼ NE. ¼ sec. 33		212		508	
Town of Donahue	NE. ¼ sec. 36		100			
Do	NE. ¼ sec. 36	160	157	3		Yellow clay; blue clay; quicksand, 15.
T. 79 N., R. 2 E. (Hickory Grove.)						
H. Klindt	SE. ¼ NW. ¼ sec. 2	81	71			
C. Rock	NE. ¼ SW. ¼ sec. 4	82	72			
F. Rock	SE. ¼ NW. ¼ sec. 4	150	144	6		
P. Burmeister	NW. ¼ NE. ¼ sec. 4	74	70			
M. Spelletich	SE. ¼ SE. ¼ sec. 5	77	69			
M. Spelletich	SE. ¼ SE. ¼ sec. 7		55		665	
J. Soutter	NE. ¼ SE. ¼ sec. 8	77	30	47		
P. Burmeister	NW. ¼ NW. ¼ sec. 9		70	75		
Do	SW. ¼ NE. ¼ sec. 9		80	85		
H. Arp	SE. ¼ SW. ¼ sec. 9		50	53		
J. Kerker	SE. ¼ SE. ¼ sec. 9		40	64		
P. Meyer	NW. ¼ SE. ¼ sec. 10		80	95		
C. Meyer	SW. ¼ SE. ¼ sec. 11	81	67			
B. Painter	NE. ¼ sec. 12		215		525	
Ira Burch	SW. ¼ SE. ¼ sec. 12	191	190		550	Yellow clay, 40; blue till, 150.
Hans Joens	SE. ¼ NW. ¼ sec. 13	157	155			Water on rock.
J. Steenbock	SW. ¼ SE. ¼ sec. 13	212	208		502	
Maysville	Sec. 15	130	120			
A. Lage	NW. ¼ SW. ¼ sec. 16	91	85			All yellow clay.
H. Klindt	SW. ¼ SW. ¼ sec. 16	74				Ends in rock.
G. Golinghast	SE. ¼ sec. 17	78	50			
M. Spelletich	SW. ¼ SE. ¼ sec. 18		270		510	
J. Paustian	SE. ¼ NE. ¼ sec. 19					Yellow clay, 20; sand, 5; blue clay, 105; gravel, 7.
M. Gries	SW. ¼ SW. ¼ sec. 22	170	165		555	Below 100 feet all quicksand and sticky clay.
W. Fry	NE. ¼ SE. ¼ sec. 24	208	206		534	Yellow clay, 17; blue clay hard, 60; sand, 129.
Schoolhouse	SE. ¼ SE. ¼ sec. 26	250	215		525	
E. Sindt	NW. ¼ NE. ¼ sec. 27					Yellow clay, 15; blue clay, 15; quicksand; ends in gravel.
C. Paustian	NE. ¼ NW. ¼ sec. 30	143	130			Yellow clay, 20; sand, 5; blue clay, 105.
Geo. Deitz	SW. ¼ SE. ¼ sec. 31					Yellow clay, 15; quicksand, 5; blue clay, 30; gravel, 5.
A. H. Lamp	NW. ¼ NW. ¼ sec. 33					Yellow clay, 20; sand, 6; blue clay, 58; gravel, 2.
Maysville Creamery	NW. ¼ SE. ¼ sec. 15	90	90		650	Yellow clay, 16; quicksand, 10; greenish clay, 64.
J. Plambeck	SE. ¼ sec. 36	240	230		510	Quicksand, 60; rock.
J. Soutter	NE. ¼ sec. 8	90	80			Yellow clay, 40; blue clay to rock.

Typical wells in Scott County—Continued.

Owner	Locality	Depth	Depth to rock	Depth in rock	Rock surface above sea level	Remarks: (Logs given in feet)
		Feet	Feet	Feet	Feet	
T. 78 N., R. 2 E. (Bluegrass.)						
S. R. Miller	SW. ¼ SW. ¼ sec. 1					Yellow clay, 35; blue, hard clay to bottom. Did not cave.
W. Arp	SW. ¼ SW. ¼ sec. 3		100		660	
G. Muhl	SW. ¼ sec. 5	104	40	64		Soft white limestone.
H. F. Strohbeen	SW. ¼ SW. ¼ sec. 5	90	47	43		
Walcott	Sec. 6		50			Yellow clay, 14; sand, 5, blue pebbly clay, 31.
J. Franz	NE. ¼ NW. ¼ sec. 8	89	86			
H. Goering	NW. ¼ sec. 10	101	91			
Do	SW. ¼ SW. ¼ sec. 10	118	90			
H. Meyer	NW. ¼ NE. ¼ sec. 12	256	235		504	
Eggert Puck	SE. ¼ NE. ¼ sec. 12	210	204		536	
A. Le Buhn	NE. ¼ NE. ¼ sec. 16					Yellow clay, 20; sand, 5; blue clay, 50; gravel, 5.
H. Schlichting	SE. ¼ NE. ¼ sec. 23	120	110			
Schoolhouse No. 3	NW. ¼ sec. 19	200	78	122		Yellow clay, 20; sand, 10; blue clay, 48; white limestone, 122.
T. 77 N., R. 2 E. (Buffalo).						
E. James	SW. ¼ sec. 3	316	35			Limestone, 160.
L. Daurer	NW. ¼ NW. ¼ sec. 8	270	50			
Barnwick	SE. ¼ SE. ¼ sec. 16	144	20			
F. Beh	NE. ¼ sec. 18	201	100			Limestone, 161.
J. Murray	NW. ¼ sec. 10	305	35			No coal; limestone, 160.
T. 80 N., R. 3 E. (Winfield).						
C. Gillian	SE. ¼ SE. ¼ sec. 7					Sand, 20; hard, blue, pebbly clay, 120; sand, 5; gravel, 5.
St. Ann's Church	SE. ¼ SW. ¼ sec. 14	100	64	36		Sand, 15; yellow clay, 10; blue clay; a little sand.
P. Jones	NW. ¼ NW. ¼ sec. 15		190		530	
School No. 3	NW. ¼ NW. ¼ sec. 16					Sand, 70; blue clay, 20; gravel, 4.
N. Denklau	SW. ¼ NW. ¼ sec. 19	173	153			
A. Brownlee	NW. ¼ SE. ¼ sec. 26		220		505	
J. Robertson	NE. ¼ NE. ¼ sec. 27	121	120			Yellow clay, 50; hard blue, stony clay, 70; sand and gravel, thin.
J. Neil	SW. ¼ SW. ¼ sec. 35		225		555	
A. D. Brownlee	½ mile north of Long Grove.	256	220			Yellow clay, 20; blue clay, 140; sand and gravel, 30; blue clay, 30.
P. E. Jones	Southwest of Noels		190			Blue clay, 100; much sand beneath it to rock.
T. 79 N., R. 3 E. (Sheridan).						
C. Clapp	SW. ¼ NE. ¼ sec. 2	128	122			
J. Lenseh	SE. ¼ SE. ¼ sec. 2	118	114			
C. Meier	SW. ¼ SE. ¼ sec. 4	199	100			Yellow clay, 25; old soil, 10; blue clay, 65; coal, 2; shale, 97.
J. Paustian	NE. ¼ SW. ¼ sec. 5	237	200		560	Shale, 37.
J. T. Cooper	SW. ¼ SW. ¼ sec. 5	145	140			Yellow and blue clay; gravel on rock.
Eldridge	SW. ¼ sec. 11	135	127			Yellow clay less than 20; mostly blue clay; ends in limestone.
Eldridge Creamery	NW. ¼ NE. ¼ sec. 14	201	180		600	
Chas. Erhsam	NW. ¼ NE. ¼ sec. 20		72		658	
W. Hughes	NW. ¼ SE. ¼ sec. 33	180	170			
Claus Lamp	SW. ¼ SW. ¼ sec. 19	285	270		470	Mostly hard blue clay.

Typical wells in Scott County—Continued.

Owner	Locality	Depth	Depth to rock	Depth in rock	Rock surface above sea level	Remarks: (Logs given in feet)
T. 78 N., R. 3 E. (Part of Davenport).		Feet	Feet	Feet	Feet	
School No. 2	NE. ¼ sec. 7					Yellow clay, 30; sand, 10; blue clay, 80; gravel, 2.
J. Carlin	SW. ¼ SE. ¼ sec. 10	140	115			
G. Conklin	SW. ¼ NW. ¼ sec. 11	106	90			
M. Boyle	NW. ¼ SW. ¼ sec. 13	94	85			
J. Armel		245	202			
Dr. G. T. Maxwell		130	100			
Schuetzen Park		240	160			
J. Hever	SE. ¼ SE. ¼ sec. 21	200	155			
Thos. Sindt	NW. ¼ NW. ¼ sec. 7	167	160			
T. 78 N., R. 4 E. (Parts of Davenport and Pleasant Valley).						
I. Barr	SE. ¼ NW. ¼ sec. 4	150	100			
C. Van Evera	SW. ¼ sec. 4	115	90			
R. Schaefer	SW. ¼ SW. ¼ sec. 4	85	80			
J. Barnholdt	NW. ¼ sec. 5	98	88			
H. Wiese	NE. ¼ sec. 6	94	79			
I. Barr	NE. ¼ SW. ¼ sec. 7	157	142			
F. Thomas	NW. ¼ SW. ¼ sec. 9	163	150			
C. Carstens	SE. ¼ SW. ¼ sec. 17	138	120			
A. J. Partridge	NE. ¼ NE. ¼ sec. 18	106	90			
I. Barr	NW. ¼ sec. 18	90	70			
J. Barr	SE. ¼ NE. ¼ sec. 18	65	58			
Wm. C. Schaefer	NE. ¼ SW. ¼ sec. 19	93	80			
J. L. McCullough	SW. ¼ sec. 20	160	90			
E. S. Kellog	NW. ¼ SE. ¼ sec. 18	105	90			
T. 80 N., R. 4 E. (Butler).						
Gambril	Sec. 7		525			
J. Henry	NE. ¼ SW. ¼ sec. 22		100			
Do	NE. ¼ SE. ¼ sec. 22		62			
E. Mueller	NW. ¼ NW. ¼ sec. 35		60			
T. 79 N., R. 4 E. (Lincoln and part of Le Claire).						
D. Arp	SW. ¼ NW. ¼ sec. 2	130	120			Ends in limestone.
I. Barr	NE. ¼ NE. ¼ sec. 7	121	101			
J. H. Barr	NE. ¼ SW. ¼ sec. 22		190		550	
M. Jones	SE. ¼ sec. 23	150	120			
M. Thompson	NE. ¼ NE. ¼ sec. 27	182	175			
H. Schroeder	SW. ¼ SW. ¼ sec. 33	75	55		665	
M. Barr	SW. ¼ SW. ¼ sec. 26	116	86			
G. Leamer	NW. ¼ NE. ¼ sec. 25	381	210		530	Shale, 210-375; ends in limestone.
J. Stafford	SE. ¼ NW. ¼ sec. 36	246	150			
H. Stafford	NE. ¼ SW. ¼ sec. 36	121	100			
G. Hyde	SW. ¼ NW. ¼ sec. 36	100	80			Lime rock, 20.
Porters Corners	NE. ¼ NE. ¼ sec. 25	305	175			Yellow clay, 30; quicksand; blue till; shale, 100; limestone, 30.
T. 80 N., R. 5 E. (Part of Princeton).						
T. Carroll	NW. ¼ NE. ¼ sec. 30		60			

Typical wells in Scott County—Concluded

Owner	Locality	Depth	Depth to rock	Depth in rock	Rock surface above sea level	Remarks: (Logs given in feet)
T. 79 N., R. 5 E. (Parts of Princeton and LeClaire).		Feet	Feet	Feet	Feet	
C. Fulmer	NW. ¼ NE. ¼ sec. 4		80			
C. Like	NE. ¼ SE. ¼ sec. 4		100			
O. Peaslee	SW. ¼ SW. ¼ sec. 9		169		551	
W. Florence	SW. ¼ SW. ¼ sec. 5	82	70		630	
J. Brown	SW. ¼ NE. ¼ sec. 17		100			
J. Wilson	SE. ¼ NW. ¼ sec. 21		100			
J. C. McGinnis	SE. ¼ NW. ¼ sec. 30	250	170			
W. H. McGinnis	SE. ¼ NE. ¼ sec. 30	150	120			
M. Miller	SW. ¼ NE. ¼ sec. 31		150			
M. Wilson	NE. ¼ sec. 32	150	60			
T. Taylor	NE. ¼ sec. 32	75	55			
H. Stone	SW. ¼ sec. 32		61			
J. Suiter	NW. ¼ SE. ¼ sec. 33		35			
T. 78 N., R. 5 E. (Parts of Le Claire and Pleasant Valley).						
J. McCaffry	NW. ¼ sec. 4		40			
A. Schurr	NW. ¼ sec. 4	78	50			Yellow clay, 25; blue clay to rock; shale.
T. 77 N., R. 3 E. (Rockingham).						
F. J. Shaeffer	NW. ¼ sec. 5	216	40			Shale, 40 to 206.
Walnut Hill School	NE. ¼ NW. ¼ sec. 5	225	40			Do.
J. A. Punt	NW. ¼ NE. ¼ sec. 5	186	30			Shale to 10 feet of bottom.
Fairview School	NE. ¼ SE. ¼ sec. 7	110				Shale and blue clay in alternate layers.

TAMA COUNTY

BY W. J. MILLER.

TOPOGRAPHY.

Tama county may be roughly divided into northern and southern provinces of about equal size. In the northern half of the county the Iowan drift forms the surface and its characteristic topography is shown by a gently undulating surface. The hills are low and broad and the drainage is fairly good. Wolf creek, which flows from west to east across this region, has cut out a broad shallow valley, modifying the generally more level surface. The southern province, including most of southern Tama county, is loess-covered and has a much more hilly and rugged topography. The hills are higher and the region is dissected by numerous small streams, giving a good drainage. Iowa river, the largest stream in the county, enters this province at the west and leaves it at the southeast; its valley is broad and deep.

GEOLOGY.

The drift formations are represented by the Nebraskan, the Kansan, and the Iowan. The Kansan drift extends over the entire county and is everywhere covered by either Iowan or loess. In some localities the Kansan is known to be underlain by small areas of Nebraskan. The Iowan drift is spread over three-fourths of the county, everywhere concealing the Kansan, and is, in turn, partly covered by loess. From the northern half of the county, which is all Iowan-drift covered, one tongue of Iowan extends southward to Toledo, and another southward, on the east side of Salt creek, to Irving. The southwest corner of the county is also Iowan-covered. The loess covers most of the southern portion of the county and a narrow strip of the northern portion along Wolf creek. These drift formations, as shown by well sections, range in thickness from 200 to 400 feet.

Immediately below the drift and extending over all the county except the extreme northeast corner are Mississippian (Lower Carboniferous) shales and limestones. (See Pl. XI, p. 458.) The northeast corner probably shows some Upper Devonian limestone.

Viewed broadly, the drift deposits may be said to be spread over the county in nearly horizontal beds with local thickening or thinning. The old rock formations show a slight inclination westward.

UNDERGROUND WATER.

SOURCE.

Water is found in sand and gravel beds in the drift and in limestones in the deeper formations. As a rule, an abundant supply is readily obtained, especially from the deeper drift and from rock wells. All the waters are generally of good quality, but always hard.

By far the most important aquifer in the drift is the sand or gravel at the bottom of the blue Kansan clay. This water-bearing stratum is absent in a few places only. Nearly everywhere it underlies a so-called hardpan, which is merely a tough compact clay which serves to confine the water in the porous sands and gravels. This aquifer is seldom struck at less than 200 feet or more than 400 feet below the ground surface. Water obtained from this source is very persistent and abundant.

Other aquifers occur as sandy layers higher up in the drift (blue clay), but these layers are local in their extent, and water supplies from them are in many places small and not persistent. In many surface wells in the yellow clays or in the alluvium along the streams the supply fluctuates according to season.

A very important water bed in Tama county lies just below the drift in the limestones or shales. Sometimes a good supply is struck soon after entering the rock and at other times the drilling must proceed a hundred feet or more. Many of the recent farm wells are rock wells with a never-failing supply of good water.

PROVINCES.

All the southeast portion of the county may be looked upon as a separate underground-water province. It possesses two types of flowing wells—those which originate in the drift and those which originate in the underlying rock formations.

The region of flowing drift wells forms a part of the well-known Belle Plaine artesian basin, which extends into Benton, Iowa and Poweshiek counties. In Tama county this basin extends northward to Elberon and Vining and westward to Chelsea. The flowing wells receive their supply from a bed of sand and gravel which underlies the impervious blue Kansan clay. The drift deposits, which were laid down in the trough cut by the preglacial Iowa river, slope downward toward the lowest part of the trough in the vicinity of Belle Plaine, developing sufficient head to cause flowing wells in the lower portion of the drift-filled basin.[1]

Closely associated with the flowing wells from the drift are others whose water is derived from rock formations below the drift. Wells of this kind occur within the drift flowing-well basin and also as far north as Clutier and as far west as Long Point. The source of water is usually a limestone (Devonian), which underlies a thin bed of shale (Carboniferous), the shale acting as an impervious covering.

Aside from the region of flowing wells all of Tama county may be looked upon as a single underground-water province.

SPRINGS.

Springs in Tama county are of little importance, consisting almost invariably of small seepages from the drift materials, especially along the main waterways.

CITY AND VILLAGE SUPPLIES.

Tama.—The town of Tama (population, 2,290) is supplied with water under a domestic pressure of 60 pounds and a fire pressure of 100 pounds. There are four miles of mains, 36 fire hydrants, and 160 taps. About 1,400 people consume 200,000 gallons daily. Ordinarily the water is good, but hard.

[1]Mosnat, H. R., Artesian wells of the Belle Plaine area: Rept. Iowa Geol. Survey, vol. 9, 1899, pp. 521-562.

A forecast of the local artesian conditions made by W. H. Norton is as follows: Tama is 820 feet above sea level. At about 550 feet above sea level the drill may be expected to enter the Devonian limestone, leaving behind shales of the Kinderhook and shales of the Upper Devonian, not easily distinguished from them. The Devonian yields largely, as is seen in the city well at Toledo and in the first rock flow found at Belle Plaine. The waters of the drift and of the Kinderhook are exceedingly poor in this vicinity and should be carefully cased out before a test of the Devonian water is made. Both Devonian and Silurian waters should be of good quality, but it is possible that the former may have been contaminated by interior higher waters which have descended to their level, and that the gypseous beds of the Silurian extend this far to the east and add a large calcium sulphate content to the water. The Maquoketa shale (Ordovician) may be estimated to extend from sea level to 200 or 250 feet below it and will be found dry. Passing through the Galena and Platteville limestones the drill will come to the Saint Peter sandstone at 475 to 550 feet below sea level. Below the Saint Peter the drill will enter the Prairie du Chien stage, the upper formation of which, the Shakopee dolomite, a creviced dolomite, should add materially to the supply. The other formations of this group (the New Richmond sandstone and the Oneota dolomite) are also large contributors of artesian water. At 400 to 500 feet below the summit of the Saint Peter the main water bed, the Jordan sandstone, should be reached. Drilling contracts should provide for continuing, if necessary, to 1,100 or 1,200 feet below sea level or, in round numbers, to 2,000 feet below the surface. The water should head at about 800 feet above sea level.

The excellent water obtained at Grinnell in well No. 2 encourages the belief that at Tama also water of low mineralization may be secured from the Cambrian and Ordovician water beds, provided the heavily mineralized waters are completely excluded.

The well of Mrs. A. Huber, near Tama (NE. ¼ sec. 26, T. 83, R. 15), has a depth of 816 feet and diameter of two inches. The curb is 880 feet above sea level and the head 20 feet below the curb. Water was found at 361 feet and at 450 feet, the latter heading at the curb. Lower veins have lower heads. Rock was reached at 108 feet. Date of completion, 1893.

Driller's estimate (generalized), Mrs. A. Huber's well.

	Thickness.	Depth.
	Feet	Feet
Soil, black	2	2
Clay, yellow (loess)	18	20
Clay, blue (Kansan)	64	84
"Hardpan" (shale and limestone?)	170	254
Flint	1½	255½
Limestone	40	295½
Limestone, flint, shale, etc.		

This is the deepest well in Tama county. The water is strongly mineralized. Analysis has shown iron, soda, magnesia, sulphur, etc. The mineral content is said to be decreasing.

Toledo.—At Toledo (population, 1,626) water is delivered under a pressure of 80 pounds through 4½ miles of mains to 36 fire hydrants and 230 taps, supplying 1.500 persons with 60,000 gallons daily. The water is of good quality, but is hard.

The city well has a depth of 344½ feet and a diameter of six to five inches; cased throughout except in limestones. The head is 30 feet below the curb, the water coming from 343 feet. The capacity is 500 gallons a minute. The well was completed in 1905.

Driller's log of city well at Toledo.

	Thickness.	Depth.
	Feet	Feet
Clay and sand	25	25
Quicksand and water	6	31
Clay	50	81
Quicksand	12	93
Clay	18	111
Limestone; water bearing near top	32	143
Shale (Kinderhook)	160	303
Limestone	40	343
Shale	1½	344½

Toledo is 852 feet above sea level. It is so near Tama that its deep-well forecast may be considered to be identical with that of the latter place. (See p. 614.)

The Tama County Farm well, which is located 2½ miles north of Toledo, has a depth of 445 or 545 feet and a diameter of 6 to 3½ inches. Its head is 150 feet below curb. The water comes from 345 feet in Devonian limestone and from 245 feet in drift sands. It was drilled by McLurk Brothers, of Traer, and was completed in 1896 (?).

Log of County Farm well near Toledo.

	Thickness.	Depth.
	Feet	Feet
Pleistocene:		
Clay, yellow, and sand	50	50
Clay, blue, and bowlders	150	200
Clay, hard, yellow and blue, and pebbles	40	240
Sand (water bearing)	40	245
Carboniferous (Mississippian):		
Kinderhook—		
Shale	100	345
Devonian:		
Limestone and water	100	445

Traer.—The Traer town well, 249 feet deep, 54 feet of which is in rock, yields 200 gallons a minute to a steam pump. The water, which is from limestone, heads 189 feet below the curb. It is distributed by gravity with a domestic pressure of 55 pounds and a fire pressure of 160 pounds, through two miles of mains to 20 fire hydrants and 150 taps to 800 persons, who consume 25,000 gallons daily. The water is good, but hard.

Driller's log of town of Traer well.

	Thickness.	Depth.
	Feet	Feet
Clay, yellow	5	5
Clay, blue; some water-bearing sand	190	195
Shale	35	230
Limestone (water bearing)	19	249

Though the high elevation of Traer (916 feet above sea level) precludes any hope of a flowing well, water should rise within easy pumping distance from the Saint Peter sandstone and the subjacent Ordovician and Cambrian water beds, the static level of whose waters is probably somewhat higher than 850 feet above sea level, or less than 70 feet from the surface.

The Saint Peter will be encountered at about 250 feet below sea level, or 1,170 feet from the surface. Small yields may also be expected in the Galena and Platteville limestones overlying the Saint Peter. Wells should be sunk 500 or 550 feet below the summit of the Saint Peter in order to tap the far larger reservoirs of the Prairie du Chien stage and the Jordan sandstone, which underlie the Saint Peter. A well about 1,700 or 1,750 feet deep is indicated.

WELL DATA.

The following table gives data of typical wells in Tama county:

Typical wells of Tama County.

Owner	Location	Depth	Depth to rock	Source of supply	Head	Remarks: (Logs given in feet)
		Feet	Feet			
Town of Toledo	Toledo	345	111	Limestone	— 30	
Mrs. A. Huber	Tama	816	106	do	— 19	
John Hodecheck	2 miles north of Vining.	380	None.	Drift sand	—120	Hill. Yellow clay, 40; bluish clay, 35; sand (water bearing), 11; blue clay, 288; sand and water, 6.
Frank Krizek	Clutier	210	196	Limestone	+ 18	Strong flow. Dark soil, 10; sand and clay (water bearing), 30; blue clay, 156; limestone and water, 14. At well bottom drill dropped 19 inches and water gushed out.
John Earhart	7 miles north of Toledo.	366	365	Limestone (?)	—150	Black soil, 3; blue clay and pebbles, 120; sand and some water, 3; blue clay and pebbles, 239; rock (limestone) and water, 1.
Town of Traer	Traer	249	195	Limestone	—189	
Tama County Farm.	2½ miles north of Toledo.	445	245	do	—150	
Fred Praher	Crystal	307	300	do	—100	Hard water. Yellow and blue clays, 287; "hardpan" or hard clay, 10; shale and some water, 3; limestone and water, 7.
Pete Schmidt	2½ miles south of Traer.	644	300	do	—150	
O. Angel	3 miles east of Gladbrook.	310	306	do	—120	Yellow and blue clay and "hardpan" or hard clay, 306; limestone, 4.

CHAPTER X.

UNDERGROUND WATERS OF THE SOUTHEASTERN DISTRICT.

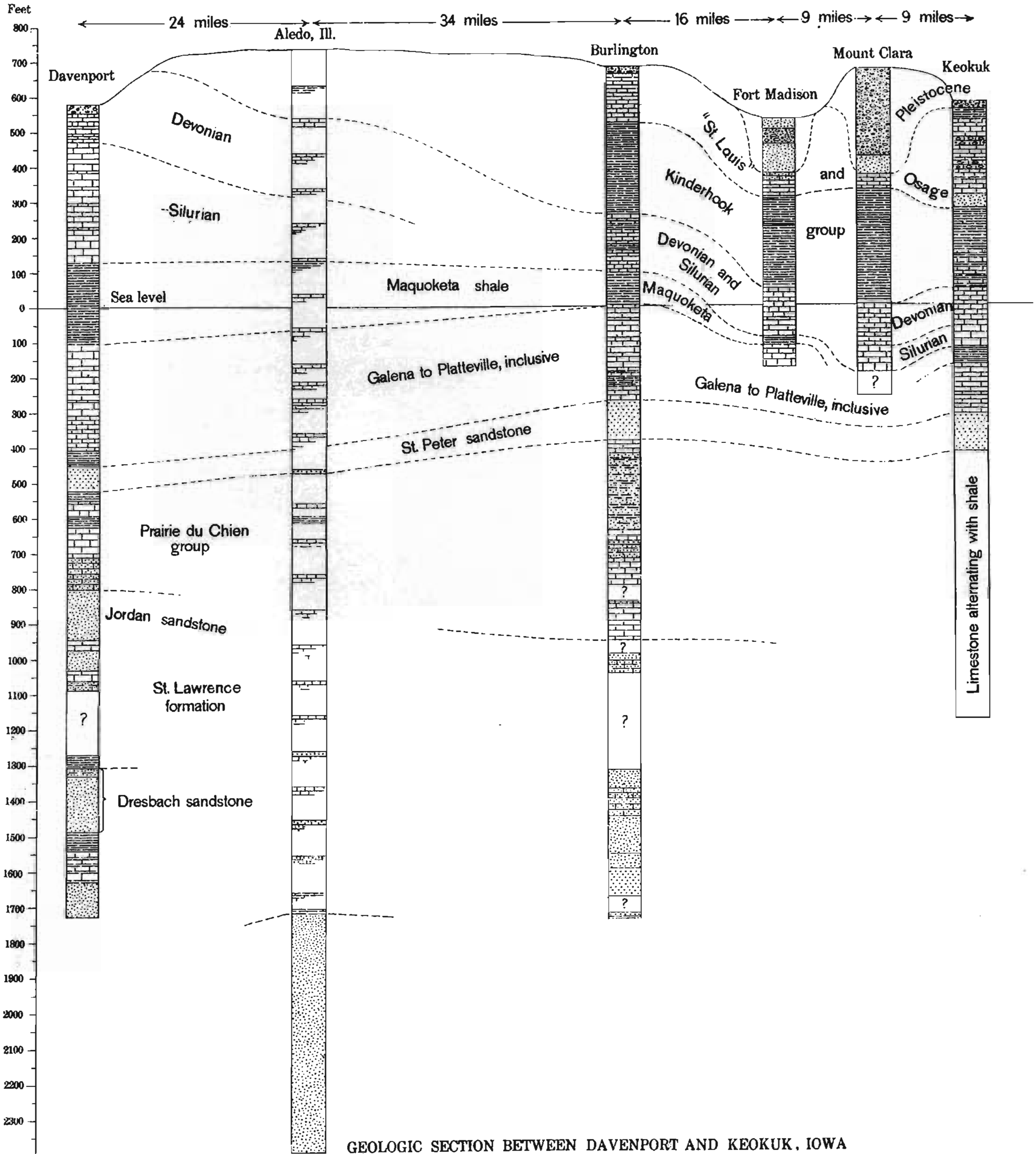
INTRODUCTION.

BY W. H. NORTON.

The southeastern district embraces the eleven counties of Davis, Des Moines, Henry, Jefferson, Keokuk, Lee, Louisa, Mahaska, Van Buren, Wapello, and Washington.

If the deeper terranes continued through southeastern Iowa with the same thickness and the same degree and direction of inclination which they hold farther north, they would be carried too deep for profitable well drilling before they reached the Missouri state line. Fortunately a reversal of dip brings the Saint Peter and its associated water beds higher in Lee and Des Moines counties than in Cedar and Muscatine counties of east-central Iowa. From Burlington, where the Saint Peter reaches its highest recorded elevation in this area, it dips northward at a rate of more than six feet to the mile to the Muscatine county line. The dip to Davenport is three feet to the mile. (Pl. XII, p. 618.) Between Burlington and Letts, the northward dip probably meets the southward in a sag. Northeast of Burlington the dip is to the north, at least as far as Aledo, Illinois. Between Burlington and Mount Pleasant (Pl. XIII, p. 626.) the dip is five feet to the mile, and to the west, to Centerville, it is 4.6 feet to the mile.

Where the Cambrian and Ordovician strata of southeastern Iowa are upwarped to form a low dome the Silurian and Devonian strata are markedly thinner. For example, between Burlington and Keokuk (Pl. XII) the Devonian and Silurian strata barely exceed 150 feet in thickness; farther north, at Letts, they are more than 300 feet thick; still farther north, at



GEOLOGIC SECTION BETWEEN DAVENPORT AND KEOKUK, IOWA
By W. H. Norton

THE NORRIS PETERS CO., WASHINGTON, D. C.

Tipton, the Silurian alone is 325 feet thick; and to the west, at Pella, these formations include more than 400 feet of rocks. (See Pls. X, p. 448, XIV, p. 660.) The Maquoketa also shares in the thinning. At Davenport it is 240 feet thick, at Pella 190 feet, at Burlington 100 feet, and at Fort Madison and Keokuk less than 50 feet. (See Pl. XII.) The Galena and Platteville limestones likewise form a wedge that tapers toward the southwest. At Davenport their combined thickness is 340 feet and at Keokuk only 140 feet.

The upwarp of the Cambrian and lower Ordovician and the thinning of the higher terranes up to the Mississippian combine to bring artesian water from the Saint Peter and deeper aquifers within easy drilling distance of the surface. (See Pl. I, in pocket.) At Keokuk, for example, the Saint Peter is reached only about 900 feet below the valley level. The Silurian and the Galena and Platteville limestones in the southeastern district also furnish exceptionally large quantities of water. At Burlington six deep wells obtain flows from the Silurian within about 500 feet of the surface, and the same formation, or possibly the Galena, is tapped by some of the deep wells at Keokuk. The wells at Fort Madison obtain their supplies largely from the Galena.

The dome of southeastern Iowa is only the northward extension of the upwarp of northeastern Missouri which brings the Saint Peter sandstone to the surface about fifty miles south of Keokuk, in Ralls county, Missouri. This upwarp appears somewhat narrower in Iowa than in Missouri. Thus, though the Saint Peter sandstone lies 613 feet below sea level at Bloomfield it is found at Baring, Knox county, Missouri, at 136 feet below sea level, a southward rise of about 13 feet to the mile.

For comparison with the section of southeastern Iowa the record of the Baring well is appended. It will be noted that the Silurian is arenaceous, that the Maquoketa has pinched out, and that the Galena and Platteville limestones and the Decorah shale combined measure only 79 feet in thickness. Water occurs in the Silurian sandstone, the Galena dolomite, the Saint Peter sandstone, and at several horizons in the Prairie du Chien stage. Reports have not been received as to water beds in the Cambrian.

Record of strata in the Atchison, Topeka & Santa Fe Railway well, at Baring, Missouri.

	Thickness.	pth.
Pleistocene (100 feet thick; top, 808 feet above sea level):	Feet	Feet
Till, blue, predominantly clayey	100	100
Carboniferous (Mississippian):		
Saint Louis limestone and Osage stage (365 feet thick; top, 708 feet above sea level)—		
Chert, with white limestone and chalcedonic and crystalline silica; in sand	175	275
Shale, green-gray, highly arenaceous; with minute irregular grains of crystalline quartz, calcareous	5	280
"Limestone, white;" no sample	65	345
Sandstone, very coarse; very imperfectly rounded grains of quartz and other minerals; water heading at 180 feet below curb	15	360
Chert; fine sand of particles of cryptocrystalline silica with some white limestone and some crystalline quartz; water at 375 feet	15	375
Marl, light yellow; rapid effervescence, large siliceous and argillaceous residue	35	410
Limestone, light drab, fine-grained	50	465
Kinderhook stage (33 feet thick; top, 343 feet above sea level)—		
"Shale;" no sample	28	493
"Blue clay;" no sample	5	498
Devonian (217 feet thick; top, 310 feet above sea level):		
"Limestone;" no sample	12	510
Limestone, gray; rapid effervescence; earthy, fossiliferous, with joints of crinoid stems and fragments of shells of brachiopods; in flaky chips	205	715
Silurian (150 feet thick; top, 93 feet above sea level):		
Limestone and sandstone; limestone, light yellow-gray, rapid effervescence; sandstone, fine-grained, larger grains of pure quartz and well rounded, a few with secondary enlargements; much cryptocrystalline silica in chips; water at 860 feet	145	860
"Sand, white;" no sample	5	865
Ordovician:		
Galena limestone (69 feet thick; top, 57 feet below sea level)—		
Dolomite or magnesian limestone, cherty; in brown crystalline sand; water at 900 feet	69	934
Decorah shale (4 feet thick; top, 126 feet below sea level)—		
"Shale;" no sample	4	938
Platteville limestone (6 feet thick; top, 130 feet below sea level)—		
Limestone, light gray; rapid effervescence; some chert; in small chips	6	944
Saint Peter sandstone (46 feet thick; top, 136 feet below sea level)—		
Sandstone, light yellow, fine-grained; of pure quartz, grains moderately well rounded, some showing secondary enlargements; 4 samples; water at 956 feet	46	990
Prairie du Chien stage (702 feet thick, top, 182 feet below sea level)—		
Dolomite, light yellow; in sparkling sand	10	1,000
"Slate, blue;" no sample	9	1,009
Sandstone, buff, very fine; grains imperfectly rounded	30	1,030
Sandstone, coarser, heavily rusted; water bearing	2	1,041
Dolomite, buff and light brown, cherty, highly arenaceous; 3 samples	67	1,108
Dolomite, light brown and gray, oolitic, cherty, somewhat arenaceous; 3 samples; water bearing at 1,140 feet	97	1,205
Dolomite, light buff, highly arenaceous	35	1,240
Dolomite, light buff, somewhat arenaceous	78	1,318
Dolomite, light buff, highly arenaceous and cherty	90	1,408
Dolomite, buff; some sand in drillings	86	1,494
Dolomite, light gray; water heading at 126 feet below curb	21	1,515
"Limestone" (dolomite); no sample; water at 1,535 feet	20	1,535
Dolomite, cherty, somewhat arenaceous; 2 samples	37	1,572
Marl, light buff, in concreted powder; and dolomite, in fine meal	4	1,576
Dolomite, light buff, cherty	14	1,590
Dolomite, light yellow	35	1,625
Dolomite, light brown	17	1,642
Dolomite, rusted grains with some chert and a few grains of quartz sand	4	1,646
Dolomite, buff, with some chert, minute grains of quartz sand and a little glauconite; two samples	20	1,666
Dolomite, buff, cherty, two samples	26	1,692
Cambrian (150 feet penetrated; top 884 feet below sea level):		
Sandstone, light yellow, in clean quartz sand; grains well rounded, larger grains reach from .6 to 1 millimeter	8	1,700
Sandstone, light yellow, coarser; three samples	60	1,760
Sandstone, light yellow, with some green shale	14	1,774
Marl, light yellow-gray, calcareoargillaceous	8	1,793
Sandstone, whitish	11	1,793
Sandstone, buff, rounded grains, with an admixture of marl; two samples	49	1,842

DAVIS COUNTY

BY O. E. MEINZER AND W. H. NORTON.

TOPOGRAPHY.

The upland surface of Davis county slopes gently toward the east and in general lies between 750 and 950 feet above sea level. It represents an original plain which still exists in extensive remnants as upland prairies, but which throughout most of the county is dissected by a complicated system of valleys and ravines that have produced a hill country with a relief of 100 feet and more. The hill topography is best developed near the principal streams, as in the vicinity of Soap creek, and the prairie topography in the districts most remote from streams, as on the divide followed by the Chicago, Burlington & Quincy railway. The prairies are sufficiently continuous to have been for the most part preferred to the valleys for railway construction, and hence it has come about that nearly all of the villages are located on the upland.

GEOLOGY.

The valleys are excavated almost entirely in glacial drift, only the deepest extending to bedrock. This fact and the information obtained from well sections indicate that in most localities the drift beneath the uneroded uplands is between 100 and 200 feet deep. S. J. Andrews, a well borer at Pulaski, sharply distinguishes two deposits, both of which are probably glacial drift. The upper deposit he describes as a crumbling clay, ordinarily yellow, and in many places about 50 feet thick, containing pebbles and bowlders; the lower he describes as more tough and "oily," generally black but exceptionally yellow, containing only a few pebbles and bowlders, but numerous leaves, shells, and pieces of wood. This lower deposit is absent over a large part of the county, but in certain localities it reaches a maximum thickness of more than 100 feet. A large specimen of this deposit was examined and found to consist of tough, dense, dark carbonaceous clay containing fragments and specks of black carbonized wood, minute lime concretions, and a few tiny greenstone pebbles, and showing an indistinct foliated or nodular structure. Below the lower of these two deposits in most localities lies a bed of white sand only a few feet thick, and this sand or, in its absence, one of the other deposits, generally rests upon a stratum which is locally known as "blackjack" or "blue daub," but which appears to be shale interbedded with limestone strata. The upper deposit is probably Kansan drift thinly covered with loess or loess-like clay, and the underlying dark deposit may belong to the Nebraskan sheet. The following section is more or less typical in this county. The bowlder clay probably begins at the depth of 15 feet.

Section of group of wells about 4 miles west of Pulaski.

	Thickness.	Depth.
	Feet	Feet
Soil	1	1
Clay, yellow	7	8
Clay, blue, stiff; without grit	7	15
Clay, yellow, pebbly	40	55
Clay, black, containing oil, wood, leaves, shells, etc.	57	112
Sand, white (good supply of water)	2	114
Shale, dark, "blackjack," entered.		

Throughout nearly all of Davis county the bedrock consists of shale, sandstone, limestone, and coal belonging to the Des Moines stage of the Pennsylvanian series. Near Soap creek, in the northern part of the county, and at many places in its northeastern part outcrops of this bedrock occur. It is also exposed in a few coal mines, and is apparently reached by wells drilled in all parts of the county.

UNDERGROUND WATER.

Water is obtained from several strata, none of which are entirely satisfactory. The chief reliance is placed on shallow wells dug or bored into the loesslike clay and upper part of the glacial drift, the seepage from which is adequate for ordinary purposes in some localities where gravelly beds are found, but is quite inadequate and unreliable in others where the material is less porous. The water table in this upper layer conforms closely to the surface configuration, the water in shallow upland wells commonly standing high above the level of deep valleys only short distances away. Especially is this true in rainy seasons.

More dependable supplies are in some localities obtained from beds of sand farther down in the drift, such as the white sand that usually lies below the carbonaceous deposit described; but beds of sand are not found everywhere, and in some places where present are not water bearing, because they have drained into adjacent deep valleys. Moreover, in wells of small diameter the sand causes trouble by rising with the water.

A number of wells drilled into the Pennsylvanian rocks to depths ranging from 300 to 400 feet find small or moderate supplies of mineralized water that rises to a level far below the surface of the uplands, but nearly or quite as high as the flood plains of the deepest valleys. A well of this kind may cost more than $500.

At still greater depths are formations which yield large amounts of water that is hard but not so strongly mineralized as the average water from the Pennsylvanian Coal Measures. On the uplands the water from these sources will remain far below the surface, but in the lowest valleys it will closely approach the surface or overflow. For farms and small municipalities the cost of drilling to the deep horizons is practically prohibitive.

Rain water is largely employed in this county for household use and for watering live stock. It is stored in cisterns and in reservoirs made by damming ravines. Many of these dams are seen in the hill country, where the drift is thin and is in great measure drained into the numerous valleys by which the upland is dissected.

CITY AND VILLAGE SUPPLIES.

Bloomfield.—The public supply for Bloomfield (population, 2,028) is derived from a well 1,817 feet deep, cased with 12-inch pipe to rock at 320 feet, below which 636 feet of 8-inch pipe extends down to 942 feet, and 519 feet 2 inches of 6-inch pipe to 1,445 feet. The curb is 845 feet above sea level and the water rises within 130 feet of the curb, or 715 feet above sea level. Its temperature is about 65° F. Water was found at depths of 300 feet, 1,425 feet, and 1,750 feet. The well was drilled in 1900 by J. P. Miller & Company, of Chicago, and cost $6,500.

The strata penetrated are indicated by the driller's log:

Driller's log of city well at Bloomfield.

	Thickness	Depth
	Feet	Feet
Drift	320	320
Lime; caves badly at 420 feet	100	420
Lime and shale	130	550
Hard lime; caves at 670 feet	120	670
Streaks of lime and shale; caves badly at 780 feet	272	942
Lime rock; caves badly at 967 feet	203	1,145
Streaks of lime and shale	45	1,190
Sand rock	70	1,260
Lime rock	102	1,362
Shale; caves badly at 1,420 feet	83	1,445
Sand rock	15	1,460
Lime rock	190	1,650
Sand rock	167	1,817

Rock caved more or less all the way down to 1,650 feet.

Rocks belonging to the Saint Louis limestone and the Osage stage (Mississippian) seem to extend to a depth of about 670 feet, and the streaks of lime and shale which are reported from 670 to 942 feet probably represent the Kinderhook. The "sand rock" from 1,190 to 1,260 feet may be correlated with the Silurian; the shale from 1,362 to 1,445 feet may be assigned to the Decorah shale or to a shale in the Platteville limestone. The water-bearing sandstone from 1,445 to 1,460 feet (613 to 628 feet below sea level) is probably the Saint Peter; all the rocks below this level probably belong to the Prairie du Chien stage.

By means of an air lift with a pipe extending to a depth of 345 feet 250 gallons a minute are ordinarily discharged from the well into an underground reservoir, but in a test this yield has been increased to over 300 gallons a minute. From the reservoir the water is pumped into a tank elevated upon a tower and is thence distributed by gravity through a system of mains whose total length is about two miles. There are 28 fire hydrants and 63 taps in the city; somewhat less than one-fifth of the dwellings have service connections, and the average daily consumption of water is about 15,000 gallons. The water is used freely for drinking and other purposes, but is very hard, as is shown by the analysis (p. 195), and for this reason is avoided for toilet, laundry, and boiler uses, rain water stored in cisterns or other reservoirs being used instead.

Before the deep well was drilled the public supply was obtained from a four-inch well that ended at a depth of about 300 feet in a thick bed of sand, from which a generous supply of hard water was obtained. The well was not provided with a screen, and it filled with sand to such an extent that it was abandoned.

DES MOINES COUNTY

BY W. H. NORTON.

TOPOGRAPHY.

The topography of Des Moines county is controlled for the most part by a few simple factors. The county is wholly in the area of the Illinoian drift, and by far its larger part is an upland molded to a nearly level surface by the Illinoian ice.

On the east the upland overlooks from a singularly straight and steep escarpment the broad bottom lands of the Mississippi. The interstream areas of the upland, chosen by the railways in preference to the valleys, present to the eye level or slightly undulating floors, with low swells and sags 10 to 20 feet in relief. The tabular divides are incised along their edges by steep, narrow, young ravines which lead down to the broader shallow valleys of the creeks. Their digitate lobes, still flat-surfaced, reach even to the escarpment overlooking the Mississippi, where the minor water courses break into cascades as they descend from hanging ravines. Ground water in an upland so young may very naturally stand high, except near the dissected edges.

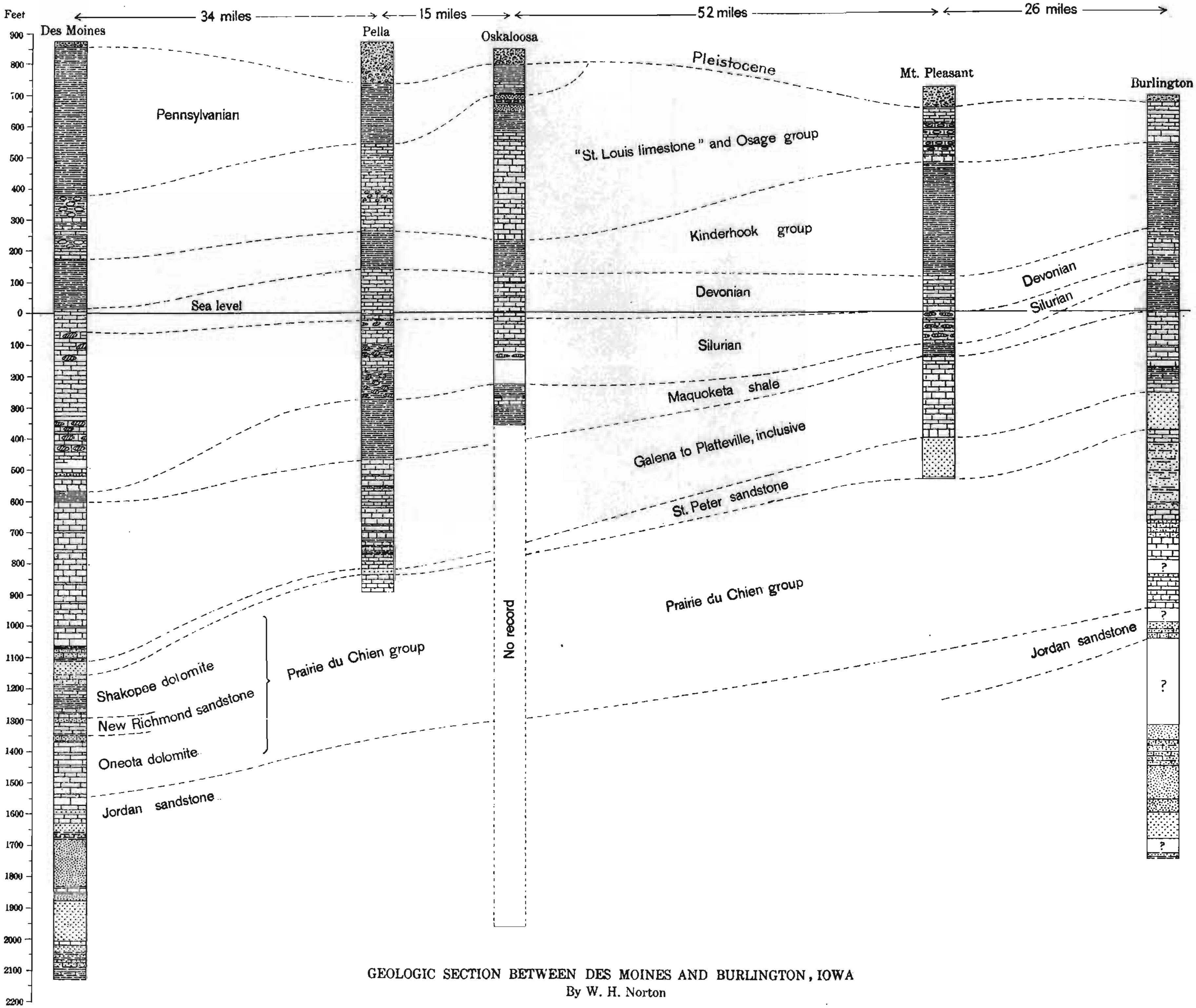
The Mississippi, which forms the eastern boundary of the county, here passes diagonally across a broad alluvial floor, five miles in width, traversed by numerous inosculating bayous and overflowed by the river's annual floods. To the south this strip of flood plain narrows until, at Burlington, where the great river saps the bluffs of the escarpment, it is entirely lacking.

Skunk river, which bounds the county on the south, flows for most of its course through a narrow valley. Five miles above its mouth it develops a flood plain which opens broadly on that of the Mississippi, since here the river traverses a deep preglacial valley filled with easily eroded drift.

GEOLOGY.

The country rock of Des Moines county belongs wholly to the Mississippian series of the Carboniferous. (See Pl. XIII.) At the base of this series lies a group of shales and shaly limestones, the Kinderhook, measuring, as sounded in the deep well at Crapo Park in Burlington, about 300 feet in thickness. (See Pls. XII, XIII.) Only the upper portions of the Kinderhook are exposed within the county. The bulk of the stage consists of soft blue "mud-rock" shale, well known and easily recognized by all well drillers. Toward the top, however, are clayey sandstones and impure limestones—transition beds to the overlying Osage stage.

The Osage stage comprises two formations, the Burlington limestone at the base, and the Keokuk limestone at the top. The lower part of the Burlington limestone is characterized by the singular whiteness of the cuttings obtained by the driller and by the fragments of crinoid stems and plates of which the limestone in places is largely composed. Because of its easy solubility this limestone has been extensively tunnelled by subterranean waterways to which numerous sink holes give access. It occurs in two beds separated by about 20 feet of cherty and calcareous shale, and forms the country rock over about one-fourth of the entire county, underlying a broad upland belt along the Mississippi. Upon this basal white limestone lies a well-defined bed of chert or flint about 30 feet thick to which the Iowa State Survey has given the name Montrose Chert. The



GEOLOGIC SECTION BETWEEN DES MOINES AND BURLINGTON, IOWA

By W. H. Norton

chert, which composes the upper division of the Burlington limestone, is overlain by the Keokuk limestone, a blue compact limestone containing much chert in flinty nodules and irregular bands, passing upward into geode-bearing shales, which furnish cuttings of milk-white chalcedonic silica and crystals of quartz.

The Saint Louis limestone forms the summit of the Mississippian series over southeastern Iowa and forms the country rock in the southwest corner of Des Moines county. The beds include white marl, gray and brown limestones, and a hard, brittle, broken, and recemented limestone of fine grain in angular fragments whose interstices may be filled with greenish clay.

The Des Moines stage of the Pennsylvanian series occupies only a few isolated areas in the southwestern part of the county. Its rocks consist of buff sandstones and may reach a thickness of 50 to 100 feet.

The surface deposit over the uplands of Des Moines county is the loess—a soft silt or dust, buff above, in many places gray at base, and free from sand, pebbles, and larger stones. Beneath the loess in many places lie as many as three distinct stony clays separated by different water-laid deposits. The uppermost is the Illinoian drift, a yellow or, where unweathered, a bluish stony clay, generally bleached and leached superficially and supporting an ancient soil developed during the long interval which elapsed after its deposition and the accumulation upon it of the loess. Beneath the Illinoian drift lies the Kansan, a hard, stony clay, blue where not weathered. Lowest of all lies the Nebraskan drift, a still darker stony clay. Ancient soils and buried peat bogs and beds of sand and gravel in many places separate the Kansan drift from both the Illinoian and the Nebraskan.

UNDERGROUND WATER.

SOURCES.

On the broad flood plain of the Mississippi, sheet water is found in river sands and gravels at depths of 16 to 20 feet. Driven wells, consisting of 1¼-inch pipe with a sand point, are almost universally employed.

On the narrow flood plains of Skunk river and the other streams of the county the alluvium is of little importance except in villages. The village of Augusta, situated on the Skunk river bottoms, draws its house supplies from wells from 16 to 24 feet deep, sunk to rock through river deposits which find a sheet of ground water about two feet deep moving riverward in sand resting on the rock surface.

Some of the silts at the base of the loess supply water, especially for shallow open wells on the tabular divides in places where ground water stands near the surface owing to the flatness of the land or to local sags. The beds lying between the Illinoian drift and the Kansan include in places sands of some thickness. Unfortunately these beds also include old soils, muck, and buried wood, which in places injure seriously the quality of the water.

Water is also obtained from the sands and gravels which separate the Kansan from the underlying Nebraskan drift and also from the sand and gravels that in some places rest on the country rock.

Besides these fairly constant water beds of the drift, irregular and inconstant beds of sand and gravel may occur in any of the drift sheets, and, where of sufficient continuity and extent or sufficient connection with interglacial sands, may form local water beds adequate for small wells.

On the whole the drift, where thickest and where least dissected by stream ways, forms an adequate reservoir for ground water and the supply of common wells. But where bedrock comes near the surface and the drift sheets are thin, and where they have been intricately cut by streams leaving the steep-sided and narrow divides locally called "breaks," the drift is often found nearly dry and water must be sought in the rock beneath. The drift is specially thick along the terminal moraine of the Illinoian sheet which extends from north to south through Washington and Pleasant Grove townships. Here the ridge of the moraine rises 60 or 70 feet above the level of the adjacent upland plains and the drift has not been found less than 120 feet in thickness. On this ridge wells find water in drift sands and gravels. Other areas of specially thick drift occur where ancient rock-cut river valleys have been filled with glacial and interglacial deposits. Several deep wells in drift from Sperry to southeast of Latta point to a buried channel which apparently debouches into the Mississippi channel between Flint river and the north line of Burlington township. A deep drift well a mile south of Kossuth marks perhaps a northeast tributary of this channel although it may point to an independent valley leading to the Mississippi. Thus near Latta, along a north-south line a mile in length, are three deep wells, two of which are nearly 190 feet deep and strike no rock, and the third—the most northern—233 feet deep, finds the blue shale of the Kinderhook[1] at 231 feet. Drillers report "deep country" from south of Dodgeville, running northwest to between Pleasant Grove and Yarmouth. Other wells of exceptionally deep drift reported from Middletown, northwest of Danville and east of New London, may mark another buried channel whose rock floor lies at about the level of the present bed of the Mississippi at Burlington. A few flowing wells from the drift are reported on low ground from Danville to south of Middletown.

The basal member of the rocks exposed in the county, the shale of the Kinderhook, is dry. Wells finding little or no water before reaching this shale have penetrated it to a depth near Augusta of 220 and 257 feet, and near the Mississippi north of Burlington to even as much as 300 feet without success. Unless the owner is prepared to go through this heavy shale and several hundred feet still deeper to tap the Galena waters, the drilling should be stopped on reaching the Kinderhook, and a well sunk in another place.

The limestones overlying the Kinderhook are water bearing, the chief aquifers lying in the lower part of the Burlington limestone. Ground water collects in this limestone in the crevices, joints and waterways formed by solution, its downward progress being stopped by the underlying floor of impervious shale. The upper cherty member of the Burlington (Montrose Chert) is also water bearing. The Saint Louis limestone probably carries water in the small area which it occupies in the southwestern townships, as may be inferred from the known water beds along its outcrop farther to the west.

[1]Fultz, F. M., Proc. Iowa Acad. Sci., vol. 3, p. 62.

At and near Burlington, except for the drift gravels found on the rock and minor veins, the first dependable water bed is the Silurian. It is apparently this bed which supplies wells about 500 feet in depth, affording to some of them a generous yield. The initial head seems to have been about 570 feet above sea level but no exact statements can be made since requests made of the city officials for information as to the elevation of the different well curbs have not been answered. A sharp fall of static level was observed in several wells on the completion of the Clinton-Copeland well. The water bed is evidently overdrawn, and flows from it can no longer be expected, except from the lowest levels. To protect the wells at Burlington which now draw from it no further drafts should be made, and all wells drilled in the city should not only seek a deeper supply but should also case off the Silurian water. In quality the Silurian water is hard and corrosive. As shown in the analyses (p. 195), calcium approaches 400 parts per million, sodium runs between 700 and 800 parts, and the sulphate ions somewhat exceed 2,338 parts in one of the wells. The total solids were about 4,000 parts per million in the wells analyzed.

The reference to the Silurian of the water bed of the 500-foot wells at Burlington is made with a good deal of hesitation, although no other reference seems possible, since the Crapo Park well record places the base of the Maquoketa shale (Ordovician) below the bottom of these wells. On the other hand the Crapo Park record is supported by but few sample drillings over the critical horizons. Some of the wells reach nearly to the supposed base of the Maquoketa. Local drillers speak of this water bed as the Saint Peter sand rock, a term rather easily applied to the water-bearing Galena dolomite, a rock which crushes under the drill to a sparkling crystalline sand, but which it seems hardly probable would be applied to any Silurian rock that appears in the samples of any of the Burlington wells. The Galena forms one of the chief water beds at Fort Madison, and appears in full thickness at Mount Pleasant, where again the Silurian contains no water-bearing rock, if the record and the large amount of anhydrite present are reliable guides. It is hoped that the question whether the Silurian or the Galena supplies the water for the 500-foot wells at Burlington may soon be definitely settled by obtaining a complete set of samples of the drillings of a well reaching to the well-defined horizon of the Saint Peter.

New wells should not fail to go as deep as the Saint Peter, which here lies about 260 feet below sea level. The formation is exceptionally thick at Burlington and yields generously. The pressure is much higher than that of the Galena, the static level apparently reaching at present 630 or 640 feet. Because of the marked difference in pressure of the Saint Peter and the Silurian waters, the Silurian should be cased off to prevent lateral escape of the deeper waters through its waterways. The quality of the Saint Peter water is much better than that of the higher flows, containing less than one-half the solids in solution, the greatest differences being in the sodium and the sulphate ions, according to Hendrixson's analyses. As but three wells at present draw water from the Saint Peter, no overdraft has yet occurred.

The water beds lying beneath the Saint Peter are tapped by but one well, that of Crapo Park. The water from these beds has about the same static level as that of the Saint Peter, but is distinctly superior in quality, the combined waters of all horizons in the park well containing only about half as much dissolved solids as that of the Saint Peter and the Galena combined and one-fourth that from the Galena alone. As the static level at Crapo Park is more than 100 feet higher than the lower grounds of the city, wells drilled in the manufacturing parts of the city situated near the level of the Mississippi will have high pressure and proportionately large discharge.

SPRINGS.

The chief spring horizon in Des Moines county is at the base of the Burlington limestone, whose massive beds are water-logged, owing to their resting upon a floor of impervious shale. As the lower part of the Burlington limestone is easily soluble and is therefore traversed by numerous channels opened up by solution, springs along the outcrops of its basal layers are exceptionally abundant and copious. They are found along the escarpment of the Mississippi and along the lower courses of the Skunk and Flint rivers. In many ravines the springs emerge above a massive basal layer of the limestone and cascade over the cliff formed by the sapping of the limestone by the retreat of the weak shale beneath. These springs are utilized only for stock and dairy and household purposes.

CITY AND VILLAGE SUPPLIES.

Burlington.—The water supply of Burlington (population, 24,324) is taken from Mississippi river and passed through settling tanks and filters. The water is brought through a 24-inch cast-iron pipe from a point near the center of the main channel of the river and above any possible source of pollution, it is said, from city drainage. The coarser materials are allowed to settle in an extension of the well, 20 feet wide and 125 feet in length. This extension is cleaned with a centrifugal pump whenever the river lowers to within four or five feet above the low-water stage. From the well the water is pumped by low-service pumps to four steel settling tanks, 30 feet in height and 44, 35, 28, and 22 feet in diameter. The water enters the tanks through several thousand small holes in cast-iron pipes about 6 feet above the bottoms of the tanks, and passes out over weirs at the top. The tanks are cleaned once each month by opening the sewer valves and washing with a hose. Cleaning requires from two to three hours.

From the settling tanks the water flows by gravity to the filters. These are in six units, fully equipped, and have a combined capacity of 3,000,000 gallons in 24 hours. The amount pumped is about 1,800,000 gallons. Each unit is eight feet wide by 26 feet long, and is of reenforced concrete. The filters are placed at a sufficient height above the clear well and above the controllers in the pipe gallery to obtain the benefit of the "down draft." Each filter bed has nine inches of gravel from Mount Tom, Massachusetts, and 30 inches of filter sand from Red Wing, Minnesota. Water strainers are placed on the floors of the filters, and air strainers in the gravel. Water for washing the filters is supplied from the clear well by a Lawrence centrifugal pump connected to a Lawrence vertical engine to which is also belted the air compressor.

There are two coagulant tanks. Compressed air is employed for their agitation. A specified number of inches is fed per hour, the feed being changed in the event of any change in the demand for water, as for example a large fire or a broken main. Sulphate of alumina is used as coagulant, the solution for the day run being stronger than that for the night. Before preparing the solution the turbidity of the raw water and of the water in the settling tanks is measured with a turbidity rod. From the records is then found the strength of solution which has been found to give satisfactory results with an equal turbidity and pumpage. Three times a week the alkalinity of both raw and filtered water is determined, and the color of the water from each filter is determined with standard disks. The color normally desired is that of disk No. 6, but the color frequently gets as high as that of No. 12. When it rises to No. 18 the strength of the coagulant solution is increased. The average amount of coagulant used is between three and four grains to the gallon. When the turbidity rises to between 2,000 and 3,000, as much as seven grains is used. Bacterial tests are made from time to time.

Once a week the filtered water is tested for alum with the logwood test, but none has ever been tested in the filtrate.

The coagulant is supplied by gravity to the suctions of the low-service pumps, which lift the raw water from the well to the settling tanks. The distribution is direct, with a domestic pressure of 100 pounds and a fire pressure of from 125 to 150 pounds. In 1907 there were 32 miles of mains, 339 fire hydrants, and 3,170 taps, and the mains were being extended about two miles each year.

The city well at Crapo Park (Pls. XII, XIII) has a depth of 2,430 feet and diameter of 6 inches from the surface to 1,700 feet and 5 inches to bottom; cased to limestone at depth of 18 feet. The curb is 685 feet above sea level, and the head 38 feet below curb. The tested capacity is 250,000 gallons a day, the water coming principally from 950 feet below surface. The well was completed in 1898, at a cost of $5,095, by Tweedy Brothers, of Keokuk. Later a casing was inserted between depths of 110 and 210 feet, as a result of which water rose to 30 feet below curb.

The following record is based on determinations by the writer of samples of drillings saved by F. M. Fultz, superintendent of the Burlington public schools. It agrees for the most part with the record given by Mr. Fultz.[1]

Record of strata in Crapo Park well at Burlington (Pls. XII., p. 618; XIII, p. 626).

	Thickness	Depth
	Feet	Feet
Pleistocene:		
Loess and drift	18	18
Carboniferous:		
Mississippian (422 feet thick; top, 667 feet above sea level)—		
Limestone, buff; effervescence rather slow; some chert in small chips	23	41
Limestone, buff and white, granular; rapid effervescence	37	78
Limestone, light yellow; in fine meal; rapid effervescence; some chert	19	97
Limestone, buff; in fine meal and flour; rapid effervescence; some chert	13	110
Limestone, magnesian or dolomite, blue-gray, crystalline	39	149
Shale, blue and drab (Kinderhook)	291	440
Devonian and Silurian (140 feet thick; top, 245 feet above sea level):		
Limestone; in light gray, highly argillaceous powder; rapid effervescence	140	580
Ordovician:		
Maquoketa shale (108 feet thick; top, 105 feet above sea level):		
Shale, light gray, highly calcareous; in powder	38	618
Shale, drab	70	688
Galena dolomite and Platteville limestone (257 feet thick; top, 3 feet below sea level)—		
Dolomite, light buff, crystalline-granular; with hard brown bituminous shale at 868 feet; 6 samples	207	895
Limestone, buff, finely granular; rapid effervescence	31	926
Dolomite, light yellow; in sand and powder	19	945
Saint Peter sandstone (120 feet thick; top, 200 feet below sea level)—		
Sandstone, fine-grained, white; some limestone; grains of considerable range in size, moderately well rounded	10	955
Sandstone, clean, white; somewhat coarser than above	45	1,000
Sandstone; as above; much hard, green shale like the basal shale of the Platteville limestone	40	1,040
Sandstone, clean, white; largest grains reach 0.7 millimeter in diameter	10	1,050
Sandstone; as above; largest grains slightly exceed 1 millimeter in diameter	15	1,065
Prairie du Chien stage (565 feet thick; top, 380 feet below sea level)—		
Dolomite, light gray; some chert	35	1,100
Marl, white and pink, highly dolomitic; large residue of fine quartz sand and argillaceous material and flakes of chert; 3 samples	235	1,335
Dolomite; in fine, light yellow, crystalline meal	15	1,350
Sandstone and pink oolitic chert	10	1,360
Dolomite, arenaceous, or sandstone, calcareous, all in fine, yellow sand	20	1,380
Dolomite, light yellow, highly arenaceous; angular grains of pure dolomite and rounded grains of quartz sand	20	1,400
Marl, white; residue minutely quartzose	10	1,410
Chert and dolomite	9	1,419
Dolomite, buff and light gray; in fine sand; cherty; 4 samples	56	1,475
Unknown; drillings washed away	44	1,519
Dolomite and chert	6	1,525
Chert and dolomite, gray	20	1,545
Dolomite, gray, cherty, and arenaceous	25	1,570
Dolomite, light brown, cherty	15	1,585
Dolomite, gray, cherty	45	1,630

[1]Proc. Iowa Acad. Sci., vol. 6, 1899, pp. 70-74.

	Thickness	Depth
	Feet	Feet
Cambrian:		
Jordan sandstone, Saint Lawrence formation, and underlying Cambrian strata (800 feet penetrated; top, 945 feet below sea level)—		
Unknown, drillings washed away	40	1,670
Sandstone, clean; grains well rounded; largest reaching 1 millimeter in diameter	20	1,690
Sandstone, calcareous, or dolomite, arenaceous, buff; dolomite in angular particles with rounded quartz grains	35	1,725
Unknown; drillings washed away	275	2,000
Sandstone, light gray; in fine angular meal; minute grains of quartz and of glauconite with dolomitic cement or matrix; 4 samples	95	2,095
Dolomite, gray; in fine chips, minutely quartzose, 3 samples	35	2,130
Sandstone; as from 2,000-2,095 feet; brownish, highly glauconiferous	95	2,225
Sandstone; fine grains of clear quartz, some pink, some with secondary enlargements	10	2,235
Sandstone, gray, glauconiferous, calciferous; grains varying in size, some being large and well rounded	35	2,270
Sandstone; as from 2,000 to 2,095 feet	5	2,275
Sandstone; in loose grains of clear quartz, largest, diameter of 1 millimeter	85	2,360
Unknown; drillings washed away	40	2,400
Sandstone, dark brown, glauconiferous; in rounded grains and minute siliceous particles; chips of drillings have rough surfaces (due to projecting granules) and not the smooth fractures of quartzite	5	2,400
Sandstone, yellow; in chips of minute grains of quartz and glauconite and some rounded quartz grains, embedded in dolomitic matrix or cement; chips crumble easily after digestion in acid; drillings contain considerable hard green shale		2,405
Sandstone, buff, calciferous, glauconiferous; much hard green shale	5	2,410
Sandstone, buff, calciferous, glauconiferous; much green and reddish shale	10	2,420
Shale, hard, dark green and reddish, fissile; and sandstone, calciferous and glauconiferous; in angular chips; grains minute and angular	10	2,430

The well of Iowa Soap Company has a depth of 509 feet and a diameter of 6 inches; casing, 70 feet to rock. The curb is 540 feet above sea level. The original head was 33.5 feet above curb and the head in 1905, 4 feet above curb; the loss was due to the sinking of the Clinton-Copeland well. The flow in 1905 was 15 gallons a minute through 1¼-inch pipe. Temperature 56° F. The well was completed in 1904 by R. J. Johnson.

Record of strata in well of Iowa Soap Company at Burlington.

	Thickness	Depth
Pleistocene (70 feet thick; top, 540 feet above sea level):	Feet	Feet
Till	15	15
Till, yellow; 4 samples	35	50
Gravel, coarse, up to 1½ inches diameter	10	60
Gravel, fine	10	70
Carboniferous (Mississippian):		
Kinderhook stage (210 feet thick; top, 470 feet above sea level)—		
Shale, blue, plastic, calcareous; 2 samples	58	128
Shale, olive-gray, fissile	7	135
Shale, light green-gray	5	140
Shale, brown, hard, bituminous	15	155
Shale, blue and green-gray; 4 samples	45	200
Shale, light brown, bituminous	10	210
Shale, olive bluish and green-gray; 9 samples	70	280
Devonian and Silurian (160 feet thick; top, 260 feet above sea level):		
Limestone, gray, soft, argillaceous; effervescence slow; 2 samples	25	305
Shale, calcareous, hard, blue; in large flaky chips	10	315
Limestone, hard, gray, in sand; rapid effervescence	10	325
Limestone, light yellow; rapid effervescence; in fine sand and argillaceous powder	15	340
Limestone, yellow-gray; fossiliferous, with fragments of brachiopods; soft; in flaky chips	10	350
Limestone, yellow; rapid effervescence; in fine meal; 2 samples	10	360
Limestone, strong blue; fossiliferous ; hard, compact; earthy luster, siliceous but not arenaceous	10	370
Shale and limestone in light yellow-gray concreted powder; effervescence rapid	10	380
Limestone, blue, dense, hard, in part of lithographic fineness of grain and conchoidal fracture; rapid effervescence; in chips	10	390
Limestone, compact, gray, in sand; rapid effervescence	5	395
No record	5	400
Limestone, blue-gray, rough; slow effervescence; some chert	10	410
Limestone, light buff and white, compact, fine-grained; rapid effervescence	10	420
Limestone, light yellow-gray or white; rapid effervescence; residue quartzose with minute grains and flakes and prismatic crystals of quartz; in fine meal; 4 samples	20	440
Unknown; no samples	69	509

The well of George Boeck, at 2-8 North Fifth Street, has a depth of 450 feet and a diameter of 5 inches; casing, 74 feet. The head is 30 feet above bottom of cellar. The well flowed "a full 5-inch stream," with no decrease in 1905. Water was found in white limestone 150 feet below soapstone (Kinderhook); temperature, 60° F.; effect on boilers, not good. The well was completed in 1904 at a cost of $650 by W. N. Jennings, of Burlington.

The well of the Clinton-Copeland Company, at 100 South Fourth Street, has a depth of 465 feet and a diameter of 5 inches throughout; casing, to 72 feet. The head originally was 28 feet above curb, and no change has been noticed. Water is said to have begun to overflow when well reached depth of 440 feet. The temperature, taken after flowing through 175 feet of hose, was 59° F. The well was completed in March, 1905, at a cost of $675 by J. R. Stanly, of Stronghurst, Illinois.

The well of the Moehn Brewing Company has a depth of 510 feet and a diameter of five inches. The original head was 30 feet above curb, but the well had ceased to flow in 1905, and the capacity under pump was small. Water was found in small quantity at 90 feet, but the main supply came from 500 to 510 feet. The well was completed in 1904 at a cost of about $1,000 by W. N. Jennings, of Burlington. The water is too heavily mineralized for use in boilers or for beer, but is used in cooling and for other purposes in the brewery.

The well of the Murray Iron Works has a depth of 831 feet and a diameter of 6 to 4 inches; casing, 120 feet from surface into blue shale. The head is 92 feet above curb. The orginal flow of 300 gallons a minute had not diminished in 1905. The first water was in a gravel just above rock at 75 feet, and the first flow at 450 feet; a strong flow came in at 500 feet and the drillings were washed away from 600 to 760 feet and from 800 to 831 feet. The rock from 800 to 832 feet said to be like granular sugar. The temperature at tap after water has passed through 300 feet of pipe in foundry was 63.5° F. The water is too hard for use in boiler. The well was completed in 1903 at a cost of $1,038 by W. N. Jennings, of Burlington.

The well of the Sanitary Ice Company, near the intersection of Osborn Street and Central Avenue, has a depth of 852 feet and a diameter of 5 inches; casing, 95 feet from surface. The head was 51 feet above curb, and the flow 500 gallons a minute. Water at 80 feet was shut off; water at 430 feet rose nearly to the surface; the first flow was at 700 feet, and the water from the 800-foot level rose 51 feet above curb. Temperature, 64½° F. The water corrodes boilers and is used for condensing. The well was completed in 1908 at a cost of $1,600 by Jennings & Sons, of Burlington.

The well of the Sanitary Milk Company has a depth of 487 feet and a diameter of 6 inches. The original head was 15 feet above level of corner of Third and Court Streets, but the head in August, 1905, was 31 feet below same level; the head lowered on completion of Clinton-Copeland well. The well was completed in January, 1905, at a cost of $700 by W. N. Jennings, of Burlington.

The well of Smith & Dalton has a depth of 460 feet and a diameter of 5 inches. The original head was 30 feet above curb. The original flow was estimated at 40 gallons a minute, but had decreased in 1905. Temperature reported as 60° F. Date of completion, March, 1905. Drillers, Jennings & Sons of Burlington.

Mediapolis.—Mediapolis (population, 858) depends for its water on drilled and bored wells from 50 to 110 feet deep, all but 30 to 40 feet of which are in rock. The water heads 20 to 30 feet below the curb.

The well of D. Hutchcroft, two miles east of Mediapolis, has a depth of 600 feet and a diameter 5 5-8 inches to 360 feet and 5 inches to bottom; casing to 360 feet. Water found at depth of 40 feet, in drift, was not cased out. Pumping capacity, 8 gallons per minute. The well was completed in 1905 by J. F. Tweedy, of Keokuk.

Record of strata in Hutchcroft well near Mediapolis.

	Thickness	Depth
	Feet	Feet
Clay, yellow, sandy, calcareous, arenaceous	75	75
Shale, drab, or sandstone, argillaceous, in concreted masses	60	135
Shale, olive-green, hard, noncalcareous	213	348
Limestone, blue-gray, argillaceous, minutely arenaceous	22	370
Limestone, light gray, nonmagnesian, argillaceous and slightly arenaceous	20	390
Limestone, light yellow-gray, granular, soft, fossiliferous, nonmagnesian	22	412
Limestone, light blue-gray and white, soft, earthy; in thin flakes	18	430
Limestone, blue-gray and white; earthy; in fine chips	25	455
Limestone, light yellow-gray and drab, nonmagnesian; cherty	20	475
Limestone, light yellow-gray, nonmagnesian; in fine sand; drillings slightly arenaceous	25	500
Shale, dark blue, in chips; calcareous and cherty	100	600

The shale whose base is found at 348 feet is evidently the Kinderhook; below it, the drill, as at Burlington, passed through about 150 feet of limestones, which may represent the Devonian and Silurian. The shale from 500 to 600 feet may be taken as the equivalent of the shale (Maquoketa) at Burlington which immediately succeeds the limestones below the Kinderhook. The drill therefore seems to have passed through the water bed which supplies the less deep wells at Burlington and yet to have found very little water.

Mediapolis is 764 feet above sea level. If an adequate supply is not found in the Mississippian limestones, a well which adventures through the heavy dry shale of the Kinderhook, here at least 200 feet thick, will probably find water in the Devonian or Silurian. Should the supply still prove insufficient, the drill should proceed through the next considerable shale, the Maquoketa, and tap what water may be found in the Galena dolomite and Platteville limestone. The water bed of the Saint Peter sandstone will be encountered at about 1,150 feet from the surface.

Minor supplies.—Minor village supplies are described in the following table:

Village supplies in Des Moines County.

Town	Nature of supply	Depth	Depth to rock	Depth to water bed	Head below curb
		Feet	Feet	Feet	Feet
Augusta	Wells	16-24		24	10
Danville	Bored and drilled wells	16-125		75	12
Roscoe	Drilled wells	60-100	40		

WELL DATA.

The following table gives data of typical wells in Des Moines county:

Wells in Des Moines County.

Owner	Location	Depth	Depth to rock	Source of supply	Remarks: (Logs given in feet)
T. 69 N., R. 3 W. (Part of Union).		Feet	Feet		
County Infirmary	Sec. 4	235	20		Rock (limestone) from 20 to 235, where soapstone, with water, was encountered. Main water at 190.
George Barnes	4 miles east and 1 mile north of Augusta.	22		Sand	Light blue clay; sand on top of blue-black clay at bottom. Flows.
S. Cartwright	¾ mile northwest of above.	42		do	Flow from sand underlying light blue clay.
Louis Pfeiff	NE. ¼ sec. 33	357	20		Soil, 20; limestone, 80; soapstone (Kinderhook), 257; little water. Midway between river bottoms and bluffs.
T. 69 N., R. 4 W. (Augusta).					
Palmer Orton	Near Augusta	400			Drift; limestone; "soapstone" (shale) at 180; ends in soapstone at 400; not enough water for windmill.
L. Hilleary	SW. ¼ sec. 11	100	20	Limestone	No shale. Water at 98.
Alfred Weg	NE. ¼ sec. 3	70		Sand and gravel.	
T. 70 N., R. 2 W. (Part of Burlington).					
—— Wykert	Sec. 19	418	164		Loam and sand, 164; limestone, 4; shale, 250. Head, 31 feet above curb.
William Penrod	2½ miles northwest of Burlington.	135		Gravel	Drift, 20; fine sand to gravel at bottom.
T. 70 N., R. 3 W. (Flint River).					
James Graham	NW. ¼ sec. 28	138		Gravel	No yellow or blue clay; all dirt and gravel; white soapstone at bottom.
John Sellers	NW. ¼ sec. 33	188		Sand	Yellow clay; white clay; blue clay to sand or rock at bottom.
Joseph Saters	SW. ¼ sec. 31	140		Gravel	Yellow clay, 40; blue clay to gravel at bottom.
T. 70 N., R. 4 W. (Danville).					
Thomas Grant	NE. ¼ sec. 8	305	300	Rock	Yellow clay; white clay; blue clay with sand at 150 feet.
—— Hurlburt	1½ miles south of Danville.	135		Sand	Largely blue till.
Mrs. Allen	1½ miles west of Middleton.	227		Sand and gravel.	Yellow clay, 54; light blue clay, 12; ——, 111; dark blue clay, 48; sand and gravel on rock, 2.

Wells in Des Moines County—Concluded.

Owner	Location	Depth	Depth to rock	Source of supply	Remarks: (Logs given in feet)
		Feet	Feet		
—— Hunter	2 miles west of Danville.	165	66	Limestone	Head, 20 feet below curb. Yellow clay, 42; light blue clay, 12; sand with water, 2; dark blue clay, 10; rock, 99. Water from upper sand heads at —5 feet.
Fair Ground	West Burlington	45	20	Limestone	Water in crevice.
T. 71 N., R. 2 W. (Benton).					
	Latty	250			Sand and mud; sand, fine, dark. No water. Bones found at 188.
Fred Kaster	Sec. 33	304		Sand	Loam; sand; black mud; sand; wood and coal; old soil; mussel shells at 257; blue till, 20, overlying sand bed at bottom.
T. 71 N., R. 4 W. (Pleasant Grove).					
Anton Totemeir	Sec. 19	276			Yellow till (Illinoian), 30; blue till (Illinoian), 10; reddish brown till (Kansan), 12; blue till with thin beds of sand (Kansan and Nebraskan), 224.
John Shepherd	SW. ¼ sec. 34	50		Coarse gravel	Well in valley; yields 2 to 3 gallons per minute; diameter, 4 inches. Head, 5 feet above curb.
T. 71 N., R. 3 W. (Franklin).					
—— Brady	Near Sperry	400			No hard rock struck, but perhaps entered Kinderhook in lower part.
T. 72 N., R. 2 W. (Parts of Yellow Spring and Huron).					
	Sec. 4	159			Largely yellow till.
	Sec. 10	127	95		
	Sec. 20	120	118		
	Sec. 27	147	40	Limestone	Limestone from 40 to bottom where shale was struck.
	Mediapolis	56	42	do	Diameter, 5 inches; yield, 5 gallons per minute; main water at 55; water at 23.
W. J. Cumings	Linton	360	90	do	Other wells find black mucky soil under the loess.
T. 72 N., R. 4 W. (Washington).					
William Steiter	Yarmouth	110		Sand	Soil and loam, 4; yellow till (Illinoian), 20; gray till(Illinoian), 10; peat bed, twigs, and bones, 15; gray sandy clay with wood, 12; fine sand, 16; yellow sandy till (Kansan), 33.
F. Smith	1 mile south of Yarmouth.	180		do	Yellow till becoming gray below (Illinoian), 36; sand with thin bed of blue clay and of cemented gravel, 73; black muck with wood, 6; sand and gravel, 8; gray pebbleless silt, 15; blue till (Kansan), 42.
M. T. Evans	1½ miles south of Roscoe.	98	55	Rock	Head, 30 feet below curb.
J. Mehmken	Roscoe	24	20	Limestone	35 feet below railway station. Yield, 3 gallons per minute. Heads 5 feet above curb.

HENRY COUNTY

BY W. H. NORTON.

TOPOGRAPHY.

Henry county lies almost wholly on the Kansan drift plain of southeastern Iowa. This upland, which originally was a nearly level surface, retains its original features over much of the northern and central portions of the county, where the drainage is still imperfectly developed and the tabular divides present the appearance of level plains, scored only by shallow swales of little-concentrated wash. In the southern townships the deep-cut valleys of Skunk river, Cedar creek, and Big creek permit a much greater dissection of the adjacent uplands, and here the interstream areas are cut to a maze of ridges with narrow level crests whose even sky line marks the common level of the ancient upland plain.

The southeastern townships, Baltimore and New London, are ridged with the low long swell of the terminal moraine, which marks the limit to which the Illinoian ice here invaded Iowa from the east.

A wide channel excavated in the Kansas drift by glacial waters lies along the northern border of the county and turning abruptly south follows the west county line, along which it has been occupied and deepened by the waters of Skunk river and Cedar creek, passing thence through Lee county by Grand Valley and the valley of Sugar creek to the Mississippi. Both Cedar creek and Skunk river are bordered by wide flood plains where they hold to this ancient channel, the entire width of the Skunk river bottoms here ranging from three-fourths to 1¼ miles. Over the remainder of their courses these two streams, like the others of the county, flow through comparatively narrow valleys destitute of any flood plains of sufficient width to be of importance in this investigation.

GEOLOGY.

The Nebraskan drift, the lowest and earliest drift in Henry county, is not exposed so far as known, but at different places wells encounter it as a dark blue stony clay, or till, resting on bedrock or separated from it by thin inconstant streaks of sand and gravel. The upper stony clay, the Kansan, is parted from the Nebraskan by sheets of sand and gravel or by old soils, peat, and forest beds (Aftonian interglacial deposits). The Kansan drift includes over nearly all the county both the yellow till immediately underlying the loess and the unweathered blue till from which the yellow till has been derived by long leaching and oxidation. On and east of the north-south ridge passing through New London and recognized as a terminal moraine a third till appears, the yellow stony clay of the Illinoian.

Over the entire county, except the river flood plains, has been spread the thin mantle of the loess, a friable siliceous silt. In color the loess is gray on the level prairies where overlain with deep humus, but yellow on hill slopes or where it attains some thickness.

The bedrock of Henry county, with the exception of small and negligible outliers of Pennsylvanian shales and sandstones, belongs to the Mississippian series. (See Pl. XIII.) Immediately beneath the drift the driller finds from 60 to 100 feet of limestones, sandstones, and shales belonging to the Saint Louis limestone. The succession from above downward is light gray limestones, variable beds of sandstones, shales, broken or brecciated limestones, and massive impure magnesian limestones. Below these lies the Osage stage, the uppermost formation of which, as exposed in the county, is the Keokuk limestone, consisting of geode-bearing limy shales 30 feet thick, underlain by about 25 feet of limestone interleaved with bands of bluish shale. No lower rocks than the Keokuk are exposed within the county, but the drill of the well driller has explored to some depth the underlying formations of the Mississippian. Beneath the Keokuk lies the white Burlington limestone, composed in part of crinoidal remains and seamed by water-bearing porous beds and crevices. The deeper wells pass through the Burlington and reach the heavy shale of the Kinderhook, which forms the base of the Mississippian series.

UNDERGROUND WATER.

SOURCES.

The flood plains of Skunk river and its larger tributaries, such as Cedar creek, afford abundant water to shallow wells from stream-laid sands and gravels. In Skunk valley above Rome the alluvium is of agricultural importance owing to the breadth of the flood plains. In the narrower valley below Rome it is important chiefly for supplying towns and villages. Thus the village of Lowell obtains water from open and driven wells in the alluvium, although the rock bottom of the narrow valley is reached at from 20 to 30 feet from the surface, the water being found in a sheet said to be two feet deep on the rock.

On the flat divides ground water stands high, and collecting in the porous silts at the base of the loess and in the reddish sands and gravels which occur in seams and lenses in the Kansan till, usually affords a supply to shallow, open, bored and driven wells. Larger and more permanent supplies are drawn from the sands overlying the Nebraskan drift and those which part it from bedrock.

From these strata most of the wells in the county are supplied. In places the lower drift sources lie deep below the surface. Wells in sections 1 and 11 of Marion township pierced the drift to depths of 190 and 250 feet without reaching either bed-rock or the sands and gravels which overlie it, indicating a channel cut in deep rock by some preglacial river and afterwards filled with drift; the course of this buried valley is, however, entirely uncertain.

Even on the wider tabular divides the drill or auger may find the water-bearing drift sands absent or too thin to convey enough water for stock wells, and the well must then be sunk into solid rock. Bed-rock must also be probed where the drift is thin, and where, owing to the dissection of the region by the streams, ground water readily drains out to the lowest levels. The sandy layers of the Saint Louis limestone and also the strata between its shale beds form water beds of value. The chief source, however, is the white porous and creviced Burlington limestone of the Osage stage. Drillers report that the main water bed is a white porous and spongy but hard limestone separated from the Kinderhook below by some twenty feet of blue-gray limestone. The Kinderhook no doubt acts as an impervious floor on which water accumulates in the overlying strata where porous or in passages opened up by solution.

At Mount Pleasant the Kinderhook was found a little less than 250 feet below the surface and was about 300 feet thick. On reaching this dry shale drilling should stop for all ordinary farm wells.

CITY AND VILLAGE SUPPLIES.

Mount Pleasant.—The succession at Mount Pleasant (population, 3,874) is shown by the following records of the wells drilled for the State Hospital for the Insane (Pl. XIII, p. 626.):

Well No. 1 has a depth of 1,125 feet. The curb is about 719 feet above sea level, and the head 30 feet below curb. The tested capacity is 165 gallons a minute, the water coming from 990 feet. Temperature, 62° F. Date of completion, 1862. The well was abandoned years ago because the water was so corrosive that it destroyed a battery of boilers and all the steam radiators of the institution.

Driller's log of well No. 1, Iowa Hospital for Insane.

	Thickness	Depth
	Feet	Feet
Limestones	295	295
Shales, soft, passing into hard	300	595
Limestone	295	890
No samples	100	990
Sandstone	135	1,125

Well No. 2 has a depth of 1,267 feet and a diameter of 12 inches to 123 feet, 10 inches to 723 feet, and 6 inches to bottom; casing, 12 inches, 123 feet to rock, 10 inches to 733 feet, 6 inches to 1,153 feet; packing ring at junction of 10-inch and 6-inch casing. The curb is about 719 feet above sea level, and the head 70 feet below curb. Pumping capacity, 70 gallons a minute. The well was completed in 1898 by L. Wilson & Company of Chicago. From it 40,000 to 50,000 gallons a day are now pumped without exhausting its supply.

Well No. 3 has a depth of 1,203 feet and a diameter of 12 to 6 inches; casing, 71 feet of 12-inch, 610 feet of 9-inch, 635 feet of 6-inch. The head is 71 feet below curb and the tested capacity 70 gallons a minute. The water comes from 250 feet and is very good for drinking but destructive to boilers; other water-bearing strata were not recorded. The yield is 70 gallons per minute. Date of completion, 1903; cost, $4,700. From this well 120,000 gallons a day are now pumped. Except for boiler water, which is supplied from a reservoir, the entire institution is supplied by wells Nos. 2 and 3.

Driller's log of well No. 3, Iowa Hospital for Insane.

	Thickness	Depth
	Feet	Feet
Soil, clay, and some sand	68	68
Slate	7	75
Limestone	29	104
Slate	4	108
Limestone (6 inches of slate at 125 feet)	107	215
Slate	10	225
Limestone	20	245
Slate	360	605
Rock ("Trenton")	511	1,116
Rock (Saint Peter)	87	1,203

Record of strata in well No. 3, Iowa Hospital for Insane.

	Thickness	Depth
	Feet	Feet
Pleistocene (68 feet thick; top, 719 feet above sea level):		
Drift, no sample	68	68
Carboniferous (Mississippian):		
Saint Louis limestone and Osage stage (182 feet thick; top 651 feet above sea level)—		
Shale, light blue, calcareous	7	75
Limestone, yellow; drillings chiefly foreign sand	5	80
Limestone, light blue, highly argillaceous; rather hard in chips	10	90
Chert, white; much sand in drillings	10	100
No record	4	104
Shale, blue, plastic, calcareous	4	108
No record	2	110
Limestone, light gray, nonmagnesian, soft, earthy	4	114
Limestone, as above; also bluish gray, highly calcareous shale and considerable dark flint	4	118
Limestone, mottled dark gray and white, crystalline, encrinital; residue arenaceous and cherty; some white chert; 3 samples	22	140
Chert, light blue cherty limestone, and light blue shale	10	150

	Thickness	Depth
Chert, white; in small chips	10	160
Limestone, light yellow and white; encrinital, earthy to crystalline; some chert; 4 samples	40	200
Chert, white; some cherty limestone	10	210
Chert, white; includes chips of dense, subtranslucent opaque-white and blue-white cryptocrystalline silica with conchoidal fracture; also irregularly shaped cuttings of a dull white, earthy chert, or less friable limestone, light yellow gray	5	215
stone, light yellow-gray	5	215
Shale, (driller's log); no sample	5	225
Dolomite, blue-gray, rather hard, subcrystalline, vesicular	5	230
Limestone, magnesian; moderately rapid effervescence, drab, earthy	20	250
Kinderhook stage (360 feet thick; top, 469 feet above sea level)—		
Shale, blue, hard; highly siliceous with minute quartzose particles; calcareous; 2 samples	20	270
Sandstone, blue, fine-grained, argillaceous and somewhat calciferous, composed of minute angular particles of quartz in chips; 4 samples	40	310
Shale, blue, calcareous	10	320
Shale, blue, and sandstone, argillaceous; thinly laminated; 2 samples	20	340
Shale, blue, calcareous; 7 samples	70	410
Shale, blue, and sandstone, yellow-gray; grains up to 1 millimeter in diameter; calcareous cement	10	420
Shale, blue and gray; 2 samples	20	440
Shale, olive-gray; yellow and reddish chert in coarse sand, perhaps foreign	10	450
Shale, blue; 15 samples	160	610
Devonian and Silurian (210 feet thick; 109 feet above sea level):		
Limestone, crystalline, buff and gray; rapid effervescence; in fine sand; 3 samples	30	640
Limestone, blue, argillaceous, soft, highly fossiliferous; rapid effervescence; in small chips	10	650
Limestone, yellow-gray and blue-gray; rapid effervescence; in sand	10	660
Limestone, light blue-gray, dense, fine-grained, laminated; in flaky chips; fossiliferous, containing fragments of crinoid stems and small brachiopods; 3 samples	30	690
Limestone, white, fine-grained, rather hard, and blue-gray with some shale	10	700
Limestone, light yellow-gray, nonmagnesian; in fine sand; 2 samples	30	730
Anhydrite; some siliceous gray limestone in powder, and snow-white granules easily friable to crystalline powder; some anhydrite in chips of pure mineral; 2 samples	20	750
Limestone, drab, nonmagnesian; a few chips of anhydrite and of anhydrite and limestone	10	760
Anhydrite, white, and limestone, drab; in meal and powder	10	770
Limestone, gray, nonmagnesian; some anhydrite; in meal; 2 samples	20	790
Anhydrite and gypsum, white, and shale, dark drab, hard, noncalcareous, and siliceous; all in chips and sand; 3 samples	30	820
Ordovician:		
Maquoketa shale (40 feet thick; top 101 feet below sea level)—		
Shale, blue, hard, siliceous, slightly calcareous; some minute grains of crystalline quartz; 2 samples	20	840
Shale, light blue, hard, calcareous; 2 samples	20	860
Galena dolomite and Platteville limestone (256 feet thick; top, 141 feet below sea level)—		
Dolomite, mostly in buff, fine crystalline sand; 25 samples	240	1,100
SAMPLES FROM WELL NO. 2.[a]		--
Saint Peter sandstone (136 feet thick; top, 397 feet below sea level)—		
Sandstone, white, fine-grained; grains about 0.3 millimeter in diameter	20	1,120

[a] Samples of the drillings of this well were shipped in open wooden trays and became much mixed. The compartments of the trays were marked as Saint Peter from 1,120 to 1,250, and all of these contained quartz sand of Saint Peter facies; some contained green shale and brown bituminous shale, assumed to be foreign and perhaps Platteville. Samples marked 1,250 to 1,267 show chiefly sand of dolomite.

Minor supplies.—Information concerning local village water supplies is presented in the following table:

Village supplies in Henry County.

Town	Nature of supply	Depth of wells			Depth to rock	Depth to water bed	Head below curb	
		From	To	Common			Shallow wells	Deep wells
		Feet	Feet	Feet	Feet	Feet	Feet	Feet
Hillsboro	Bored and drilled wells	15	150	35	60	40-100		— 30
Lowell	Open and driven wells	15	35	25	25	25	— 18	— 28
Mount Union	Open, bored and drilled wells	20		32	70	30		— 20
New London	Open and drilled wells	15	300	25	100-200			—100
Alds	Bored wells	16		25		25		— 5
Salem	Wells	28	300	35	35	40	—20	
Swedesburg	Dug, bored and drilled wells	40	200	100	60	200	—20	— 20
Winfield	Drilled and bored wells	30	100	40	50		—30	— 30

WELL DATA.

The following table gives data of typical wells in Henry county:

Typical wells in Henry County.

Owner	Location	Depth	Depth to rock	Depth to water bed	Source of supply	Head below curb	Remarks: (logs given in feet)
T. 70 N., R. 6 W. (Jackson).							
		Feet	Feet	Feet		Feet	
John Abraham	SW. ¼ NW. ¼ sec. 24.	290	80	180-200	Limestone		First rise above Skunk river. Drift, 80; limestone, 55; shale, 35; limestone, 70; shale, 20; limestone, 25; shale, 5 (Kinderhook?).
Beckwith	Sec. 19	290	80	270	do	40	Drift, 80; limestone, 60; shale, 35; limestone, 115; shale. Pumping 15 gallons per minute reduces water level to 140 below surface.
T. 71 N., R. 5 W. (New London).							
Greenlee	New London	135		132	Sand		3-foot sand bed at 100, weak water; another at 110, some water; third at 132, yields 2 gallons per minute.

Typical wells in Henry County—Concluded.

Owner	Location	Depth	Depth to rock	Depth to water bed	Source of supply	Head below curb	Remarks: (lo given in feet)
		Feet	Feet	Feet		Feet	
Andrew Johnson	1½ miles south of New London.	55					Loess, 6; yellow till, 20; sand, 3; blue till, 12; peat and wood, 4; gray gummy clay with few pebbles, 10.
John Shipley	New London	220	200		Rock		
T. 71 N., R. 7 W. (Tippecanoe).							
F. McNeely	S. ½ sec. 16	270	60		Limestone		Rock all limestone except some shale; flinty rock below the shale.
Thos. Campbell	E. ½ sec. 26	190	35		do		Upland drift, 35; limestone, 55; limestone alternating with shale, 100; limestone cherty.
T. 72 N., R. 5 W. (Canaan).							
John A. Wicks	SE. ¼ sec. 15	224	80	204	White porous limestone.		Drift, 80; limestone, 35; shale, 25; limestone, 84.
T. 72 N., R. 6 W. (Marion).							
August Wicks	SE. ¼ sec. 28	100	14		Limestone	30	Drift, 14; limestone, 7; blue shale, 25; limestone with water in crevice, 54.
E. June	SE. ½ sec. 1	190					All in drift, well failure, struck bowlder at 190 feet and bore hole abandoned; black cement clay, 160 to 190.
	Sec. 11	250					All in drift; abandoned.
T. 72 N., R. 7 W. (Trenton).							
Oscar Fitch	NE. ¼ sec. 20	260	150	240-260	Limestone	80	Drift clays, etc., 145; dry blue sand, 5; blue limestone, 20; shale, 25; gray limestone, white toward bottom, 65.
T. 73 N., R. 6 W. (Wayne).							
	1 mile east of Swedesburg.	85					Lower 50 feet blue till.
T. 73 N., R. 5 W. (Scott).							
	Winfield or Fairground	123	115				Loess and yellow till, 40; hard blue till, 30; gravel, 30; hard blue till, 15; white sandstone, 3; shale, 4; cherty limestone at bottom.
J. England	3½ miles east of Winfield.	110	100		Sand		Sand on rock 60 feet thick.
—— Lehart	8 miles northwest of New London.	200			do		Drift clay, 30; sand, 170.
Alda Delashmitt	do	120	105		Rock		
T. 70 N., R. 7 W. (Salem).							
	Salem	52			Sand		Yellow clay, 35; light blue clay, 15; sand, 1; blue-black clay, 1.
T. 71 N., R. 6 W. (Center).							
Chas. Leedham	4½ miles southeast of Mount Pleasant.	70	69				Yellow clay; blue clay; rock at bottom; water on rock.

JEFFERSON COUNTY

BY W. H. NORTON.

TOPOGRAPHY.

The surface of Jefferson county is a plain of ancient drift dissected by streams from 50 to 150 feet below a once level surface, remnants of which remain throughout the county in tabular divides whose flat surfaces have been estimated to constitute about one-fourth or one-fifth of the entire area. These remnants are naturally widest along the main divide between the two master streams, Skunk river and Cedar creek, where they form a featureless prairie plain extending diagonally across the county from northwest to southeast. Before the settlement of the country wet-weather marshes and shallow ponds occupied slight original depressions, but these, for the most part, have disappeared with the lowering of ground-water level consequent on sod cultivation.

Near the larger streams the country is deeply ravined, and here, as throughout southeastern Iowa, the intimately dissected areas are known as "breaks."

The maturely developed valley of Skunk river affords bottom lands more than a mile in average width. The flood plain of Cedar creek varies in width from a mile where cut in easily eroded glacial drift and one-half or one-fourth mile where cut in the shales of the Pennsylvanian and to a narrow gorge bearing all the marks of youth where the valley is incised in the more resistent limestones of the Mississippian.

GEOLOGY.

Beneath the dark soil or later humus of the surface lies a mantle of fine yellow silt—the loess—which on the uplands has a thickness of 12 to 15 feet or more. On the slopes it is somewhat thinner, owing to rain wash.

The loess rests on the Kansan drift, which is normally a blue stony clay, but which has been changed, under the oxidizing influence of long weathering, to yellow, and is known to drillers as "true red hardpan." The upper surface of the Kansan may be modified to a sticky noncalcareous clay—the gumbo—through which water can not pass, or in places may consist of pervious sands.

Beneath the Kansan, and separated from it in places by layers of sand and gravel (Aftonian), is a lower stony clay, the Nebraskan drift, a tough dark bluish deposit, which is rather difficult to drill and which generally contains splinters and bits of wood and fragments of coal.

Over most of Jefferson county the rock beneath the drift sheets belongs to the Pennsylvanian series (Coal Measures) of the Carboniferous, and consists of a variable succession of shales and sandstones, with an occasional thin bed of limestone and some seams of coal. (See Pls. X, XIII, pp. 448, 626.) The thickness of these strata ranges from a few feet to 150 feet and attains its maximum in the southwestern part of the county. In the northeastern part of the county, in Walnut and in parts of Penn townships, the Coal Measures have been stripped off by the tributaries of Skunk river, and the underlying Saint Louis limestone of the Mississippian series is exposed to view. The total exposed thickness of the Saint Louis amounts to eighty feet.

Beneath the Saint Louis limestone lies the Osage stage, thirty feet or more thick. The most easily recognized of the different beds of the Osage are the basal white limestone and the overlying flinty cherts (Montrose Chert), both of which belong to the Burlington limestone.

The Osage rests on shales of the Kinderhook stage, here about 150 feet thick. The rock formations of the area below the Kinderhook have not been penetrated by the drill within the county.

UNDERGROUND WATER.

SOURCE.

On the bottom lands of Skunk river and of its larger branches river-laid sands and gravels, saturated with water, are encountered near the surface. On these open wells and driven wells here suffice, and in places plenty of water is obtained within ten to twenty feet of the surface.

Water in greater or less quantity is obtained at the base of the loess, in the yellow Kansan drift, especially near its base, and in or at the base of the Nebraskan drift.

On the level ill-drained uplands, where the run-off is small and much of the storm water is either evaporated or sinks to feed the stores of water underground, the base of the loess silt is in many places saturated, and under favorable conditions water may still be obtained by wells of moderate capacity at depths of twenty-five feet or less. These conditions obtain especially in Polk and the west half of Black Hawk townships. On the tabular divides, where the loess is dry, water may in many places be found by the well borer in the less clayey portions of the Kansan drift, especially at or near its base. In Fairfield and Locust Grove townships, along the flat divide extending northwest from the town of Fairfield, a large number of wells find water above the blue stony clay within forty feet of the surface. In the town of Fairfield many house wells do not exceed thirty feet in depth, but the well borer can not depend on striking water at this depth. Here, as elsewhere in the county, the ground-water surface has gradually lowered and shallow wells must now be bored ten to fifteen feet deeper than was necessary in the early history of the town. On the level prairies, where fifteen years ago water could almost universally be obtained with a forty-foot auger, it must now be sought at deeper horizons. On the breaks or belts of dissected country along the streamways shallow wells have quite generally failed. Well borers lose an increasing number of holes, and the driller who is able to carry his quest for water into solid rock has an ever-increasing advantage.

Water-bearing sands and gravels are encountered in the yellow Kansan drift. The sand may be but a pocket, in which case it is easily pumped out, or it may be a seam or bed sufficiently thick and extensive to supply a good stock well. No layer of sand and gravel within the blue stony clay is marked enough to impress the memories of well makers, though the water-bearing sands resting on bedrock at its base are often mentioned. In the west half of Penn township and in the northeastern part of Des Moines township, water is found beneath the blue stony clay at about 100 feet from the surface. Two wells drilled in the town of Fairfield are said to have found abundant water in fine sand lying on bedrock at a depth of 195 feet but were abandoned as the sand could not be screened out. In general, however, the sands beneath the Nebraskan drift are not reliable in the county.

The Pennsylvanian series is extremely variable in character. Beds of sandstone thin out rapidy and may be replaced by shales. The succession of strata in one township or even in one section may not be maintained in the one adjacent. For these reasons each well drilled in the Coal Measures is largely experimental, and the experience derived from other wells serves only as a general guide indicating probabilities. In places the Pennsylvanian contains considerable bodies of sandstone and supplies a soft but often highly mineralized and usually sulphurous water.

In many of the rock wells of the county it has been necessary to go through the Coal Measures to the water-bearing limestones and interstratified sandy beds composing the Saint Louis limestone. The distance to which the drill must go to reach these beds in any locality is difficult to foretell. The overlying Coal Measures vary greatly in thickness, for they were laid on the deeply eroded surface of the Saint Louis limestone and have also an uneven eroded upper surface of their own, now deeply buried beneath the drift.

In some part of every township except Fairfield and Locust Grove the Pennsylvanian has been entirely swept away, usually along the streamways; in Walnut township it is found only over about six square miles in the southwestern and northwestern parts. The following township data from Udden,[1] giving the average thickness of the Coal Measures in each township may be of some help to drillers if it is remembered that in any section their thickness may be several times that given, or, again, may be much less than the average stated for the township.

Thickness of Pennsylvanian rocks in Jefferson County townships.

Polk	20	Penn	30
Locust Grove	80	Buchanan	20
Des Moines	50	Cedar	20
Black Hawk	15	Walnut	10
Fairfield	75	Lockridge	40
Liberty	50	Round Prairie	20

SPRINGS.

Few noteworthy springs are reported from the county. In the southwest corner of section 1, Walnut township, a number of springs emerge from glacial or preglacial gravels resting on bedrock. Large springs are said to occur near Merrimac on Skunk river. Near Perlee in Penn township some sulphur springs, rising from the Coal Measures, yield 5 to 10 gallons per minute.

CITY AND VILLAGE SUPPLIES.

Fairfield.—The city supply of Fairfield (population, 4,970) is drawn from ponds and is not satisfactory. The distribution is both direct and from standpipe, the domestic pressure being 24 pounds and the fire pressure 140 pounds. There are 15 miles of mains, 55 fire hydrants, and 440 taps. The daily consumption is estimated at 250,000 gallons.

In forecast of artesian possibilities it may be said that the shales of the Kinderhook stage should be found about 350 feet from the surface. Any highly mineralized water found in connection with them should be carefully cased out, although it may be potable. The thickness of these heavy shales is variable and can not be forecast with any certainty, but it probably will not

[1] Ann. Rept. Iowa Geol. Survey, vol. 12, p. 414.

exceed 200 feet. The Devonian limestones and shales below the Kinderhook may contain water, and water will in all probability be found in the underlying Silurian limestones and sandstones. Before leaving the Silurian strata the water of the well should be analyzed, as the Silurian may include beds of gypsum which may have added a large lime sulphate content to the water. Should such beds of gypsum or anhydrite be disclosed, it would be well to case out all Silurian waters. The Maquoketa shale should next be reached, lying within 950 feet of the surface.

Water will be found probably in the Galena and Platteville limestones, underlying the Maquoketa, and its quality should also be tested by analysis. The Saint Peter sandstone should be reached within 1,260 to 1,350 feet of the surface and should contain a liberal supply of water. If the supply should fall short of the probable needs of the city, the well may be sunk several hundred feet deeper to a depth of at least 2,000 feet, in order to obtain more water.

The water in such a well will probably stand about 100 feet below the curb. Its quality will depend largely on the care with which the upper waters of the Mississippian and Silurian formations are cased out, and would probably be improved by going deeper than the Saint Peter sandstone.

Minor villages.—Information concerning the water supplies of other towns and villages is presented in the following table:

Town and village supplies in Jefferson County.

Town	Nature of supply	Depth of wells		Depth to rock	Depth to water bed	Head below curb	
		From	To			Shallow wells	Deep wells
		Feet	Feet	Feet	Feet	Feet	Feet
Abingdon	Wells	25	45		45	15	20
County Line	Open, bored and drilled wells	12	300				
Germanville	Wells and cisterns	25	250	100		10	
Glendale	Bored and drilled wells	20	130			8	
Lockridge	Cisterns, bored wells						
Merrimac	Dug wells	16	18	16		10	
Packwood	Open wells	12	50		25	12	
Perlee	Springs, cisterns and wells	20	250	50–150		6–20	50
Pleasant Plain	Open and bored wells	28	40		35	20	
Veo	do	15	75			10	
Woolson	Open wells	18	30			10	

WELL DATA.

The following table gives data of typical wells in Jefferson county:

Typical wells in Jefferson County.

Owner	Location	Depth	Depth to rock	Depth to water bed	Source of supply	Remarks: (Logs given in feet)
T. 72 N., R. 8 W. (Lockridge).		Feet	Feet	Feet		
G. B. Parsons	1½ miles west of Glendale.	125		115	Sand	Yellow clay, 35; blue clay, 60; black "cement" clay, darker and harder than blue clay with few pebbles and no sand, 20; sand, grayish yellow, 10.
Kaliff	5 miles north of Glendale.	290			Limestone	
M. R. Cullins	Salina	79			Sand	Soil and yellow clay, pebbly, 45; blue clay, 20; dry sand, 5; blue clay, 3; blue sand, 3; shale and coal, 3.
T. 71 N., R. 8 W. (Round Prairie).						
Thomas Raines	3½ miles southwest of Glasgow.	317	80	300	Limestone	Drift, 80; rock, 40; shale, 30; limestone, 167. Heads 175 feet below curb.
Spratt	SE.¼ SW.¼ sec. 8	319	130	317	Sandstone	Drift, 105; drift, gravel, and sand, 25; white limestone with bands of shale, 187; sandstone, 2. Heads 85 feet below curb.
	SE.¼ sec. 28	246	100			Yellow clay, 40; dark clay, 50; not known, 12; limestone, 98; chert 2-3; 2 feet of shale in other materials, 15; hard yellow sand rock with balls of hard material, 40.
T. 71 N., R. 9 W. (Cedar).						
Hosette	SE.¼ SW.¼ sec. 26	230	105			About 30 feet above creek. Drift, 105; shale, 3; limestone, 119; sandstone, 3; lime rock.
T. 71 N., R. 10 W. (Liberty and part of Fairfield).						
L. Howard	Sec. 1	185	115			
G. P. Spratt	NW.¼ sec. 11	265	70			Upland. Joint clay, 20; blue till, 50; shell rock, bastard limestone and coaly shale, 38; limestone, 152; sandstone, 5.
E. R. Smith	SW.¼ NW.¼ sec. 2	306	95		Sandstone	Red till, 45; blue till, 50; coal and slate, ½; white limestone, 100; brown limestone, 20; sandstone with a little water, 2; white limestone, 85; sandstone yielding 10 barrels an hour, 4; water soft and a little salt. Heads 67 feet below curb.

Typical wells in Jefferson County—Continued

Owner	Location	Depth	Depth to rock	Depth to water bed	Source of supply	Remarks: (Logs given in feet)
		Feet	Feet	Feet		
Charles Webb	1 mile east of Libertyville.	368				Water salty.
P. H. Heston	NE.¼ sec. 9	438	50	420		Water also in sandstone, 70; water lowers on pumping to —170. Well 4 inches in diameter; capacity, 10 gallons per minute.
T. 71 N., R. 11 W. (Des Moines).						
E. McCleary	NW.¼ sec. 1	230	64			Sandy loess, 20; till, yellow and blue, 44; limestone, 2; shale?, 32; limestone, 4; gritty shale, 20; yellow arenaceous rock, 108. Water salty.
T. 72 N., R. 11 W. (Locust Grove).						
	Brookville	241	95			Yellow till and blue till, 85; sand, water bearing, 10; limestone with beds of sandstone, 142; sandstone, hard, 4.
W. C. Ball	NW.¼ NE.¼ sec. 25	172	50	172	Sandstone	Loess, 25; blue till, 25; "blue granite" (siliceous rock), 12; brown sandstone, 93; limestone and sandstone, 17. Water soft.
T. Z. Gillett	SW.¼ sec. 3	218	140			Loess and yellow till, 60; dark till, 80; black shale with much pyrite, 40; bluish black carbonaceous material, 8; sandstone, shale and fine clay, 30.
T. W. Gobble	NE.¼ sec. 5	188	108		Gravel	Yellow drift, 30; dark till, 60; gravel, 18; black shale, 80.
L. A. Patterson	NE.¼ sec. 10	160	120			Loess, 10; gumbo, 10; yellow till, 40; dark till, 60; sandstone, mostly fine, but somewhat coarser below, 40.
T. W. Hill	Batavia	200	(?)			Creek bottom; marl at 60; coal at 115; hard sandstone at bottom.
T. 72 N., R. 10 W. (Part of Fairfield)						
Patrick Kennedy	SW.¼ SW.¼ sec. 9	76			Sand	Valley. Flowing well. Water from sand below blue clay.
F. J. Shearer	NW.¼ SW.¼ sec. 14	165	90			Loess, 10; joint clay or gumbo, 20; red till, 30; dark till, 30; white shale, 20; some arenaceous material.
J. W. Wilson	Sec. 17	143	95			Joint clay, 10; red hardpan, 3; blue till, 82; limestone, 48, with crevice in which drill dropped 4 feet. Water contains sulphureted hydrogen; laxative, soft. Heads 60 feet below curb.

Typical wells in Jefferson County—Continued.

Owner	Location	Depth	Depth to rock	Depth to water bed	Source of supply	Remarks: (Logs given in feet)
		Feet	Feet	Feet		
J. F. Seahill	Near center sec. 17	145	110			Loess and yellow till, 60; sand and gravel, 10; dark till, 40; sandstone, in bottom. Mineral water.
G. W. Ball	SW.¼ sec. 19	186	95			
L. Snider	SW.¼ SE.¼ sec. 21	146	90			"Soil," 10; red till, 80; white and brown limestone, 50; "slate," black, 2; coal, 4.
S. Sackett	NW.¼ NW.¼ sec. 23	200	200		Sand and Gravel	Loess, 10; red till, 30; blue clay, 155; sand and gravel, 5; resting on bedrock.
B. T. Raines	Fairfield	151	151		do	Loam, 5; brown "joint clay," 10; yellow till, 30; dark till, 78; gravel and sand, 28, resting on shell rock.
C. W. Whitam	NE.¼ SE.¼ sec. 28	230	120			Drift, 120; black shale, fire clay, and several small coal seams alternating, 45; coal,6; alternations of shale, sand rock, and fire clay with dark sandstone below, 59.
J. B. Steever	SE.¼ sec. 28	185	80			Drift, 80; shale and fire clay with thin seams of coal, 50; sandstone, 20; coal, 4; limestone at bottom.
D. W. Manning	SE.¼ sec. 31	200	100			Drift, 100; dark sandstone, 20; common sandstone, 80.
T. 72 N., R. 9 W. (Buchanan).						
M. Fordyce	SE.¼ SW.¼ sec. 23	237	97		Sandstone	Loess, 20; yellow till, 25; blue till, 50; sand and a little water, 2; limestone, 88; sandstone, 2; yielding 2 barrels of water per hour; limestone, 46; brown sandstone, 4.
Wayne Green	3 miles west of Salina.	97	97			Joint clay, 6; yellow till, 40; black hardpan, hard and irony, 20; dark till, 24; old soil with wood, 3; sand with water, 4; limestone.
T. H. Clover	SW.¼ sec. 27	186				Loess and gumbo, 25; yellow till, 20; dark till, 141.
J. P. Manatry	SW.¼ SW.¼ sec. 35	240	129			Drift, 129; limestone, 30; bastard rock and sandstone, 51; limestone, 30.
T. 73 N., R. 11 W. (Polk).						
	1 mile west of Abingdon.	165	165		Gravel	Loess, 20; yellow till, 20; brown soft clay, sandy streaks, 117; gravel, 8; on bedrock. Heads 40 feet below curb.

Typical wells of Jefferson County—Concluded.

Owner	Location	Depth	Depth to rock	Depth to water bed	Source of supply	Remarks: (Logs given in feet)
		Feet	Feet	Feet		
	Abingdon	250	140		Sandstone	Loess, 30; yellow till, 30; dark till, 80; bedrock with pyrites, 10; black shale, 4; coal, 6; fire clay; white limestone to 247; coarse sandstone, 3.
L. K. Wallace	SW.¼ SW.¼ sec. 2	300	160			Drift, 160; dark shale, 30; cherty limestone, 110.
Geo. E. Estes	W.½ sec. 16	186				Limestone with some chert at 104; sandstone from 144 to 186.
T. R. Smith	SE.¼ sec. 20	79	76			Drift, 76; shale, 3.
A. T. Downey	Sec. 33	75	70			Drift, 70; shale and coal in bottom.
T. 73 N., R. 10 W. (Black Hawk).						
T. A. Webb	NW.¼ sec. 6	160	130			Upland. Loess and yellow till, 60; dark till, 70; red shale, 10; some black shale.
	SW.¼ sec. 27	161	85		Sandstone	Yellow till, 50; dark till with inclusions of sand, 35; shale; sandstone, 4, to bottom.
A. Freshwater	SW.¼ sec. 28		165		Limestone	Loess, 25; yellow till, 20; dark till, 115; red ocherous clay, 5; sandstone?, 12; shell rock, 2; shale, 4; limestone with crevice 1½ feet deep, 44. Water contains sulphureted hydrogen.
J. L. Knight	SW.¼ sec. 37	170			Gravel	Loess, 20; soft sandy yellow till, 140; gravel, 10.
T. 73 N., R. 9 W. (Penn).						
J. Pascha	Sec. 1	130	130			Loess and yellow till, 60; some sand; dark till, to 100 from curb; limestone with some sandstone, 30.
M. Polus	NW.¼ sec. 24	106				Loess and yellow clay, 50; dark till, 53; gravel, 3.
T. 73 N., R. 8 W. (Walnut).						
C. Shaffer	E.½ sec. 26	240	60			Drift, 60; "rock and shale", 180; "hard rock" (limestone) in bottom.

KEOKUK COUNTY

BY W. H. NORTON.

TOPOGRAPHY.

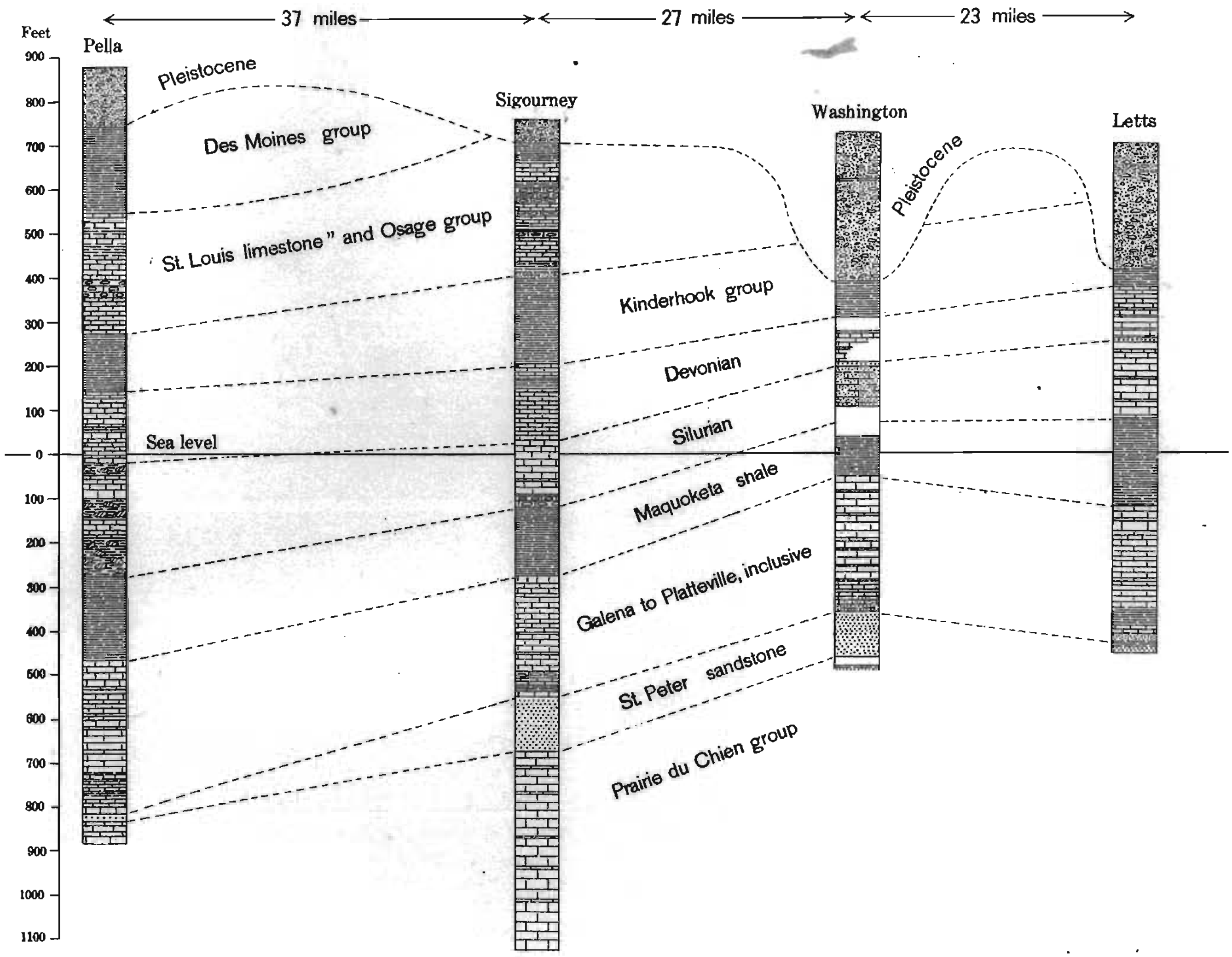
The surface of Keokuk county is an upland plain scored with the channels of numerous converging streams. The sky line as seen from the summits of the divides is everywhere even and horizontal. Extensive remnants of the ancient level surface, which must have been singularly flat and featureless, still exist on the main divides and extend to the rather steep slopes of the valleys of the larger streams. Even in the southern part of the county, where North and South branches of the Skunk flow in parallel and adjacent courses and where the upland is most dissected by their tributary streams, there are remnants of the original plain three or four miles wide, with a maximum relief of less than 12 feet. In this part of the county the valleys of the major streams have been worn to a depth of 100 to 200 feet below the upland level and have been widened by long lateral erosion and the action of the weather. The valley of the Skunk, for example has been planed and filled to a flat alluvial floor two to six miles wide.

GEOLOGY.

The surface deposit over the entire county, except on the river flood plains, is the yellow or ashen pebbleless silt known as the loess. It mantles valley slopes as well as level uplands and is in few places more than 8 or 10 feet thick.

Below the loess is a yellow clay that is distinguishable from the loess by its brighter tint, by the presence in it of sand and gravel, and by its greater hardness. This yellow stony clay or till is the weathered upper portion of the Kansan drift sheet, the unaltered portion being normally bluish gray in color.

Beneath the Kansan lies another tough stony clay, the Neb-



GEOLOGIC SECTION BETWEEN PELLA AND LETTS, IOWA
By W. H. Norton

THE NORRIS PETERS CO., WASHINGTON, D. C.

raskan. It is hardly to be distinguished from the Kansan in well drilling, unless it should be separated from it by ill-smelling soils, by peat and forest beds, or by the more welcome water-bearing sands and gravels which not infrequently mark this horizon. The Nebraskan till rests either on bedrock or on thin sand and gravels which separate it from the rock.

The rocks of Keokuk county belong to two great series of the Carboniferous system, the Pennsylvanian and the Mississippian. (See Pl. XIV, p. 660.) The Pennsylvanian is exposed to view or is found by the drill immediately below the drift over large areas in the western townships and in several scattered outliers over the remainder of the county. The rocks of the Pennsylvanian series consist of shale ("soapstone" or "slate") with seams of coal and beds of fire clay, and lenticular bodies of sandstone. These rocks lie on a deeply eroded surface of Mississippian strata.

The outcrops of the Mississippian series in this county present only its higher subdivisions. The Saint Louis stage, with its variable beds of limestone (some fine-grained and compact, some magnesian, some sandy, some interbedded with sandstone layers, and some made up of angular fragments) and sandstone, which in places may attain a thickness of 40 feet, underlies the greater portion of the area. The total thickness of the Saint Louis may reach 150 feet.

The Osage stage underlies the Saint Louis limestone. Its exposures in the county show a subcrystalline limestone locally made up of crinoidal fragments in many places pure white. It occurs in layers commonly less than a foot thick, separated by bands of chert or of clay. The Osage underlies the drift northeast of a line drawn diagonally across the county from a point three miles south of Keota through South English. The thickness of the Osage in the deep well at Sigourney is 168 feet.

The Osage rests upon the heavy shales of the Kinderhook. Everywhere throughout the county these shales lie too deep to be shown by even the deepest valleys. Some of the deeper wells of the county reach them, however, and their total thickness, shown by the Sigourney boring, measures 229 feet.

UNDERGROUND WATER.

SOURCE AND DISTRIBUTION.

On the broad bottom lands of Skunk river "sheet water" is found in river sands and gravels at a depth of 24 to 30 feet. The water derived from this formation by some wells is said to have a slight odor of organic matter.

The chief water supply of the county is obtained from the drift. Ground water beneath the level prairies stands high. Under favorable local topographic conditions the basal silts and sands of the loess yield a supply sufficient for house use, and in certain localities, at least in wet years, sufficient for stock wells. Thus near Richland a well 33 feet deep, dug in 1906, struck water at 12 feet, the quantity increasing to the bottom; this well, which supplies 30 head of cattle, probably obtains water from sands and Kansan drift as well as from the basal loess.

There are several well-marked water-bearing beds in the drift. At Sigourney these are reached at depths of 25 and 55 feet in loose gravelly beds, and at varying depths in gravels immediately overlying the Saint Louis limestone, which here occurs 35 to 70 feet from the surface. The following section of the drift at Sigourney is given by a driller:

Section of drift at Sigourney.

	Thickness	Depth
	Feet	Feet
Joint clay, without pebbles (loess)	16	16
Clay, sandy, loose, yellow, pebbly, caving; containing water toward base	22	38
Clay, blue, with streaks of yellow; hard, with small pebbles, many of them white in color; penetrated to a sufficient distance for reservoir	to rock	

At Delta, in Warren township, the section of the upper portion of the drift is given as follows:

Section of drift at Delta.

	Thickness	Depth
	Feet	Feet
Soil, black	5	5
Clay, yellow, with black streaks	15	20
Clay, yellow, caving, soft; with sand streaks; water bearing in basal portions	15	35

On the upland about South English a different section is given:

Section of drift near South English.

	Thickness	Depth
	Feet	Feet
Clay, yellow (loess)	12	12
Soil, ashen, dry (Kansan)	5	17
Clay, blue, tough, with small white pebbles	10	27
Soil, old, ill smelling, and wood	1	28
Sand, clean, coarse, white, with water		

In Steady Run township, on the flat prairie about Martinsburg, the succession is said to be as follows:

Section of drift near Martinsburg.

	Thickness	Depth
	Feet	Feet
Soil, black	5	5
Clay, yellow, ashen at bottom	20	25
Clay, yellow	12	37
Clay, blue, stony	40	77
Sand, with water		

Other sections showing drift deposits and water sources, as related by the drillers, will be found in the list of wells (p. 668). These sections seem to show that the upper weathered zone of the Kansan till is still water-logged under favorable topographic conditions, and that it furnishes water at very moderate depths from its sandy beds; they show also, however, that a more dependable source of supply is to be found in the sands beneath a sheet of blue till which in many places is probably the unweathered Kansan, the sands being those which immediately overlie the Nebraskan drift.

The thickness of the drift and the depth to its different water beds varies greatly. In the town of Sigourney the depth to bedrock ranges from 35 to 70 feet; a mile north of town, wells 190 feet deep find water in gravels without reaching rock. In the southeastern sections of Lafayette township rock is struck within 30 feet of the surface; in the western sections the drift is 130 to 160 feet thick and in the northeastern sections from 100 to 130 feet. On the uplands in the vicinity of South English the average thickness of the drift is about 100 feet; about Webster it is from 90 to 100 feet thick. In the area about Haysville rock is struck in wells 50 and 60 feet deep.

Until the series of dry years in the nineties it was rarely necessary to sink wells into the indurated rocks for water, except in the well-dissected areas where drift is thin and ground water normally stands low.

The Pennsylvanian supplies good water in but few localities, a fact which causes serious difficulty in the mining regions of the western townships, where most of the water obtained is drawn from the drift.

The Saint Louis limestone usually yields a good supply of water from the soft sandstones that lie between the limestone beds, as, for example, in the wells at Keswick. Where the Osage stage forms the country rock, as in Liberty and Lafayette townships, wells which fail of finding water in the drift are drilled a considerable distance in this limestone before finding water. Of the wells reported from these townships, more than one-half exceed 200 feet in depth.

In the southeastern townships, Richland and Jackson, a number of deep wells have been sunk. The deepest of these, 548 feet deep, passed through 150 feet of drift, eight feet of flinty, pyritiferous rock, and 50 feet of "clay" (shale), which may be either Coal Measures or Saint Louis limestone; then 200 feet of solid limestone (the Osage and perhaps the lower part of the Saint Louis); and finally 140 feet of shale evidently the Kinderhook. Whenever the thick and dry shale of the Kinderhook is struck, drilling should cease unless the owner is prepared to sink his well to the much deeper formations reached by the deep well at Sigourney, (p. 667). In other counties where like conditions exist the experiment of shooting a well with nitroglycerin at the top of the shale when water has not been made above it is successfully made as a last resort.

SPRINGS.

Only in the western townships are noteworthy springs reported. A number of unfailing springs, the water of which is said to rise from gravel and from sandstones, emerge along Richland creek north of Richland, the measured discharge of one being three gallons per minute. Other springs are reported northeast of Harper in Lafayette township.

CITY AND VILLAGE SUPPLIES.

Keota.—The water supply of Keota (population, 988) is taken from a well 180 feet deep. The amount used daily is 13,500 gallons. The water is distributed from a tank having a capacity of 68,000 gallons. The fire and domestic pressure is 65 pounds. There are 1¾ miles of mains, 21 fire hydrants, and 150 taps.

The well reached rock at 70 feet. To this distance it was excavated to a diameter of 10 feet, to serve as reservoir, the casing of the drilled well occupying the center. The supply, however, is insufficient for the needs of the town, and at times of greatest consumption the well can be pumped dry several times each day.

Sigourney.—The water supply of Sigourney (population, 2,032) is drawn from a well 14 feet in diameter and 20 feet deep, situated 1½ miles from the town on the flood plain of Skunk river and about 150 feet from the river bank. The water is distributed by gravity from a tank holding 50,000 gallons. The domestic pressure is 50 pounds; the fire pressure, 100 pounds. There are 7 miles of mains, 41 fire hydrants, and 100 taps.

Besides supplying water for its own use the town furnishes water to the Chicago, Rock Island & Pacific and the Chicago. Milwaukee & St. Paul Railways for use in their engines. The amount of water consumed by these companies and the objectionable qualities of the water of the deep well for use in boilers, may, it is said, have had something to do with the abandonment of the deep well drilled for the city by Hopkins and Gordon in 1882. (See Pl. XIV, p. 660.)

The depth of the well is 1,888 feet and the diameter, 6 inches to 1,091 feet, 4½ inches to bottom; casing to 1,091 feet. The curb is 756 feet above sea level, and the head 30 feet below curb. At 1,320 feet, in the Saint Peter sandstone, mineral water with strong odor was found; at 1,360 feet, a crevice was encountered in which the drill dropped 2 feet and a current of water carried off the cuttings. The supply of water increased to 1,388 feet, when it flowed over the top of the well while the drill was in and stood within 30 feet of curb when the drill and rods were removed. No water was found below 1,388 feet.

On account of the poor quality of the water the well has never been used. It is also stated that its capacity was insufficient, but if any pumping tests were ever made they have not been reported.

Record of strata in city well of Sigourney.

	Thickness	Depth
	Feet	Feet
Pleistocene:		
Drift	50	50
Carboniferous (Mississippian):		
Saint Louis limestone and Osage stage (306 feet thick; top, 706 feet above sea level)—		
Shale, blue; a few drift pebbles fallen from above	18	68
Clay, brown, fine, noncalcareous; in flakes; disaggregates in water with about ten times the difficulty of the blue till; quartzose and cherty residue; some glacial pebbles	30	98
Limestone, brown-gray, arenaceous	22	120
Limestone, gray, arenaceous, cherty; 2 samples	15	135
Shale, calcareous; much gray flint in flakes	20	155
Limestone, highly siliceous, highly argillaceous; much flint and blue shale; drillings largely chert	10	165
Limestone, bluish gray; drillings mostly chert of the same color	5	170
Limestone, bluish gray, or shale, highly cherty, quartzose, and argillaceous	17	187
Shale, blue, calcareous, highly siliceous	3	190
Limestone, blue-gray, highly cherty	5	195
Limestone, soft, blue-gray	10	205
Limestone, blue-gray; much chert	5	210
Limestone, light bluish; earthy luster, in large flakes, highly siliceous	15	225
Limestone, blue-gray	15	240
Limestone, drab, granular	10	250
Limestone, brown, somewhat cherty	6	256
Chert, blue-gray	14	270
Limestone, brown, somewhat cherty	15	285
Limestone, light gray, soft, angular, crystalline	25	310
Shale, hard, greenish, calcareous, microscopically siliceous; in fragments; 2 samples	20	330
Shale, dark greenish; in large fragments; calciferous; so highly siliceous with microscopic particles of limpid quartz that it might perhaps be called sandstone; 3 samples	12	342
Limestone, light and darker blue-gray; in flaky chips; argillaceous and microscopically arenaceous	14	356
Kinderhook stage (198 feet thick; top, 400 feet above sea level)—		
Shale, greenish, soft, slightly calcareous, fine-grained; 4 samples	198	554
Devonian (171 feet thick; top, 202 feet above sea level):		
Limestone, green-gray, argillaceous	31	585
Shale, indurated, calcareo-siliceous	21	606
Shale, calcareous, or limestone, argillaceous; highly fossiliferous; drillings largely fragments of Spirifer, Orthis, and perhaps other brachiopods, and of crinoid stems	12	618
Limestone, blue-gray; earthy luster; fossiliferous	12	630
Limestone, brown and buff; earthy luster; fossiliferous	13	643
Limestone, soft, yellow; earthy luster; 4 samples	25	668
Limestone, gray, cherty	5	673
Limestone, white; in powder	52	725
Silurian (146 feet thick; top, 31 feet above sea level):		
Limestone, magnesian, buff; in sand; 2 samples	5	730
Dolomite, gray-buff; in chips; subcrystalline, much white chert; 2 samples	56	786
Dolomite, yellow, buff, and gray; mostly cherty; 5 samples	79	865
Limestone, magnesian; mostly white and translucent chert, with interbedded cubes of pyrite, and a large number of minute rounded grains of limpid quartz	6	871
Ordovician:		
Maquoketa shale (159 feet thick; top, 115 feet below sea level)—		
Shale, blue, green, gray, and drab; 7 samples	159	1,030
Galena and Platteville limestones (283 feet thick; top, 274 feet below sea level)		
Dolomite, brown, hard, argillaceous	25	1,055
Limestone, light yellow-gray	34	1,089
Dolomite, brown	------	------
Limestone, magnesian, cherty, white, gray, buff, and brown; all effervesce more rapidly than Galena dolomite	149	1,238
Chert	17	1,255
Limestone, light yellow-gray, cherty	5	1,260
Limestone; a little shale	15	1,275
Shale, green, soft, calcareous	6	1,281
Limestone, gray	9	1,290
Limestone, magnesian, brown	25	1,315
Saint Peter sandstone (115 feet thick; top, 557 feet below sea level)—		
Sandstone, fine-grained; white and light gray in mass; mostly angular fragments with some rounded grains; 7 samples	115	1,430
Prairie du Chien stage (458 feet thick; top, 674 feet below sea level)—		
Dolomite; 2 samples	398	1,828
Same (reported)	60	1,888

Minor supplies.—Information concerning the water supplies in the smaller towns and villages is presented in the following table:

Village supplies in Keokuk County.

Town	Nature of supply	Depth	Depth to water bed	Depth to rock	Head below curb	
					Shallow wells	Deep wells
		Feet	Feet	Feet	Feet	Feet
Delta	Dug and drilled wells	22-470	100-300	50	12	50
Gibson	Wells				4-15	
Haysville	Dug, drilled and bored wells	16-40		55	15	
Hedrick	Wells	15-55	25		12	45
Kinross	Open wells					
Nugent	Dug, bored and drilled wells	18-180	90-180	20-60	20	40
South English	Open and drilled wells	10-60			20	
Tallyrand	do	20-230		50-75	15	55
Thornburg	Open wells	20-50	35			8
Webster	Bored wells	15-30	10&18		5	
What Cheer	Wells and cisterns	18-45	25	90	8	35

WELL DATA.

The following table gives data of typical wells in Keokuk county:

Typical wells in Keokuk County.

Owner	Location	Depth	Diameter	Depth to rock	Depth to water bed	Source of supply	Head above or below curb	Remarks: (Logs given in feet)
T. 77 N., R. 10 W. (Liberty).		Feet	In.	Feet	Feet		Feet	
W. Oliver	SE. ¼ sec. 6	253		230				20 feet of sandstone and some gray soapstone below drift.
Daniel Coffman	NW. ¼ sec. 31	290		176				All limestone below drift.
—— Graham	SW. ¼ sec. 31	232		160				
Casper Troutman	SE. ¼ sec. 32	240		155				
Albert Dill	Southeast of Kinross.	220		130				
T. 77 N., R. 12 W. (Adams).								
J. O. McBride	NE. ¼ sec. 13	41	2		40	Gravel	+1	Foot of hill.
	SW. ¼ NE. ¼ sec. 32.							Soil and yellow clay 20; yellow pebbly clay, a little water at bottom, 30; hard black pyritiferous shale, 16.
T. 76 N., R. 10 W. (Lafayette).								
Ephriam Bouzloz	NE. ¼ sec. 5	220		155				
John Curtis	NW. ¼ sec. 5	325		100				
Creamery	Harker	92				Sand	—16	Soil and loess; yellow pebbly clay, 12; hard, blue clay with wood, 60; sand.
Cook	NE. ¼ sec. 6	208		150				
Simon Herr	NE. ¼ sec. 7	260		160				
David Clyde	NW. ¼ sec. 9	150		120				
E. A. Kenrell	SE. ¼ sec. 11	147		97				
Scott Kirkpatrick	SW. ¼ sec. 12	202		130				
—— Klein	NE. ¼ sec. 13	175		120				Shale 1 foot, at bottom.
Frank Holmes	SE. ¼ sec. 2	110		109		Sand		

Typical wells in Keokuk County—Concluded.

Owner	Location	Depth	Diameter	Depth to rock	Depth of water bed	Source of supply	Head above or below curb	Remarks: (Logs given in feet)
		Feet	In.	Feet	Feet		Feet	
Ed Van Fossen	SE. ¼ sec. 36	70		30				
T. 75 N., R. 11 W. (Parts of German and Lancaster).								
J. F. Doensing	NW. ¼ sec. 6	156						
	NE. ¼ sec. 2	60				Sand		Yellow clay, 40; blue clay, 20; sand.
Charles Brallier	Sec. 34	224	4½	120	175		—90	Capacity, 1½ gallons per minute.
—— Teuscher	SE. ¼ sec. 14	230		180				
H. Brain	SW. ¼ sec. 26	190		120		Limestone		
T. 76 N., R. 11 W. (Part of German).								
	About 1 mile southwest of Harper.	180		134				
	About 1 mile northwest of Harper.	130						Ends in quicksand; abandoned.
	SE. ¼ NE. ¼ sec. 36.	54				Gravel	—30	Loess, 20; yellow clay 15; blue clay, 16; fine gravel, 3.
E. W. Mohne	Southwest pt.	156		141				Rock outcrops on neighboring creek 65 feet lower than curb.
T. 75 N., R. 10 W. (Clear Creek).								
John Wright	NE. ¼ sec. 5	180		105				
A. D. Conrad	SE. ¼ sec. 11	170		130			—75	
T. 74 N., R. 10 W. (Richland).								
John W. Lemly	Sec. 18	302	6	70	70		—70	Capacity 1 gallon per minute.
F. H. Heilman	do	213	6	26			—30	Capacity 30 barrels a day; easily lowered to —100 feet.
Jerry Reddig	Sec. 29	113	48		105	Gravel	—78	Soil, 2; yellow clay, 10; yellow joint clay, 48; blue till, 35; yellow sandy clay, 9; gravel 8; soapstone, 1.
Samuel A. Altman	Sec. 30	548	5½ to 3½	150	400	Limestone	—92	Water lowers to —200 feet. Drift, 150; flinty rock, pyritiferous, 8; clay, 10; solid rock (limestone), 200; shale, Kinderhook, 140.
T. 74 N., R. 11 W. (Jackson).								
John Altenhofen	Sec. 1	418	6	85	102		—60	Capacity, 3½ gallons a minute; lowers to —275 feet. Drift, 102; limestone, 58; flint, slate, pyrite, 65; soapstone, 193 with water at 410.
Isaac Brown	Sec. 12	118	6	50			—106	Mostly limestone; some sandstone and a little black rock.
Isaac Shelly	Sec. 13	105	6	48	103	Saint Louis	—40	Capacity, 12 gallons a minute; can not be lowered. Drift, 48; sandstone, 10; hard, white flint-rock, 47.
C. C. Bottyer	2½ miles from Ollie.	125	6	38	125		—40	Can not be lowered.
Pierce Hollingsworth.	Near Ollie	250	4	60			—60	

LEE COUNTY

BY W. H. NORTON.

TOPOGRAPHY.

Lee county, occupying the southeast corner of the state, and bounded on the southeast by the Mississippi, on the northeast by the Skunk, and on the southwest by the Des Moines, may be described as an upland overlooking its boundary rivers from a height of 100 feet and more. From Montrose to Keokuk the Mississippi flows through a narrow rock-bound valley. From Montrose north to Fort Madison a wide, crescentic flood plain on the right bank has been opened in the drift on either side of the lower course of Sugar creek, and north of Fort Madison a still broader alluvial plain has been opened on either side of Skunk river. These two patches of the Mississippi flood plain and a plain of similar character along the Des Moines at Sand Prairie are the only lowlands within the county.

A low ridge, sufficiently prominent to give name to Pleasant Ridge township, rises above the general level of the upland plain and extends nearly north and south from the Henry county line through West Point to Sugar creek. East of this broad swell —the terminal moraine of the Illinoian ice sheet—the upland is overlain with Illinoian drift; west of it the upland is formed of the older drift sheet, the Kansan. A broad shallow depression, a temporary drainage channel of Pleistocene times, entering from Henry county on the north, is known as Grand Valley until, trending to the southeast, it is occupied by Sugar creek. With these exceptions the entire upland may be regarded as a plain once nearly level and now etched with the valleys of a drainage system as yet immature. The divides are in the main tabular and are still so wide as to allow a high ground-water surface.

GEOLOGY.

The lowest drift sheet of Lee county is the Nebraskan, a dark stony clay, in places separated from bedrock by outwash sands and from the overlying Kansan drift by forest beds, old soils or still more commonly by sands and gravels of special importance to the well driller. The Kansan drift sheet is a dense, tough stony clay, weathering to reddish yellow, but bluish in its unweathered deeper portions. East of a line drawn north and south through West Point from the Henry county line to Sugar creek is a third drift sheet, deposited by a still later ice invasion, the Illinoian. Over the area of the Illinoian drift an old soil (Yarmouth) in many places separates it from the underlying Kansan.

The rocks under the drift in Lee county belong entirely to the Pennsylvanian and Mississippian series of the Carboniferous. (See Pl. XII, p. 618.)

The rocks of the Pennsylvanian series or Coal Measures lie on an ancient land surface eroded in the rocks of the underlying Mississippian series. They consist chiefly of drab clay shales, not commonly associated here with coal, and yellow friable sandstones. As outliers of the Iowa coal field they occur in the western part of the county and are found in four tracts, occupying more or less of Pleasant Ridge, Marion, Franklin, Cedar, Harrison and Van Buren townships.

The Mississippian series of this area includes the Saint Louis limestone and the Osage and Kinderhook stages. The term Saint Louis limestone of the Iowa State Survey reports and as employed in this report includes the upper part of the Warsaw limestone, the lower part of the Warsaw being included in the underlying Osage stage. The Osage stage of the United States Geological Survey, however, excludes the Warsaw limestone.

The Saint Louis limestone forms the country rock over perhaps one-third of the county, with a thickness of hardly more than 30 feet. It is variable, including magnesian and nonmagnesian limestones, sandy limestones, and blue sandstones. Much of it consists of breccia, a rock that has been broken into angular fragments. The sandstone beds of the Saint Louis should yield a moderate amount of water.

The Saint Louis limestone rests on the Osage stage, which includes as its basal formation the Burlington limestone, the lower part of which is characterized by its brilliant whiteness, its crystalline texture, and its numerous fragments of crinoid stems and plates. Upon the lower division of the Burlington lies the Montrose Chert, well exposed along the Mississippi from Montrose to Keokuk, where its resistance to corrasion has given rise to the Lower Rapids of the Mississippi. This chert constitutes the upper division of the Burlington limestone. As flint or chert is considerably harder than steel it might be supposed that these beds of chert would be difficult to drill, but the thin, brittle layers break easily under the heavy stroke of the drill and the chips do not pack. The Osage stage also includes the Keokuk limestone, the lower part of which is bluish and cherty, about 25 to 40 feet thick, and the upper part a shale about 40 feet thick containing many geodes lined with banded chalcedony or crystals of quartz. The lower part of the Warsaw limestone, consisting of alternating sandy limestones and sandy shales, about 30 feet thick at Keokuk, is, for convenience, also included in the Osage stage. The Kinderhook stage underlies the entire area but is exposed in a few places only.

UNDERGROUND WATERS.

SOURCES.

The river-laid sands and gravels of the broad Mississippi bottom lands and those of the narrower flood plain strips along Skunk and Des Moines rivers yield abundant water of excellent quality to shallow open or driven wells.

The uplands of the county are mantled by the loess, a soft friable silt that is too fine to be called sand and too coarse to be called clay, and that furnishes water to shallow wells that reach its base wherever conditions bring ground water near the surface.

Water is obtained from thin sandy streaks in the Illinoian drift, and especially from sandy layers of the interglacial deposits separating the Illinoian and the Kansan drift sheets. These interglacial beds, known as the Yarmouth, from their occurrence at the village of that name, comprise not only sandy beds in places but also old soils that contain wood and beds of peat or muck. The water from the Yarmouth is therefore likely to be ill smelling and available only for stock.

The depth to the Yarmouth ranges from 20 to 40 feet in the northeastern part of the county. Along the ridge of the terminal moraines of the Illinoian drift sheet the increased thickness of this drift increases this depth to 40 to 70 feet.

The deeper water beds in the drift are sands in the Kansan and Nebraskan tills, water-laid interglacial deposits (Aftonian) which separate them, and sand and gravels which overlie the bedrock. None of these horizons are altogether dependable. In Washington and Green Bay townships, for example, little or

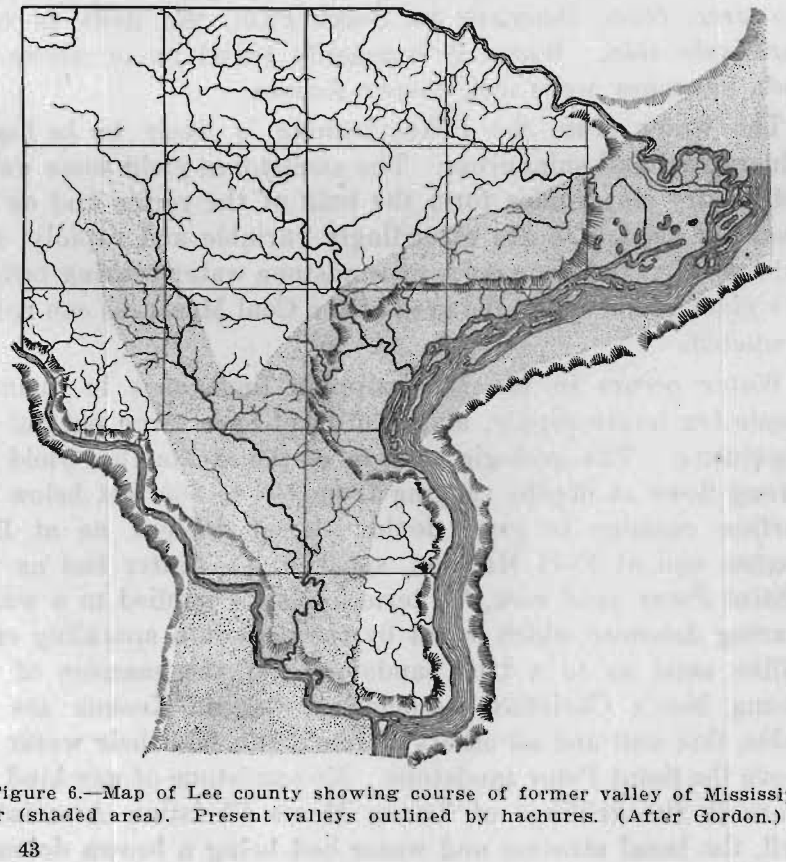


Figure 6.—Map of Lee county showing course of former valley of Mississippi river (shaded area). Present valleys outlined by hachures. (After Gordon.)

no water is found from the top of the blue till (unweathered Kansan and Nebraskan) to its base, although at Fort Madison it reaches a thickness of 260 feet. The quicksand below it, however, about 100 feet deep at Fort Madison, yields generously. On the thick drift of the Illinoian terminal moraine water is found within 70 feet of the surface. An ancient drift-filled channel of the Mississippi, whose extent is shown in figure 6, contains a thickness of 300 feet and more of Pleistocene deposits, including heavy sands and gravels. At Mount Clara and west and north of Summitville, wells in this old channel encounter 50 to 125 feet of sand containing more or less driftwood and in places overlain with an ancient soil. In one well dry reddish sand above was succeeded by gray sand underlain by water-bearing gravel. In nothern Lee county, in the area from Denmark to Saint Paul, the drift is comparatively thin. Water is commonly found on or above the rock, but many wells seek deeper sources.

The water from the Pennsylvanian is likely to be highly mineralized and sulphurous. The sandstones yield some water, but as dry clay shales form the bulk of the series and as the lenses of sandstone are exceedingly variable and rapidly thin out laterally, the occurrence of sandstone water-bearing beds at any given point within the area of the Coal Measures can not be predicted.

Water occurs in the Mississippian limestones in quantity ample for house supply, and is utilized by a large part of the population. The geologic horizon of the strata that yield the strong flows at depths ranging from 700 to 800 feet below the surface remains in some doubt. Local drillers, as at Burlington and at Fort Madison, speak of the water bed as the "Saint Peter sand rock," a term as easily applied to a water-bearing dolomite which is cut by the drill into sparkling crystalline sand as to a true sandstone. If the samples of the Young Men's Christian Association well at Keokuk are reliable, this well and all others of like depth find their water far above the Saint Peter sandstone. No sandstone of any kind appears in the drillings of Young Men's Christian Association well, the basal stratum and water bed being a brown dolomite belonging to the Silurian or to the Ordovician (Galena). According to several logs it is sandy, as the Silurian is known to be at Washington and Centerville. By the log of the Hubinger wells at Keokuk a shale referable to the Maquoketa and separated from the Saint Peter by the Galena and Platteville limestones is found beneath it. On the other hand, supporting the reference to the Galena is the facies of the brown dolomite itself. At Mount Pleasant, where alone in southeastern Iowa there is a complete record of samples to below the Saint Peter, dolomite is absent from the Silurian, whereas precisely such a brown dolomite constitutes the bulk of the Galena. At Fort Madison a similar brown dolomite, covered by the Maquoketa, forms the water bed. If the water bed is the Galena, the Maquoketa is absent and the shale of the Hubinger wells found below the water bed is difficult to account for.

In other counties of similar geologic structure the Montrose Chert (upper part of Burlington limestone) yields considerable water, but the main water bed in the Osage stage is the lower part of the Burlington limestone, especially the part near its base, where descending ground water finds its farther downward progress stopped by the impervious shale floor of the Kinderhook. The water occurs in irregularly spaced and quite unpredictable crevices and passages dissolved along bedding planes by percolating underground water. Hence, a well may be drilled even to the Kinderhook and fail to find an adequate supply because it has missed a channel, perhaps by only a few feet or yards. In this event, access to any near-by channels in the limestones may be gained by "shooting" the well with nitroglycerin a short distance above the top of the shale. If this experiment is a failure, it remains to try the chances at some other place. The shale of the Kinderhook stage underlies the entire area, but for several hundred feet below the top carries no water. The deeper water-bearing strata have been tested at a number of points, as at Fort Madison, Keokuk, Mount Clara, Mooar and Montrose (see pp. 677ff).

On the whole, the larger supply of the county is still drawn from the drift, and that, too, from its higher horizons, but as these have been found less and less adequate, an increasing number of wells of recent years have been drilled to the water beds of the country rock.

SPRINGS.

Good springs occur in almost every township of the county, those which issue from the Mississippian limestones along the escarpments fronting the larger streams being especially copious. Small springs of highly sulphated waters occur in areas underlain by Coal Measures rocks. Springs and oozes are also numerous in the drift. The springs on the east bank of Sugar creek, near its mouth, issue from sands and gravels interbedded between blue and yellow tills. Large springs are reported from near Belfast, Overton, West Point and Augusta.

CITY AND VILLAGE WATER SUPPLIES.

Denmark.—The following information in regard to Denmark (population, 350) is taken mainly from notes by Frank Leverett:

The R. B. Quinton well, located one and one-half miles northwest of Denmark, has a depth of 1,715 feet. The curb is 715 feet above sea level and the head 54 feet below curb. The supply is stated by driller to be "plenty." Drift continues to 80 feet. The first sandstone, at 900 feet, was rather fine and was called by driller the Saint Peter. A second sandstone was reached, but no change in head of water was noticed. Date of completion, 1890.

The Isaac Bell well, located in section 21, Cedar township, has a depth of 1,220 feet. The curb is 700 feet above sea level and the head 28 feet below curb. The date of completion, 1890.

Record of strata in Isaac Bell well at Denmark.

	Thickness.	Depth.
	Feet	Feet
Loess	7	7
Gumbo, gray	4	11
Yellow till	79	90
Cemented crust	2	92
Sand	18	110
Coal, thin bed of shale, limestone, etc.	706	816
Sandstone, white, water bearing; water overflowed for nearly a day and then dropped to about 28 feet below surface; a few feet thick; at		816
Limestone, mainly		1,200
Sandstone, yellow		
Sandstone, white, to		1,220

Fort Madison.—Fort Madison (population, 8,900) is supplied by a water system owned by the Fort Madison Water Company. Water is drawn from the Mississippi and pumped to a reservoir with a capacity of 6,000,000 gallons. The consumption amounts to 1,500,000 gallons a day. The domestic pressure is 60 pounds and the fire pressure from 120 to 130 pounds. There are 130 fire hydrants and 750 taps.

The geologic horizon of the chief water bed at Fort Madison is doubtful. (See Pl. XII, p. 618.) The rock is called by drillers of southeastern Iowa the "Saint Peter sand rock," but all samples submitted are a sparkling brown dolomite sand. Such cuttings have often been supposed to represent sandstone, even when, as at Fort Madison, quartz sand is entirely absent. The rock yields a bountiful supply of water, and probably on this account was designated the Saint Peter by drillers. In this part of the state, however, few wells reach that famous sandstone aquifer.

The water-bearing dolomite has the characteristics of the Galena. It is overlain by a shale which, when compared with the sections of neighboring deep wells, appears to represent the Maquoketa. For these reasons it is assumed to be the Galena. The large yield may be compared with that from the same bed at Davenport.

It is not impossible, however, that the dolomite is Silurian and that the so-called Maquoketa shale is really a basal shale of the Devonian. In support of this theory is the fact that Silurian rocks yield largely at Keokuk and supply the less deep wells at Burlington. The limestones above the so-called Maquoketa are nondolomitic, but at Burlington the Silurian contains little dolomite.

Artesian water at Fort Madison is exceptionally destructive to casings, so that the wells soon lose pressure and cease to flow because of leakage. The latest well drilled, however, registered 30 pounds in 1908, indicating that the local field is still far from depletion. Assuming that the water bed supplying the wells is the Galena, there remain untouched the large stores of water in the Saint Peter and underlying formations.

The S. Atlee well is 740 feet deep and 6 to 4½ inches in diameter; 6-inch casing to rock at about 110 feet and 4½ inch to water bed near bottom. The curb is 553 feet above sea level. The original head was 85 feet above curb and the present head is stated to be the same. The temperature of the water is 64° F. Date of completion, 1889. The water is so corrosive that the casing lasts only a few years. Thus, in 1901, the well had ceased to flow, but a pressure of 35 pounds was re-established by recasing. It was recased again in 1904. The water supplies a fountain at Mr. Atlee's residence, a public fountain in the city park, and a drinking fountain on one of the principal streets.

The S. and J. C. Atlee lumber mill well is on ground about 20 feet lower than the house well of Mr. S. Atlee and is 20 feet shallower. In other respects the wells are apparently similar.

The Ivanhoe Park well is 670 feet deep and 6 inches in diameter. The curb is approximately 563 feet above sea level and the head more than 12 feet above the curb. The well was completed in 1888 by Tweedy Brothers of Keokuk. In 1896 the well had stopped flowing. It was then recased with 4-inch pipe and the flow was restored. Still later it became clogged, but on treatment discharged considerable black muddy sediment and flowed freely as before. In 1905 it was plugged up.

The Brown Paper Company well No. 1 is 689 feet deep and 6 inches in diameter; casing, 175 feet. The curb is 528 feet above sea level. The original head was 20 feet above curb and the head in 1895 was the same; head in 1905, at curb. The original flow was 600 gallons a minute, the water coming from about 680 feet. Temperature, 62° F. Date of completion, 1888. Drillers, G. W. Adams & Company. In 1894 a 4-inch casing, inserted as the outer casing, had given way. Some time after 1905 the casing again gave way, the well caved in, and was abandoned.

The Brown Paper Company well No. 2, located 12 feet from well No. 1, has a depth of 689 feet and a diameter of 8 to 6 inches; cased to bedrock. The head in 1905 was 20 feet above curb. The water comes from depths of 100 and 679 feet. The well was completed in 1903 by Haggerty & Skog of Keokuk.

The Brown Paper Company well No. 3 has a depth of 681 feet, and a diameter of 8 inches to 153 feet, 7 inches to 165 feet, and 5 inches to bottom. The curb is 528 feet above sea level. The head is variously reported at 20 and at 80 feet above curb and flow variously reported at 200 and 600 gallons per minute. The water is from a depth of 607 feet; temperature, 65° F. The well was completed in 1907 by Haggerty & Skog of Keokuk.

To obviate the difficulty experienced in well No. 1 from the rusting of the casing and the caving of the alluvial sands through which the well passes, a method of casing hitherto unused in Iowa was employed. The well was cased with an 8-inch casing to bedrock at 153 feet. A 5-inch pipe was then inserted to the base of the 7-inch hole, 165 feet from the top, and there packed with rubber spring packing. To hold the inner pipe, central stud bolts, extending out so they barely slipped inside the outer casing, were placed on the inner pipe at intervals of 30 feet. Cement, composed of one-half pure Portland and one-half sharp sand, made thin enough to flow through an inch pipe was then poured into the space between the inner and outer casings, the pipe being gradually withdrawn as the filling progressed. To the depth, then, of 153 feet the well is lined with a shell of Portland cement 1½ inches thick, held between two iron casings.

Driller's log of Brown Paper Company well No. 3, Fort Madison.

	Thickness.	Depth.
	Feet	Feet
Sand	23	23
Clay, blue	39	62
Sand and coarse gravel	81	143
Flint rock, white	20	163
Limestone, gray	40	203
Flint, blue	12	215
Limestone, brown	47	362
Sand rock	6	368
Shale, black	86	454
Reddish rock, very hard	135	589
Flint, blue	10	599
Shale, blue	8	607
Sand rock, water bearing	74	681

The Atchison, Topeka & Santa Fe Railway hospital well had a depth of 764 feet, but was deepened in 1903 to 865 feet.

Diameter, 6 to 4 inches; 6-inch casing to 184 feet; 200 feet of 4-inch casing. The curb is approximately 553 feet above sea level. The head in 1905 was 6 feet above curb; head in 1908, a few inches above curb. The well was completed in 1892 by Tweedy Brothers of Keokuk. The pressure was originally sufficient to carry the water to the third floor of the hospital. In 1902 there was a sudden loss of head, and the deepening and recasing of the well in 1903 made but slight improvement. The well discharges through a fountain into an artificial lake on the grounds of the hospital.

Drillers' log of railway hospital well at Fort Madison.

	Thickness.	Depth.
	Feet	Feet
Sand	50	50
Clay, black	62	112
Sand	65	177
Limestone	7	184
Shale	5	189
Limestone	39	228
Shale	266	494
Limestone, white	167	661
Shale	8	669
Limestone	23	692
Sandstone (Saint Peter)	64	756

The Atchison, Topeka & Santa Fe Railway shops well is 700 feet deep and 8¼ to 6¼ inches in diameter; 8¼-inch casing to rock at 80 feet; 150 feet of 6¼-inch casing. The curb is 522 feet above sea level and the original head and head in 1908, 69 feet above curb. The flow is 300 gallons per minute, water coming from about 650 feet. The well was completed in 1906 at a cost of $1,500 by Haggerty & Skog. The water flows into a tank over the well, the top of the pipe being 38 feet above the ground; thence it is piped to the various buildings and the yard of the Santa Fe shops.

Record of strata in railway shops well at Fort Madison.

	Thickness.	Depth.
	Feet	Feet
Pleistocene in old channel of Mississippi river (148 feet thick; top, 522 feet above sea level):		
Clay, brown, sandy	18	18
Sand, gray, coarse, and gravel	6	24
Till, drab, predominantly clayey	42	66
Sand, coarse, yellow	36	102
Sand as above, and gravel	46	148
Carboniferous (Mississippian):		
Osage stage (62 feet thick, top, 374 feet above sea level)—		
Sandstone, blue, argillaceous; minute, angular, quartzose particles	8	156
Limestone, white, soft, nonmagnesian; some chips of blue shale	14	170
Limestone, drab, nonmagnesian; in fine sand	30	200
Limestone, light gray, fossiliferous, with blue, laminated shale	10	210
Kinderhook stage (268 feet thick; top, 312 feet above sea level)—		
Shale, blue, calcareous, plastic	268	478
Devonian and Silurian (142 feet thick; top, 44 feet above sea level):		
Limestone, drab, earthy; rapid effervescence, at	6	484
Limestone, soft, blue-gray, nonmagnesian, argillaceous; 3 samples	70	554
Limestone, blue and yellow-gray, soft, earthy luster; rapid effervescence; in thin flakes	26	580
Limestone, light brown-gray, soft, compact, fine-grained, in minute chips	20	600
Limestone, light yellow-gray, compact; fracture subconchoidal; lithographic; effervescence rapid; in flaky chips	20	620
Ordovician:		
Maquoketa shale (18 feet thick; top, 98 feet below sea level)—		
Shale, blue, somewhat calcareous	18	638
Galena dolomite (62 feet penetrated; top, 116 feet below sea level)—		
Dolomite, light buff in fine sand; 2 samples	62	700

The State Penitentiary (439 inmates) is supplied from a well 100 feet deep and 4 inches in diameter. One hundred thousand gallons are used daily for all purposes. The maximum supply which can be drawn is 400,000 gallons in 24 hours. The water does not corrode the boilers, but gives some trouble where hot and cold water come together in pipes.

The well was drilled in 1905 and is cased with 4-inch wrought-iron pipe to the water bed, quicksand at 98 feet. Water rises within 18 feet of the surface, which is 21 feet above the level of Mississippi river. The temperature of the water in August is 54° F. Water is lowered on continuous pumping to 21 feet below the surface.

Keokuk.—Keokuk (population, 14,008) is supplied with water drawn from Mississippi river and filtered, the system being owned by the Keokuk Waterworks Company. The daily consumption is 900,000 gallons. The distribution is direct; the fire pressure is 140 pounds, and the domestic pressure 60 pounds. There are 28 miles of mains, 142 fire hydrants, and 1,700 taps.

The well of the Kertz Brewery is 700 feet deep. Its curb is

600 feet above sea level. Temperature, 65° F. This was the first artesian well drilled in Keokuk and it is still flowing, but has not been used for about 25 years.

The J. C. Hubinger & Company well No. 1 is 2,230 feet deep and 10 inches in diameter. The curb is 637 feet above sea level. The original head was 30 feet above curb; the present head is unknown. The original discharge was 300 gallons a minute. Temperature, 65° F.

The J. C. Hubinger & Company wells Nos. 2, 3 and 4 are 2,000 feet deep and 12 to 10 inches in diameter. The curb is 637 feet above sea level. The original head was 30 feet above curb; present head, about at curb. The original discharge of the three wells combined is 1,700 gallons a minute.

These wells are situated on a bluff overlooking Mississippi river and discharge into an artificial lake which covers the top of at least two of the wells. From this lake the water was originally carried in a chute down the face of the bluff about 130 feet and was utilized in running two dynamos for furnishing electric light to the city. In 1894 the discharge of the four wells had fallen from the original amount of 2,000 gallons to 1,500 gallons a minute and in 1894 to 900 gallons. At an unknown date, but earlier than 1905, well No. 1 had ceased to flow and had been closed. The other three wells still supplied the artificial lake in 1905, the surface of the water being practically on a level with the top of the casing of one of the wells. In 1908 it was reported that the water level of the lake was gradually falling. The head of water necessary to supply the lake is somewhat more than 140 feet above high-water level of Mississippi river at Keokok, so that wells of this depth drilled on low ground would still develop enormous pressure.

Record of strata in Hubinger well (Pl. XII, p. 618).[a]

[a] Gordon, C. H.: Am. Geologist, vol. 4, 1889, p. 238; assignment of strata to formations by author.

	Thickness.	Depth.
	Feet	Feet
Pleistocene (28 feet thick; top, 637 feet above sea level):		
Bluff (loess)	25	25
Bowlder clay	3	28
Carboniferous (Mississippian):		
Saint Louis limestone and Osage stage (262 feet thick; top, 609 feet above sea level)—		
Limestone	5	33
Sandstone	5	38
Limestone	12	50
Shale	58	108
Limestone	62	170
Shale	10	180
Limestone	110	290
Kinderhook stage (270 feet thick; top, 347 feet above sea level)—		
Shale, calcareous	65	355
Limestone	10	365
Shale	195	560
Devonian and Silurian (177 feet thick; top, 77 feet above sea level):		
Limestone	65	625
Sandstone	20	645
Limestone, sandy	55	700
Sandstone	37	737
Ordovician:		
Maquoketa shale (63 feet thick; top, 100 feet below sea level)—		
Shale	63	800
Galena and Platteville limestones (140 feet thick; top, 163 feet below sea level)—		
Limestone; sandy below	140	940
Saint Peter sandstone (110 feet thick; top, 303 feet below sea level)—		
Sandstone	110	1,050
Prairie du Chien stage and underlying Cambrian ? (775 feet penetrated; top, 413 feet below sea level)—		
Limestone, alternating with sandstone	755	1,805

The Hubinger Tile Works well is 800 feet deep and 6 inches in diameter. The curb is 620 feet above sea level and the original head 47 feet above curb. Temperature, 50° F.

The Rand Park well is 1,800 feet deep and 5 inches in diameter. The curb is 637 feet above sea level. The temperature of the water is 60° F. This well seems to have been drilled earlier than the Hubinger wells and on their completion it nearly ceased to flow. It is now pumped by a Rider-Ericsson engine.

The Keokuk Pickle Company well is 710 feet deep and 4 inches in diameter; casing to 611 feet, packed with rubber. The original and present heads are 35 feet above curb, and the original discharge was 250 gallons a minute. Water comes from 530 feet, flowing from 635 feet. Temperature, 64° F. Date of completion, 1892.

The Keokuk Poultry Company well is 700 feet deep and 6 inches in diameter; casing 60 feet, with rubber packing at base; repaired in 1900, replacing casing which had rusted out. The curb is 541 feet above sea level; the original head was 4 feet above curb; the present head is reported to be 40 feet. The original flow was 250 gallons a minute; present flow, 1,000 gallons. Date of completion, 1895. Drillers, Tweedy Brothers, Montrose.

Record of strata in Keokuk Poultry Company's well.[a]

[a] Record made by Mr. George W. Crofts, Keokuk.

	Thickness.	Depth.
	Feet	Feet
Drift, promiscuous material	5	5
Limestone, magnesian	2	7
Dolomite (magnesian limestone) in which lime carbonate predominates	5	12
Dolomite, cherty	5	17
Dolomite, in which magnesium carbonate predominates	18	35
Limestone, slightly siliceous	15	50
Limestone, rather highly siliceous	18	68
Limestone, light colored; rather pure; slightly siliceous	30	98
Limestone, gray; rather highly siliceous	23	121
Limestone, gray; slightly mixed with shale	14	135
Dolomite; large amount of chert	11	146
Chert, mostly, and fossil limestone	19	165
Limestone and white sand (siliceous limestone)	17	182
Limestone with chert; slightly siliceous	5	187
Shale, almost pure	10	197
Shale, blue; highly siliceous	6	203
Shale, almost pure	5	208
Limestone, gray, quite pure	17	225
Dolomite, in which magnesium carbonate greatly predominates	46	271
Limestone, light colored, almost pure	19	290
Shale, blue, would weather into a tenacious clay	73	363
Shale, bituminous	39	402
Shale, gray; would weather into a tenacious clay	94	496
Limestone, light colored; almost pure; two samples	25	521
Limestone, gray; almost pure	60	581
Limestone, siliceous	47	628
Sandstone, gray, calcareous; yields traces of iron	73	701

The Young Men's Christian Association well has a depth of 769 feet and a diameter at top of 6 inches; casing to 56 feet. The curb is 580 feet above sea level and the head 50 feet above curb. The original discharge was 350 gallons a minute; discharge in 1905, 60 gallons a minute. The principal water bed is at 700 feet. Temperature, 64° F. The well was completed in 1902 at a cost of $1,600, by D. W. Haggerty of Keokuk. The water is used for drinking and to supply a swimming pool.

Driller's log of Young Men's Christian Association well at Keokuk.

	Thickness.	Depth.
	Feet	Feet
Clay	15	15
Soil, light	15	30
Soapstone, blue	20	50
Limestone, gray	10	60
Limestone, black	16	76
Limestone, white	6	82
Flint; solid bed	8	90
Flint and blue lime	26	116
Lime, white, and flint	46	162
Lime, gray, and flint	38	200
Lime, blue	15	215
Lime, black	5	220
Shale, blue	4	224
Sand, black	8	232
Lime, white	28	260
Sand, gray, and flint	42	302
Shale, blue	12	314
Shale, black	90	404
Shale, white or light brown	125	529
Limestone, black	16	545
Limestone, gray	100	645
Sand rock with water	30	675
Saint Peter	94	769

Record of strata in Young Men's Christian Association well at Keokuk.

	Thickness.	Depth.
	Feet	Feet
Clay, somewhat sandy, yellow, noncalcareous	15	15
Sand, yellow, clayey	5	20
Shale, light blue, calcareous, some broken pieces of milky quartz in concreted powder	10	30
Shale, blue; in fragments; flint, white, in angular chips; limestone, very soft, white	20	50
Limestone, white, soft, crystalline, in large flaky chips; cuttings of shale	10	60
Limestone, as above; 2 samples; encrinital	16	76
Chert; sand of light yellow limestone	4	80
Limestone, light yellow; moderately slow effervescence; soft, earthy, in large chips; much blue-gray flint	8	88
Limestone, soft, nonmagnesian, white and drab mottled; earthy to crystalline; encrinital; some flint	12	100
Chert, white; some crystalline quartz	16	116
Chert, white; light yellow limestone	6	122
Chert, bluish white; sand of light colored nonmagnesian limestone	10	132
Limestone, white, encrinital, cherty; 3 samples	18	150
Limestone, white, minutely granular, soft; composed of minute loosely cemented calcite crystals; some chert	12	162
Limestone, white, encrinital; much chert	14	176
Chert, blue, white; some white limestone	6	182
Chert, white, and siliceous limestone; 2 samples	23	205
Limestone, soft, white; earthy to crystalline	10	215
Limestone, drab, nonmagnesian, soft; encrinital	5	220
Shale, calcareous, blue, plastic	4	224
Sandstone, blue-drab, earthy, fossiliferous, slightly calcareous; composed of microscopic angular quartzose particles	8	232
Limestone, white, soft, nonmagnesian, earthy; residue siliceous; some darker limestone and shale	36	268
Sandstone, drab, argillaceous, calcareous, soft; in flaky chips, chiefly composed of microscopic angular particles of quartz	34	302
Shale, blue-gray, hard, siliceous, calcareous; in chips	12	314
Shale, brown, somewhat calcareous, bituminous	76	390
Shale, blue-gray, plastic, calcareous	30	420
Limestone and shale; small chips and sand of nonmagnesian limestones, some crystalline and yellow or drab, some dark and argillaceous, many fragments of blue-gray and olive-gray shale in large flaky chips; pyritiferous, fossiliferous; driller's log: "404-529, white or light brown shale"	112	532
Limestone, light blue-gray, nonmagnesian, compact, fine-grained; in thin small cuttings	108	640
Dolomite, brown, hard, crystalline; in coarse sand but containing no quartz grains; "sand rock" of driller's log; 2 samples	60	700

The S. C. Carter Company's well has a depth of 661 feet and a diameter of 6 inches; casing for 12 feet. Rock at 16 feet. The flow is 5 gallons a minute, and the pumping capacity 30 gallons a minute. Water was found at 130 feet, but the main horizon was in the basal sand rock. Temperature, 61° F. The water is unfit for use in boiler. Date of completion, 1903. Driller, D. W. Håggerty of Keokuk.

Driller's log of S. C. Carter Co.'s well at Keokuk.

	Thickness.	Depth.
	Feet	Feet
Clay and soil	16	16
Shell rock	6	22
Limestone, blue	20	42
Limestone, brown	10	52
Limestone, white	8	60
Lime, blue, and flint	26	86
Lime, white, and flint	46	132
Lime, gray, and flint	38	170
Lime, blue	20	190
Sand rock, dark, yielding 5 gallons of water a minute	5	195
Shale, blue	4	199
Sand rock, dark	8	207
Lime, white	42	249
Shale, blue and black	117	366
Shale, white	135	501
Lime, black	35	536
Lime, gray or light	112	648
Sand rock	13	661

The log of the Popel-Miller Brewing Company's well, three miles south of Keokuk, is given to assist in the elucidation of the difficult geologic section in southeastern Iowa. The information was secured by J. A. Udden. The curb is about 523 feet above sea level.

Log of Popel-Miller Company's well, Warsaw, Illinois.

	Thickness.	Depth.
	Feet	Feet
Soil and clay drift	40	40
Limestone, blue, and shale	15	55
Lime rock, blue	50	105
Lime and grit	25	130
Grit and fire clay	10	140
Limestone, gray	45	185
Soapstone, blue	30	215
Sandstone	19	234
Lithograph rock, light	46	280
Lithograph rock, dark	10	290
Limestone, bastard	6	296
Soapstone	69	365
Shale, brown	40	405
Shale	99	504
Limestone	126	630
Sandstone	182	812

Montrose.—At Montrose (population, 708) water is obtained from driven wells ranging in depth from 20 to 50 feet. At Bluff Park is a well 1,960 feet deep. The curb of the well is 680 feet above sea level and the water originally rose 9 feet above the curb; in 1896, the water stood 10 feet below the curb. The original discharge was 200 gallons a minute, the water coming from a depth of 800 feet.

Mooar.—At Mooar (population, 250) the E. I. du Pont de Nemours Powder Company well is 800 feet deep and 6 inches in diameter; casing to 600 feet. Water from 110 feet, heads 3 feet below curb; from 240 feet, 5 feet below curb; and from 800 feet, overflows. The discharge, original and present, is 165 gallons a minute; temperature, 67° F. Date of completion, 1901. The well is about five miles northwest of Keokuk and no doubt draws its copious supply from the same bed that yields so generously to the Keokuk wells of the same depth. It is said to deliver a good stream of water, which is used for watering stock on the farms through which it passes for four miles to Des Moines river.

Mount Clara.—The W. J. R. Beck well at Mount Clara is 939 feet deep and 6 inches in diameter. The curb is 679 feet above sea level. The original head was above curb; the present head is 12 feet below curb. Original discharge was 200 gallons a minute, capacity being limited to that of the pumps. The main water bed extends from 889 to 939 feet, the water being sufficient for farm purposes by pumping; other beds are from 250 to 343 feet, 660 to 793 feet, and at deeper levels. The well was completed in 1890.

Record of strata in well at Mount Clara (Pl. XII, p. 618).

(Based on drillers' log.)

	Thickness.	Depth.
	Feet	Feet
Pleistocene (305 feet thick; top, 679 feet above sea level):		
Clay	250	250
Sand	55	305
Carboniferous (Mississippian):		
Osage stage (38 feet thick; top, 374 feet above sea level)—		
Limestone, white	25	330
Shale, white	8	338
Limestone	5	343
Kinderhook stage (325 feet thick; top 336 feet above sea level)—	325	668
Devonian, Silurian, Ordovician (?):		
Limestone	115	783
Do.	10	793
Limestone, flinty	25	818
Limestone	40	858
Limestone, hard	5	863
Samples washed away	76	939

Minor supplies.—Information concerning water supplies in the smaller towns and villages in Lee county is presented in the following table:

Village supplies in Lee County.

Town	Nature of supply	Depth of wells		Depth to rock	Depth to water-bearing stratum	Head below curb	
		From	To			Shallow wells	Deep wells
		Feet	Feet	Feet	Feet	Feet	Feet
Belfast	Dug and drilled wells	16	275	30		6	45
Charleston	Wells and cisterns	20	200			15	
Cottonwood	Wells	25	225				
Croton	Wells and springs	14	20	12	20		
La Crew	Bored or drilled wells	15	500	95		6-20	30-90
Overton	Open wells	18	300	20	30	16	20
Primrose	Open and bored wells	20	50		18	13	20
Sawyer	Bored and drilled wells	14	200	100	50	4-20	50
Summitville	Open wells	20	60			8	20
Warren	Wells	18	400	70-100		12	60
West Point	Bored and drilled wells	20	350	90		12	20

WELL DATA

The following table gives data of typical wells in Lee county:

Typical wells in Lee County.

Owner	Location	Depth	Depth to rock	Depth to water bed	Source of supply	Head below curb	Remarks: (Logs given in feet)
		Feet	Feet	Feet		Feet	
T. 65 N., R. 5 W. (Jackson).							
L. E. McCrary	NE.¼ sec. 15	110					
—— Applebaum	NW.¼ sec. 10	225					
	SE.¼ NE.¼ sec. 33	116	16				Des Moines river bottoms.
	SE.¼ SE.¼ sec. 27	265	98				
Henry Rein	SW.¼ NE.¼ sec. 23.	265	165				
	SE.¼ NE.¼ sec. 16	136			Sand		Sand from 100 to 136.
Henry Reters	NW.¼ SE.¼ sec. 28.	250	100				
—— Hinman	NW.¼ SW.¼ sec. 27.	254	115				
	NE.¼ SE.¼ sec. 19	154			Sand		
	SW.¼ NW.¼ sec. 20.	130			do		
	SW.¼ NW.¼ sec. 27.	244	126				Hill.
	NE.¼ NE.¼ sec. 29	175			Sand		Valley.
—— Hollingsworth.	Sandusky	160	36				
—— Merritt	West Keokuk	54	53		Sandstone	14	Bluff, about 150 feet above Des Moines river.
Keokuk Cooperage Co.	Soap Creek, Keokuk.	420	10	250	Crevices in limestone.		Diameter, 5⅝ inches; soil, 10; limestone, 180; white hard rock (cuts drill, could drill but 3 feet in 10 hours), 34; limestone; sandstone, shale (Kinderhook), from 380 to 420.
Pechstein and Nagel.	Keokuk	215		200	Sandstone		
L. Nelson	do	114		95	do		
Baker Medicine Co.	do	300	20	260		60	Capacity, 8 gallons per hour (?) ; diameter, 6 inches; soil, 20; brown limestone; white limestone and shale; white limestone (at bottom), 20.
H. H. Trimble	1 mile northwest of city limits, Keokuk.	118	100				
James Jones	3 miles northwest of Keokuk.	140		45	Gravel	45	Blue clay; sand; coarse gravel.
H. H. Trimble	3 miles north of Keokuk.	272	90	50		50	Clay; sand; limestone; flint; sandstone.
Joseph Bloundies	5 miles northwest of Keokuk.	200			Gravel and sand.	80	Clay; sand and gravel.
County Farm	½ mile southeast of Summitville.	300			Sand and gravel.	100	Diameter, 6 inches; capacity, 20 gallons per minute; yellow clay; blue clay; sand and gravel.

Typical wells in Lee County—Continued

Owner	Location	Depth	Depth to rock	Depth to water bed	Source of supply	Head below curb	Remarks: (Logs given in feet)
		Feet	Feet	Feet		Feet	
County Farm	½ mile se. of Summitville.	212			Gravel		Yellow and blue clay to 125; dry reddish sand, 125-212; gray sand; gravel; water soft.
T. 66 N., R. 6 W. (Part of Des Moines).							
—— Lowry	SE. ¼ NW. ¼ sec. 22.	190					Sand and clay, 29; alternate strips of sand and blue till, 40; sand at 140; ended in sand.
T. 66 N., R. 5 W. (Montrose).							
Tweedy Brothers	Sec. 22	235	50	215	Limestone		Water comes in gradually in 20 feet of limestone at bottom of well.
William Fowler	NW.¼ SE.¼ sec. 6	112			Sand		Foot of bluff.
	NW. ¼ SE. ¼ sec. 17.	145			do		Upland.
	NE. ¼ SW. ¼ sec. 20.	265	200				Creek bottom.
	NW. ¼ SW. ¼ sec. 15.	240	120				About 50 feet above Mississippi river.
Thomas Joyce	12 miles north of Keokuk.	272			Sand and gravel.	172	Blue clay; sand and gravel.
T. 67 N., R. 4 W. (Madison).							
High School	Fort Madison	134		132	Sand and gravel.		Loam and sand, 24; blue till, 108; sand and gravel, 2.
Canning factory	do	181	95	77			Diameter, 4 inches; sand, 20; blue clay, 57; quicksand with water, 4; blue clay, 14; rock to bottom.
State penitentiary	do						Till, 10; sand, gravel, and blue till, 65; sand and gravel, 25.
—— Hoffmaster	Near penitentiary Fort Madison.	152	141				Soil and sand, 12; blue till, 123; gravel and sand, 6; limestone at bottom, 11.
Mrs. Heitz	Fort Madison	315			Gravel		Yellow drift, 27; blue till, continuous with the exception of one thin sand bed, 260 feet; gravel, 28; on bluff.
T. 68 N., R. 4 W. (Washington).							
John Cook	2 miles south of Denmark.	418	100				Drift, 100; limestone, 155; alternate limestone and shale, 10; shale (Kinderhook), 153.
T. 69 N., R. 4 W. (Denmark).							
James Conaro	Denmark	49					Loess, 9; brown till, 10; old soil, 5; yellow till, 25.

Typical wells in Lee County—Continued

Owner	Location	Depth	Depth to rock	Depth to water bed	Source of supply	Head below curb	Remarks: (Logs given in feet)
		Feet	Feet	Feet		Feet	
William Sloat	do	56			Sand		Loess, 6; yellow till (Illinoian), 20; gray mucky clay, 15; yellow till (Kansan). soft; dark blue till with beds of sand, bearing water, 5.
Mill	do	55	55		Gravel		Loam, 2; yellow clay, 38; dark blue hard till, 14; gravel, 1, to limestone.
S. Van Tuyl	Sec. 30	59	55				Loess, 7; Illinoian till, 28; mucky soil with wood, 2; yellow and blue till (Kansan), 18; limestone, 4.
Dr. Randall	South Augusta	438	80	90		60	Drift, 80; limestone and flint, 85; shale, (Kinderhook), 273.
Ed. Marsh	3 miles east, 1 mile south of Denmark.	230	94	124	Sandstone		Drift, 94; limestone, 30; sandstone, 9; limestone, 84; shale, 13; well a failure.
G. Adimeier	3 miles north of Denmark.	82	14		Limestone		Skunk river bottom near high-water level; dry sand and gravel, 14; limestone, 68.
D. Klophenstein	3 miles northwest of Denmark.	265	60		do		Drift, 60; limestone, 205.
T. 68 N., R. 5 W. (West Point).							
Axhandle factory	West Point	375	115	200 and 300	Limestone	65	Yellow clay, 40; blue till, 40; sand and gravel, 20; hard, dark blue till, 15; limestone, 260.
T. 69 N., R. 6 W. (Marion).							
Henry Schindstalk	2 miles east, ¾ mile north of Houghton.	105			Sand		Yellow clay, 45; light blue clay, 45; sand, 1½; dark blue till, 13½.
Garrett Sanders	½ mile east of Houghton.	95			Sand		Yellow clay, 94; sand bed with abundant
	Saint Paul	165	94		Limestone		Yellow clay, 65; dark-blue till, 29; limestone and flint, 71.
John Cook	1 mile east of Saint Paul.	85	35		do		Yellow clay, 33½; "hardpan" from cement, 1½; limestone, 50.
T. 69 N., R. 5 W. (Pleasant Ridge).							
Andrew Foggy	Sec. 16	131	119				Loess, 6; old soil, 4; yellow till, 20; sand affording weak vein of water, 6; blue till, 33; sand and peat underlain by fine gravelly sand, 50; limestone, 12.
S. Kennedy	3 miles west, 1 mile north of Denmark.	40			Old soil		Yellow clay, 37; old soil, wood and leaves, 1½; blue hard till, 1½; water in old soil, ill-smelling, used only by stock.

Typical wells in Lee County—Concluded

Owner	Location	Depth	Depth to rock	Depth to water bed	Source of supply	Head below curb	Remarks: (Logs given in feet)
T. 69 N., R. 7 W. (Cedar).							
	Near Hillsboro	318	104	260		265	Yellow clay, 45; soft light blue till, 27; dark hard till, 32; limestone, 154; soft white sandstone, water bearing, 41; limestone, 19. water, 1.
	Cottonwood	52½			do		Yellow clay, 40; light blue clay, 12; sand on dark blue clay, 1½.
Geo. Woolman	5 miles southwest of Cottonwood	72			do		Yellow clay, 36; light blue clay, 35½; sand on hard dark blue clay, ½.
Thaddeus Church	3 miles south of Laurel.	102	100	90		60	Yield, 2 gallons per minute; rock, limestone; diameter 5 inches.
T. 68 N., R. 6 W. (Franklin).							
Chas. Blocksuth	3 miles west of West Point.	100	32	70	Limestone	60	Yield, 2 gallons; water lowered 20 feet when pumped at that rate; yellow clay, 32; limestone, 68.
	2 miles east of Locheen.	110	50	80	do	30	Yield, 10 gallons per minute; yellow clay, 50; shale on fire clay, 20; limestone, 38.
Henry Tempsay	1½ miles north of Franklin.	120	40	98		60	Yield, 2 gallons per minute; water lowered 12 feet when pumped at that rate; yellow clay and sand, 40; limestone, 80.

LOUISA COUNTY

BY W. H. NORTON.

TOPOGRAPHY.

Louisa county includes on the east a continuous belt of lowland, the Mississippi flood plain, from one mile to five miles wide. A second lowland, traversed by Iowa river and for a short distance by the Cedar, crosses the county diagonally from its northwestern to its southeastern corner where it joins the Mississippi bottoms. The second lowland is more than six miles wide at Wapello and more than four miles wide at Columbus Junction; it comprises the present flood plains of the rivers and also a broad alluvial lowland, which stands 20 to 40 feet above the river flood plains and is built of sand and gravel covered with a thin mantle of loess.

The flood plain of the Iowa has been cut in the once continuous upland of the county and divides it into two areas, the eastern upland and the western. The surface of the former consists entirely of loess-capped Illinoian drift; that of the latter consists of both Illinoian and Kansan drift, each veneered with loess. The two drift sheets of the western upland are divided in part by a marked topographic feature—a flat-floored valley one to three miles wide and forty feet deep, cut in Kansan drift from Columbus Junction to the southwestern corner of the county, and standing at an average height of 120 feet above the higher terraces of the flood plain of Iowa river.

The gently undulating surface of the eastern upland is diversified by the shallow troughs of the minor streams and by a few long, low swells whose major axes run northwest and southeast. A singularly straight and unbroken escarpment, as much as 150 feet high, overlooks the Mississippi flood plain.

The western upland, about equal in height to the eastern, is ridged by two parallel broad swells which run north and south near Cairo and are believed to be the terminal moraines of the Illinoian ice sheet.

GEOLOGY.

The Pleistocene deposits of the county comprise the loess—a yellow silt which covers the uplands and the higher parts of the river plains—and beneath the loess, three massive sheets of stony clay. The Kansan, a thick, tough, blue stony clay, weathered deeply to yellow and reddish, rests on a bed of sand and gravel 2 to 10 feet thick, known as the Aftonian, which separates it from the dense dark bluish stony clay of the underlying Nebraskan drift. The uppermost stony clay—the Illinoian drift sheet—appears on the eastern upland, where it is separated from the underlying Kansan drift by sands and old soil beds of the Yarmouth interglacial stage. The upper surface of the Illinoian drift sheet may be either weathered to a reddish yellow or, where overlain by the decaying vegetable matter of ancient soils, may be bleached to a whitish clay. Unlike the drift sheets on which it rests, the loess is soft and very easily drilled, and is quite devoid of pebbles and larger stones. In passing from the loess to the weathered stony clays the color distinctly changes to a brighter yellow.

The Pleistocene deposits are underlain by rocks belonging to the Mississipian series of the Carboniferous, except over an area covering about 15 square miles in the northeastern corner of the county, where Devonian rocks may be expected beneath the superficial deposits. (See Pl. XIV, p. 660.)

The highest beds outcropping consist of a succession of limestones and cherts and alternating beds of shale and limestone—the Osage stage—the thickness of the whole reaching 50 feet. The limestones belong chiefly to the Burlington limestone and form persistent beds recognized by the driller by their clean white color. The lowest beds outcropping belong to the Kinderhook stage and comprise (1) limestones 15 feet thick which form a natural highway for ground water, (2) a less pervious, soft, bluish, fine-grained sandstone 16 feet thick, and (3) a blue-green basal shale or soapstone, practically impervious, the total thickness being as much as 180 feet.

In the southwestern part of the county wells have encountered sandstones belonging to small outliers of the Pennsylvanian series.

UNDERGROUND WATER.

SOURCE AND DISTRIBUTION.

On the lowlands bordering the Mississippi river water is obtained from driven wells ending in heavy alluvial sands and gravels. Sand points sunk 15 to 20 feet find abundant soft water in what is called the first sand, and if bored or jetted to about 50 feet, enter a second sand. So abundant is the water drawn from these sands that at Wapello five-inch driven wells about 20 feet deep are used as fire hydrants.

Wells on the uplands draw water from several beds. The eastern upland, south of Letts, is traversed by a number of low east-west loess ridges with sandy nuclei that furnish water to wells of very moderate depth which supply near-by farmsteads. Locally, on ill-drained areas on both uplands shallow wells find water in the basal layers of the loess, but as a rule these beds are wholly unreliable and inadequate. Interglacial gravels underlying the Illinoian, the Kansan, and the Nebraskan drifts constitute the main aquifers of both uplands, the most important being the Aftonian, which underlies the Kansan drift. On the eastern upland these interglacial gravels are the only source of water supply for deep wells. Here rock lies far below the surface and no wells are known to have reached it. A wide, buried valley underlies the eastern upland and both lowlands, the rock bed of which does not rise higher in places than about 400 feet above sea level. The deepest drift wells on this upland exceed 200 feet in depth and show a succession of as many as three tills or stony clays parted by old soil beds and water-bearing sands and gravels. At only one point on the eastern upland, at its southern end, near Toolsborough, has rock been reported, and this one was at a depth of about 212 feet below the surface or 443 feet above sea level.

On the western upland the same drift aquifers occur, but by no means continuously. In the southern tier of townships and in Marshall and Elm Grove and parts of Columbus townships the drift is relatively thin, rock outcropping in many ravines and being reached by the drill on the divides at 40 to 120 feet. Some wells which show much deeper drift are supposed to indicate ancient buried valleys, though none of these have been definitely traced. It is suggested by Leverett that the lower course of preglacial Washington river may probably cross the western tier of townships north of Columbus Junction. On the bluffs about Columbus Junction wells range in depth from 80 to 140 feet and find water in glacial gravels without reaching rock. Two or three miles west of town the drift is about 140 feet thick, and in the extreme northwest section of Columbus township wells from 135 to 150 feet deep end in water-bearing sands.

In the southern townships many wells find water in the limestones overlying the impervious floor of the shales of the Kinderhook stage. The limestones of the Osage stage are exceptionally pure and readily dissolved by seeping waters. Sinkholes on different outcrops, as north of Morning Sun, indicate well-defined underground waterways along joints and bedding planes. The perfection of the underground drainage and its confinement to definite channels renders the finding of such a channel by the drill somewhat uncertain. Several wells not finding water above the Kinderhook have gone deep into the dry shale of that stage, reaching total depths of 300 and 400 feet. Where a well enters the shale without finding water it would probably be less expensive in the end and give better results to abandon the drill hole and sink another well at a convenient location near that of the first well.

Where the limestones are lacking owing to erosion, and the shales form the bedrock, the case is far more difficult, and a careful search is necessary for the best location for a drift well. This may in some places be found where the converging of ravines brings an unusual amount of seepage.

The succession of strata and the probability of obtaining water from the deeper formations is indicated by the record of a prospect hole for gas on the land of W. W. Wagner, one-half mile west of Letts. (See Pl. XIV, p. 660.) The depth of this hole was 1,135 feet, and the elevation of its curb 698 feet above sea level. Water was noted at depths of 818 and 850 feet, heading 65 feet below curb; at a depth of 1,025 feet the water raised the tools in the well, heading 42 feet below curb. The well was completed in 1903.

Record of strata in deep boring at Letts.

	Depth in feet
Quaternary (285 feet thick: top, 698 feet above sea level):	
Old soil, brown, clayey, empyreumatic odor	90
Sand, white, coarse; grains mostly quartz; a few of limestone and green rock	100
Sand and gravel	140
Sand and clay, drab; in powder and compact lumps	175
Sand, buff; most grains less than 1 millimeter in diameter	206
Sand, orange, moderately coarse; gravel pebbles of chert, greenish quartzite, brownish quartzite, and shale	247
Gravel; pebbles large, of brownish limestone, greenish quartzite, and a black siliceous rock	250
Sand and coarse gravel	280
Carboniferous (Mississippian):	
Kinderhook stage (41 feet thick; top, 413 feet above sea level)—	
Shale, brown, rather hard, laminated, slightly calcareous, somewhat bituminous; in flaky chips	285-290
Shale, blue, calcareous	306
Shale, as above; drillings mostly of coarse yellow sand; small pebbles of Archean rocks	308-310
Sand, quartz, bright buff; finer than above	312
Shale, blue, calcareous, siliceous	315
Sand, coarse, buff; with chips of compact, hard, dark reddish brown limestone of slow effervescence, apparently pre-Cambrian	318
Shale, green, calcareous, rather hard; in chips	319
Same as at 318 feet	320-325
Devonian (137 feet thick; top, 372 feet above sea level):	
Limestone, blue-gray, porous; effervescence moderate; nests of calcite	326-332
Limestone, mottled gray, crystalline, earthy, rather soft; brisk effervescence; much sand	342
Limestone, gray, fossiliferous; rapid effervescence; soft; crystalline to earthy	357
Limestone, buff, highly fossiliferous; brisk effervescence	359-362
Limestone, light gray, highly fossiliferous, soft	373
Limestone, white and blue-gray; soft; crystalline to earthy	378
Limestone, blue-gray, hard; in flaky chips; nonmagnesian, dense, earthy luster; fine-grained; slightly siliceous	383
Limestone, light gray, fossiliferous; fragments of Brachiopods, Bryozoa, and a few crinoid stems	388
Limestone, light drab, nonmagnesian, hard, crystalline	425
Limestone, blue-gray, hard, argillaceous, pyritiferous	435-440
Sandstone, light yellow-gray; calciferous; grains fine, of crystalline quartz	446
Limestone, yellow-gray, cherty	443
Silurian (157 feet thick; top, 235 feet above sea level):	
Limestone, buff, magnesian; in fine sand	463
Limestone, magnesian or dolomite; brown, crystalline; in sand	468
Limestone; as above, very hard, siliceous	480
Dolomite, white, and light blue-gray; crystalline, vesicular; four samples	500-578
Ordovician:	
Maquoketa shale (198 feet thick; top, 78 feet above sea level)—	
Shale, drab; in rounded cuttings, with fine yellow quartz sand (from above)	620
Shale, olive-gray; in hard, siliceous, calcareous cuttings	657
Shale, olive-gray, hard, calcareous, siliceous; at 790 feet brown, green, and highly siliceous	720-810
Galena dolomite to Platteville limestone (317 feet thick; top, 120 feet below sea level)—	
Dolomite, buff, crystalline; in fine sand; four samples	818-855
Dolomite, light buff, cherty; rounded grains, moderately fine, of clear quartz, apparently native	875
Limestone, light buff, cherty	918-935
Limestone, magnesian, dark buff	950
Limestone, dark and light yellow-gray; rapid effervescence	960
Limestone, gray, earthy, and brown, crystalline; rapid effervescence; cherty	1,000
Limestone, light brown; rapid effervescence; crystalline	1,025
Shale, brown, highly bituminous	1,048
Shale, green, and limestone, gray, fossiliferous	1,063
Limestone, gray; nonmagnesian; hard; in sand	1,088

Limestone, buff, hard, with rounded grains of crystalline quartz in drillings	1,095
Sandstone: clear quartz, fine grains, many well rounded; but an unusual number ill-rounded or chipped; some gray limestone	1,105
Shale, green, hard, fissile, noncalcareous	1,125
Saint Peter sandstone (top, 437 feet below sea level)—	
Sandstone; grains well rounded, largest 0.75 millimeter in diameter; drillings red from superficial staining grains with ferric oxide	1,135

Analysis of rock from boring near Letts.[a]

	At 833 feet	At 545 feet
$CaCO_3$	51.93	52.42
$MgCO_3$	42.02	41.85
$CaSO_4$	------	.21
SiO_2	3.24	2.68
FeO	1.20	------
Fe_2O_3	------	.37
Al_2O_3	.69	2.34
H_2O	1.42	.16
	100.50	100.03

[a]Made in chemical laboratory of Cornell College, Mt. Vernon, Iowa.

SPRINGS.

As the chief water-bearing formations are cut by the major stream ways, springs are by no means uncommon in the county. The alluvial gravels underlying the abandoned flood plains of Cedar and Iowa rivers discharge large amounts of ground water into the rivers and their tributary creeks by means of springs and seepages. Strong springs emerge from glacial gravels along the bluffs bordering the river valleys. In the southern tier of townships the creeks are fed by springs discharging from the country rock, the leading horizon here being the top of the shale of the Kinderhook stage.

CITY AND VILLAGE SUPPLIES.

Columbus Junction.—At Columbus Junction (population 1,185) water for the city supply is obtained from a well 16 feet in diameter and 20 feet deep, sunk in the sand and gravel of the flood plain of Iowa river a short distance below its junction with the Cedar. Although distant about one-fourth mile from the channel, the water of floods overflows the area of the well. The supply is large and a distinct inflow is noticed from the up-valley side. The pumping does not affect two wells about 200 feet away. When the well was dug water could not be pumped out through a six-inch pipe as fast as it came in. The water is found in a bed of clean gravel and is pumped to a tank with a capacity of 57,000 gallons. The gravity pressure is 95 pounds and the fire pressure 140 pounds. There are two miles of mains, 15 fire hydrants, and 120 taps. The consumption is 18,000,000 gallons a year, the Chicago, Rock Island & Pacific Railway being a large consumer. The waterworks are owned by the town.

Wapello.—Water for domestic supply of Wapello (population, 1,326) is obtained from city wells from points driven 20 feet in the sands and gravels of the flood plain on which the town is built. So large is the supply that driven wells placed at intervals along the streets afford fire protection, being pumped by steam as from so many hydrants. Five drive points are attached by a five-inch pipe along the top.

The depth of the principal water-bearing formations below Wapello (588 feet above sea level) can not be closely predicted because of the deformation of the strata. The southward dip of the strata is uninterrupted to the north county line, but south of this line the dip is reversed and the deeper strata are so upwarped that at Burlington they stand higher than at any point south of Cedar county. The limit of the southward dip, the position of the bottom of the trough, at which the ascent toward Burlington begins, has not been determined. The dip of the Saint Peter sandstone from West Liberty to Letts is 11 feet per mile. If the dip continues at this rate as far south as Wapello the Saint Peter should lie about 615 feet below sea level, or 1,203 feet below the surface; but it is possible that the dip is reversed north of Wapello and that the Saint Peter may be found 100 to 200 feet nearer to the surface. The depth of the old drift and alluvium-filled valley in which the channel of Iowa river lies is unknown. Possibly it may cut deep into the shales of the Kinderhook stage, whose base here should be about 200 feet above sea level provided the southward dip continues this far south of Muscatine county. Between the base of the Kinderhook and the top of the next heavy shale, the Maquoketa, there are about 300 feet of Devonian and Silurian limestones in whose crevices water may be found should the drill fortunately strike them. Beneath the Maquoketa shale, the base of which lies here about 298 feet below sea level, are limestones with some shales (Galena to Platteville), which will probably yield some water. The yield will be increased by water from the Saint Peter sandstone, which in this area seems to be exceptionally thick and may afford a supply adequate for the town. If it should not it may be necessary to sink the well to formations lying 500 to 600 feet below the summit of the Saint Peter, or to a total depth of 1,800 or 2,000 feet, in order to materially augment the supply.

The waters will probably be strong in sulphates, though by no means beyond the limits of potability. The waters of the Saint Peter and the deeper formations should be better in quality than those of higher strata. The closed pressure of the well should be 20 to 30 pounds.

Minor supplies.—Information concerning minor village supplies in Louisa county is presented in the following table:

Minor village supplies, Louisa County.

Town	Nature of supply	Depth of wells			Depth to water bed	Depth to rock	Head below curb	
		From—	To—	Common			Shallow wells	Deep wells
		Feet	Feet	Feet	Feet	Feet	Feet	Feet
Cotter	Drilled wells	25	100	75-100	75			
Elrick	Driven and bored wells	8	52	9-15	50		— 8	
Fredonia	Driven wells	16	22	16-20	18		—16	
Grandview	Dug and bored wells	45	55	45	36		—33	
Morning Sun	Wells	18	26					
Newport	Drilled and open wells	18	120	80-120	20	40	—10	—40
Wyman	Bored wells	20	200	25	75	70-200	—10	

WELL DATA.

The following table gives data of typical wells in Louisa county:

Typical wells of Louisa County.

Owner	Location	Depth	Depth to rock	Source of supply	Remarks: (Logs in feet)
T. 73 N., R. 2 W. (Parts of Jefferson, Elliot and Wapello).		Feet	Feet		
W. Clark	Sec. 8	60		Sand	Slope of bluff of Iowa river. Yellow clay, 30; sand, 30.
John Hays	Sec. 11	210		do	Upland. Yellow clay, 40; blue clay, 80; sand.
J. Parson	Sec. 11	210		do	Upland. Yellow clay, 30; sand, 6; blue clay, 80; sand, 14; blue clay, 25; sand, 25; blue clay, 30; rock at bottom.
Dr. Parsons	Sec. 23	107		Sand	Second bottoms; loam, sand, and gravel, 31; blue clay, 60; wood and black loam, 10; sand with water, 6.
T. 73 N., R. 3 W. (Parts of Wapello and Morning Sun).					
Concord School	NE. ¼ sec. 18	300	8		Upland ravine. Drift, 8; limestone, 15; "soapstone," 148; dark shale, 30; "soapstone," 99.
H. Harris	NE. ¼ sec. 20	140	135	Sand	Upland. Drift, 135; shale, Kinderhook, 5.
W. D. Jamison	NW. ¼ sec. 22	300			Drift, 90; shale, 210.
Cyrus Hewitt	NW. ¼ sec. 29	76	73		Drift, 73; limestone, 3.
T. 73 N., R. 4 W. (Parts of Morning Sun and Marshall).					
	NE. ¼ NE. ¼ sec. 2	152		Sand	Yellow clay, 22; blue clay, 116; sand, 14.
D. C. Marshall	NW. ¼ sec. 9	126	95		Drift, 95; limestone, 31.
	SW. ¼ NE. ¼ sec. 12	110	104	Limestone	Yellow clay, pebbly, 25; dry yellow quicksand, 5; blue clay, 74; broken limestone, 6.
J. K. Brown	SE. ¼ SE. ¼ sec. 16	141	118	do	Drift, 118; limestone, 23.
James Chilson	SW. ¼ sec. 20	126	40		Drift, 40; rock, 86.
Town	Morning Sun	162	65	Limestone	Drift, 65; limestone, with some shale, 97.
T. 74 N., R. 2 W. (Parts of Jefferson and Port Louisa).					
P. B. Stetson	E. ½ sec. 31	70		Sand	Yellow clay, 8; blue clay, 42; sand, 5; blue clay, 10; sand, 5.
T. 74 N., R. 3 W. (Parts of Wapello, Port Louisa, Grand View and Jefferson).					
Joseph Schofield	Sec. 24	247		Sand	Yellow clay, 10; blue clay, 8; old soil, 3; blue clay with sand at 70 and old soil at 160; sand at bottom.

Typical wells of Louisa County—Continued

Owner	Location	Depth	Depth to rock	Source of supply	Remarks: (Logs in feet)
		Feet	Feet		
Average of several wells.		123		do	Low upland. Soil, 4; loess and yellow clay, 40; blue clay. 76; sand, 3.
T. 74 N., R. 4 W. (Parts of Wapello, Marshall and Columbus).					
	NW. ¼ NW. ¼ sec. 35	150		Sand	Yellow clay, 80; blue clay, 58; sand, 12. Water head, 110.
Lyman Bluff	SE. ¼ sec. 8	176		do	Upland; all drift.
Jesse Van Horn	SW. ¼ SW. ¼ sec. 27	180		do	All drift.
	Cairo	124		Gravel	Soil, 8; yellow clay, 25; blue clay, 83; gravel, 8.
H. Freeman	SW. ¼ sec. 29	180	150		Drift, 150; with sand at 120; shale, 30.
R. S. Cummings	SW. ¼ sec. 32	120	45	Limestone	Drift, 45; limestone, 75.
Jos. Bates	E. ½ sec. 33	209			Yellow clay, 70; blue clay, 68; sand, 1; blue clay, 25; sand and clay, 23; dark drift, 22.
T. 74 N., R. 5 W. (Elm Grove; part of Columbus).					
L. M. Sampson	SE. ¼ SE. ¼ sec. 20	60	53		Loess, 10; bowlder clay, 40; sand, 3; rock, 7.
Evan Paris	NE. ¼ sec. 28	115	95		Drift, 95; sandstone, 20.
T. 75 N., R. 3 W. (Part of Grand View).					
	NE. ¼ NW. ¼ sec. 3	265		Sand	Ridge. Yellow clay without pebbles, 28; red sand, 30; blue clay, 38; quicksand with water, 4; blue, pebbly clay, 158; sand with water, 7.
Joseph Wagner	Sec. 6	137		do	Yellow clay and sand, 15; blue clay, 60; coarse gravel, 2; sticky blue clay with wood below, 47; sand, 13.
W. W. Wagner	SW. ¼ sec. 6	89½		do	Loess, 2; yellow sand, 16; bowlder clay, 40; quicksand, 20; old soil and wood, 4 inches; dark blue stony clay, 2; sand with gas and water.
M. A. Gray	N. ½ sec. 22	178		do	Soil, 6; yellow clay, 50; quicksand, 40; white and blue clay mixed, 74; sand with gas and water.
L. S. Gresham	W. ½ SW. ¼ sec. 27	150		do	Loess, 12; peat, 3; blue clay, 65; quicksand, 1; blue clay, 3; quicksand, 1; blue clay, 55; sand, 10.
	NE. ¼ NE. ¼ sec. 9	45		do	Yellow clay, 20; blue clay clear of pebbles, 14; peat, 1; quicksand, 4; blue clay, 6. Head of water, 16.
	SE. ¼ sec. 14	84		do	High knoll. Loess, 22; yellow sand and pebbles, 42; blue clay, 1; gray sand with water, 19.
Roy Letts	SE. ¼ SE. ¼ sec. 19	100		do	Yellow clay, 20; blue clay, 60; sand with water and gas, 20.
	NE. ¼ SW. ¼ sec. 24	78		do	Foot of Mississippi bluff. Yellow clay, 4; blue clay, 28; white sand, 26; red clay, 1; red sand with water, 19.
B. W. Haff	SE. ¼ NW. ¼ sec. 35	153		do	Yellow clay, 34; yellow sand, 8; blue clay, 96; sand with water and gas, 15.

Typical wells of Louisa County—Concluded

Owner	Location	Depth	Depth to rock	Source of supply	Remarks: (Logs in feet)
		Feet	Feet		
John Sneider	Near Letts	300		do	Yellow clay, 18; quicksand, 8; blue clay, 70; yellow clay and gravel, 20; blue clay and gravel, 30 (?); sand to bottom.
T. 75 N., R. 4 W. (Concord; parts of Columbus and Oakland).					
C. Estle	SW. ¼ NW. ¼ sec. 8	150		Sand	Water and gas in basal sand.
M. A. Turkington	S. ½ sec. 10	215		do	Loess, 5; yellow till, 16; yellow sand, 3; blue "sand," 26; white sand, 80; dark bluish hard "sand," 45; light soft sand, 40.
D. Overholt	SE. ¼ sec. 29	164		do	Bottom. Alluvium, 8; blue pebbly clay, 72; sand, 2; blue clay, 14; sand, 68.
T. 75 N., R. 5 W. (Parts of Columbus and Union.)					
General section	Near Columbus Junction.			do	Yellow clay, pebbly, 15-20; blue pebbly hard clay, sand, 2-15 at from 125 to 150 feet from surface, with water; blue clay.
Ruben Stapp	Sec. 16	400	150		Drift, 150; shale, Kinderhook, 250.
	Cotter Station	136	133		Drift, 133; sandstone, 3.
J. W. Garner	Columbus City	170		Sand	Loess. 13: blue till. 157: sand.
D. W. Overholt	SE. ¼ sec. 25	166		Sand and gravel.	Loess and yellow till, 35; blue till, 125; sand and gravel, 6.
Martin Schaum	Sec. 27	68	65		Drift, 65; sandstone, 3.
T. 76 N., R. 5 W. (Parts of Oakland and Union)					
Edward Murdock	NW. ¼ sec. 6	152			All drift.
J. Lucky	NW. ¼ sec. 18	133			Do.

MAHASKA COUNTY

BY HOWARD E. SIMPSON.

TOPOGRAPHY.

Topographically Mahaska county comprises an upland plain, sloping from an elevation of about 900 feet in the northwest to about 800 feet in the southwest, across which Des Moines, Skunk and North Skunk rivers flow southeastward in approximately parallel courses and into which they have carved their valleys to depths ranging from 100 to 200 feet. Between these valleys broad, flat remnants of the former rolling drift plain remain. In places the streams are bordered by sharp rock terraces, but as a rule they have gradually sloping valley sides which rise from floors half a mile to three miles wide.

Only near the borders of the larger valleys, and particularly near the Des Moines valley, is the topography rough and broken. but the tributary streams extend into all parts of the area, draining it so completely that ponds and lakes exist only on the flood plains.

GEOLOGY.

The bottom lands of all the larger streams are covered with alluvial deposits consisting of alternating layers of sands and silts that afford an abundant supply of water to drive point wells, few of which exceed thirty feet in depth. The water is usually good, though in some wells it has a slight odor or taste due to organic matter deposited in the silts.

Except on the flood plains of the streams, the entire surface is covered, in places to a depth of ten feet, with the light yellow clay called loess; and everywhere beneath the loess is a deposit of unconsolidated clay and gravel in heterogeneous mixture. though showing in many places definite layers and lenses of stratified sand and gravel, the whole forming the glacial drift of Kansan age. Old soils, peat, and forest beds found locally beneath the Kansan drift, accompanied by well defined layers of sand and gravel and in places resting on till, give evidence of an older drift, the Nebraskan. The whole drift commonly rests on layers of coarse sand and gravel immediately overlying the bedrock. The drift yields moderate quantities of water to dug and bored wells from fifteen to thirty feet deep; small pockets of sands at depths ranging from 100 to 200 feet supply many wells, the largest supplies being obtained from the thick deposits of gravel at or near the base of the drift. These gravels can not be traced as a distinct bed over large areas, but wherever found they yield an unfailing supply of water which is generally hard but is entirely satisfactory for domestic, farm and stock use. In many places large open wells are dug down into the shale below in order to form a reservoir for water from gravels resting on the shale and thus maintain a large supply. Such wells should be carefully protected from pollution by surface drainage.

From southwestern Oskaloosa an old preglacial valley extends northwest and southeast, crossing Spring Creek township and entering Harrison township about the middle of its north line. The H. Crookham well (E. ½ SW. ¼ sec. 29, Spring Creek township) passes through forty feet of soil and till and then eighty feet of fine yellow sand, which changes to coarser sand and gravel below, without striking rock. Water began to come in at 45 feet and increased downward. Abundant good soft water stands 85 feet below the curb of the well. To the northwest this old valley passes underneath the farm of J. B. Cruzen (NE. ¼ sec. 34, Madison township), whose well passes through 196 feet of drift, chiefly sand, to bedrock. Across the road, T. J. Ferree's well reaches bedrock at 172 feet after passing through 90 feet of drift and 82 feet of sand. At a depth of 167 feet woody matter was found mixed with the sand.

The rock underlying the drift consists chiefly of Carboniferous shale, with a few beds of sandstone, limestone and coal belonging to the Des Moines stage of the Pennsylvanian series. (See Pl. XIII, p. 626.) In narrow strips along the three principal streams, however, the rocks have been eroded away, and the underlying hard Mississippian limestone (Saint Louis limestone) becomes the country rock. The Saint Louis limestone unconformably underlies the Pennsylvanian Coal Measures throughout the county and is readily distinguished in drilling by its hardness, its thin, soft interbedded marly layers, and its thickness, 20 to 40 feet being common.

The shales of the Des Moines stage are comparatively dry; only the coal and sandstone layers are water bearers, and the coal waters are always, and sandstone waters usually, impregnated with iron, sulphur, and other minerals. In a few places, however, thick local lenses of sandstone furnish excellent water. Chief among these is the brownish red sandstone underlying New Sharon and other portions of the northeastern part of the county, from which the New Sharon Electric Light Company well and several farm wells in the vicinity draw their supply. The granular white sandstone of the Saint Louis yields water of such quantity and quality as to give it locally the name of the "white water sand rock." Even above this thin sandy layers alternating with heavy limestone beds in many places yield a moderate quantity of water, which as a rule is hard but is rarely mineralized if the water from the Coal Measures is properly cased out. On the whole, the Saint Louis is the most satisfactory aquifer in the county.

Only a few wells passing the upper limestone have failed to find the sandstone, but three such have been reported. Two of these are in Scott township—that of Fred Oswandle (SW. 1/4 sec. 2), 250 feet deep, and that of Williams Brothers (section 13), 317 feet in depth. Another is at the Allandale stock farm (NE. 1/4 sec. 22, Union township). These wells probably all draw their supply from the limestone which immediately underlies the Saint Louis limestone; and two of the three, the Oswandle and Allandale wells, yield water that is very strongly mineralized. Unless the deep aquifers are to be sought, drilling below the sand-rock layer of the Saint Louis limestone is to be discouraged.

In general, the upper limestone of the Saint Louis is reached about 120 feet below the uplands, and the sandstone about 20 to 40 feet deeper. The depth, however, varies greatly. Between Skunk river and the Des Moines the "white water sand rock" is found at depths ranging from 150 to 250 feet, and the water is everywhere reported good. South of Des Moines river it lies somewhat deeper and in many wells is strongly mineralized. Between Skunk and North Skunk rivers, many wells draw from this bed at depths of 150 to 175 feet. The bed thus rises to the north and east, though perhaps not so often drawn upon in that direction, owing to the fact that the drift waters there are better and that there are numerous sandstone layers in the overlying Des Moines stage.

The quality of all these waters unfits them for use in boilers, for which purpose it is, as a rule, necessary to impound storm waters.

UNDERGROUND WATER.

SHALLOW FLOWING WELLS.

In Mahaska, as in the adjoining counties, the drill used in coal prospecting may strike a vein of water under such pressure as to cause it to flow from the top of the hole, though, as a rule, without much force. Most of these holes are located in low valleys or draws, and the aquifer is ordinarily a gravel layer low in the drift or a sandstone or coal seam of the Des Moines stage. Many of these holes are abandoned and forgotten, but when advantageously located with respect to pasture lands they are cased and retained for stock supplies.

Such are the two flowing wells on the farm of C. A. Coryell, one mile southeast of Olivet, Scott township. One well, 80 feet deep, yields about two-thirds gallon per minute of strong mineral water flowing from a coal vein; the other well, one-fourth mile south, is 52 feet deep, enters sand rock at 40 feet, and yields six gallons per minute of excellent water; the water rises eight feet above the surface. A third well, 167 feet deep, also in Scott township, on the farm of Con Ellis, 1½ miles southeast of Tracy, is drilled on a valley side, and reaches its aquifer in rock described as "dark limestone with flint" in the Des Moines stage; the water has a strong mineral taste.

On the farm of Ed De Long (NE. 1/4 sec. 26, Scott township) a 47-foot well yields a 2½-gallon flow with head 18 feet above the surface; the aquifer is a heavy bed of sand beneath the till. This is an excellent stock well.

SPRINGS.

Many springs issue on valley sides, most of them flowing from the Des Moines stage, but a few from drift deposits. The impervious stratum which collects the downward percolating waters and brings them to the surface, where it outcrops on the valley sides, is commonly a shale bed. Many of these waters are mineralized, and some of the springs yield sufficient water to form a permanent supply for stock. If such springs are advantageously located in pasture land they are piped into tanks.

The most interesting spring reported is on the farm of Edward Edris, 2½ miles northeast of Oskaloosa. This spring is said to have formed 10 or 12 years ago after the closing of a coal mine in the vicinity, where underground waters gave so much trouble that the mine was abandoned. It flows about 75 gallons per minute, and the water has a local reptuation for its medicinal properties.

CITY AND VILLAGE SUPPLIES.

New Sharon.—The public supply of New Sharon (population, 1,122) is secured from a well drilled to a sandstone horizon in the Des Moines stage. Three wells have been drilled, all reaching the same aquifer, but only one is now used. The well, which is nine inches in diameter and cased 80 feet to the sandstone bed, has yielded 35 gallons per minute.

The water is pumped by a gasoline engine into an elevated tank having a capacity of 43,000 gallons, and is distributed by gravity through two miles of mains under pressure of about 45 pounds. Twenty-one fire hydrants and 160 taps utilize about 15,000 gallons daily.

Shallow drift wells are common in the city, but an excellent water, like that used by the city, may be found in the same or similar lenses of reddish brown sandstone near the base of the Des Moines stage at depths ranging from 40 to 175 feet. The water is very pleasant to taste, neither hard nor soft nor mineral. Should the drill pass through shales of the Des Moines without finding this water, the sandstone horizon of the Saint Louis limestone might be found 40 to 50 feet below.

Oskaloosa.—The public supply of the city of Oskaloosa (population, 9,466) is owned by the Oskaloosa Water Company and is operated under a 20-year franchise, dating from November 12, 1899.

The supply is obtained from 15 driven wells, six inches in diameter and about 50 feet deep, put down to bedrock in the alluvium and sands underlying the flood plain on the north side of Skunk river, 3½ miles north of the city Each casing carries a seven-foot Cook strainer and is connected with piping in such a way that all siphon into an open well, 34 feet deep and several feet in diameter, in the bottom of which are 11 other drive points. The wells on the north and farthest from the river end in coarser sand and supply much more water than those nearer the river.

The pumping station is on the south river bank immediately opposite the wells. A cable from this plant runs a centrifugal pump in the main well, raising the water to a cistern from which it is forced into the mains by two steam pumps. A large open reservoir has been cut into the bank on the south side in such a way as to impound some storm waters, and into this water from the river is pumped directly in order that sedimentation may take place. In emergencies water can be pumped from this reservoir. An ordinary pressure of 110 pounds is maintained at the plant, and a fire pressure of 185 pounds is obtainable.

A large main leads from the pumping station to the filtration plant at the north edge of the city, where six Hyatt filters (two with a capacity of 250,000 gallons and four with a capacity of 150,000 gallons), and one Jewell filter (capacity 500,000 gallons) are utilized to filter the water through sand before it passes into the standpipe and mains of the city. It is estimated that about

1,300,000 gallons a day are filtered, and only in case of emergency is the water passed directly into the mains. The ordinary pressure on the mains from the filter plant is 35 pounds, but a pressure of 100 pounds or more may be had for fire engines.

A standpipe 20 feet in diameter and 130 feet high connected with the city mains stores the reserve and equalizes the pressure and flow. The greatest objection to the use of this water is that the mains are flooded with unfiltered water with every serious fire.

An artesian well, 2,517 feet in depth, was sunk by the city in the center of the city square about 1875, partly for the purpose of securing a flowing well for city supply and partly to prospect for coal and other mineral. No record has been preserved and little is now known of the well, save that at 800 feet a strong aquifer was reached which gave a head only 40 feet below the curb. This was tested by a steam pump throwing a four-inch stream for 48 hours without lowering, but the water was so strongly mineral as to be unfit for drinking. The well has never been utilized.

Some time previous to 1888 a well was sunk to a depth between 2,800 and 3,000 feet. Two or three companies were engaged in drilling this well, litigation ensued, and the well was abandoned after a cost to the city of $2,800 or $3,000—an extraordinarily small sum for so deep a well, if the depth is correctly reported.

Record of strata to 1,200 feet in city well at Oskaloosa (Pl. XIII, p. 626).

	Thickness.	Depth.
	Feet	Feet
Quaternary (50 feet thick; top, 843 feet above sea level):		
Soil, black	5	5
Clay, joint	33	38
Sand and gravel	3	44
Clay, blue	9	50
Carboniferous:		
Pennsylvanian series—		
Des Moines stage (111 feet thick; top, 793 feet above sea level)—		
Fire clay	13	63
Slate, black	34	97
Coal	10	107
Sulphur (pyrite)	½	107½
Limestone	19½	127
Soapstone	12	139
Sandstone, gray	9½	148½
Plumbago, traces (?)	½	149
Sandstone, gray	12	161
Mississippian series—		
Saint Louis limestone and Osage stage (449 feet thick; top, 682 feet above sea level)—		
Flint	4	165
Limestone	15	180
Sandstone	9	189
Plumbago, traces (?)	1	190
Sandstone	10	200
Slate, black	50	250
Slate, white	20	270
Porous rock	10	280
Limestone	330	610
Kinderhook stage (110 feet thick; top, 233 feet above sea level)—		
Slate	110	720
Devonian and Silurian (356 feet thick; top, 123 feet above sea level):		
Marble, hard	150	870
Limestone, very dark, hard; with streaks of sandrock and mica; also fossils at 935 feet	100	970
Sandstone, hard, gray	7	977
Gypsum and magnesia	5	982
Feldspar (calc-spar?)	15	997
Sandrock, porous	5	1,002
No samples	74	1,076
Ordovician:		
Maquoketa shale (124 feet penetrated; top, 233 feet below sea level)		
Slate, black	19	1,095
Slate, blue	20	1,115
Limestone	25	1,140
Slate, blue	60	1,200

Outside of the city water, which is generally used, the chief supply comes from shallow drift wells, which, with few exceptions, are unfit for domestic use, owing to unavoidable contamination from surface, cesspools, coal mines, and open wells.

WELL DATA.

The following table gives details of typical wells in Mahaska county:

Typical wells of Mahaska County.

Owner	Location	Depth	Depth to rock	Source of supply	Head below curb	Remarks: (Logs given in feet)
T. 75 N., R. 16 W. (Garfield and part of Spring Creek).		Feet	Feet		Feet	
Sewer Pipe Manufacturing Co.	Oskaloosa	217	------	Sandstone (Saint Louis)	35	6 inches diameter; good clear water. Clay, yellow and blue, and slate and soapstone shale, 100+; gravel, some water, 5; limestone, solid, 60+; sandstone, white, porous, water bearing, 50+; limestone, shaly, 2; test 1½ inch stream one-half day; curb 5 feet below Minneapolis & St. Louis R. R.
Oskaloosa Light & Power Co.	Oskaloosa	360	63	do	60	Unused account mineral. Yields 6 to 8 gallon flow under pump. Clear; pleasant taste.
Blake Wilson	SE. ¼ sec. 28	182	40	do	143	Test 154+ barrels per day.
J. W. Hunt	4½ miles southwest Oskaloosa.	179	25	Sandstone (Des Moines).	59	
J. K. Hook	SE. ¼ sec. 29	140	27	Sandstone (Saint Louis)	------	Slightly mineral. Soil and clay and sand, red, 27; slate, chiefly coal, fine clay, limestone, 46; sandstone, "white water rock," 37; soft, porous sand, 30.
T. 75 N., R. 15 W. (Parts of Spring Creek and Adams).						
H. Crookham	Sec. 29	120	------	Drift sand	85	Good water in 80-foot bed, and gravel.
Spring Creek Coal Co.	SE. ¼ sec. 11	220	38	Sandstone (Saint Louis)	100	4 inches diameter. Pumps 2½ gallons only.
A. H. Rogers	NW. ¼ sec. 3	124	30	Sandstone (Des Moines)	------	
T. 76 N., R. 15 W. (Parts of Adams and Spring Creek).						
Moses Barr	SE. ¼ sec. 19	170	134	do	------	Bowlder clay, 60; blue clay, soft, 65; wood fragments common, log 1 foot thick at bottom; sand and gravel, 9; white sandstone, 35+.

Typical wells of Mahaska County—Continued

Owner	Location	Depth	Depth to rock	Source of supply	Head below curb	Remarks: (Logs given in feet)
		Feet	Feet		Feet	
W. G. W. Anderson.	SW. ¼ sec. 19	600	85	Chiefly Saint Louis.	100	Clay, yellow, bowlder, 35; clay, blue, bowlder, 50; shale, 23; coal blossom, 1; clay shale, red, 18; limestone and white clay interbedded, 28; sandstone (fine water), 10; limestone, 331; clay shale, light colored, 4; shale, thin, 2; limestone and shale, 88. Head, 100 feet; lowered to 180 feet on heavy test; 4-inch casing to sandstone, which is fine, water bearing and yields 45 barrels in 24 hours. All water united below. Probably ends in Kinderhook.
J. N. Allgood	NE. ¼ sec. 35	135	80	Sandstone (Saint Louis)	------	
J. A. Reynolds	Sec. 15	128	128	Sand	73	
T. 76 N., R. 16 W. (Madison).						
Ben Cruzen	S. ½ sec. 28	216	50	Sandstone (Saint Louis)	------	Soft water; yields 3 gallons per minute
Bert Stiger	SW. ¼ sec. 5	225	150	Limestone or sandstone.	85	Good, hard water.
C. W. Bartlett	NW. ¼ sec. 9	120	------	Sand	------	
Mrs. R. H. Davis	----------	282	195	Sandstone (Saint Louis)	92	Good water. Strong test.
W. B. Stiger	NE. ¼ sec. 8	175	115	Saint Louis	90	Strong test without lowering.
C. L. Steddon	Lacey	198	85+	Sandstone (Saint Louis)	------	Strong well.
T. 74 N., R. 15 W. (Harrison).						
Pekay Mine	NW. ¼ sec. 20	225	35	Sandstone (Saint Louis)	------	4 gallons per minute on test.
Miss Lullis	6 miles southeast Oskaloosa.	225	26	Sandstone (Saint Louis)	------	
Owen Mobley	5 miles southeast Oskaloosa.	188	20	Limestone	135	
T. 74 N., R. 17 W. (Part of Jefferson).						
Walter Jones	5 miles east Bussey.	105	15	Sandstone (Des Moines)	------	
Catherine Strain	SE. ¼ sec. 14	100	24	Sandstone (Saint Louis)	------	Good hard water.
T. 75 N. R. 17 W. (Scott; part of Jefferson).						
J. H. Evans	W. ½ sec. 25	171	90	Sandstone (Saint Louis)	------	Soil and clay, 38; sand, 4; blue clay, 48; slate, 10; limestone, 40; sandstone, 31. Cased to limestone.
E. S. Godfrey, Jr	1½ miles southeast Tracey.	167	15	Limestone	------	Flows mineral.
J. J. Henry	SE. ¼ sec. 13	177	19	Sandstone (Saint Louis)	------	Soft water. Strong well. Clays, 19; slate, 51; coal, 3½; soapstone, etc., 64½; limestone, 16; sandstone, 23. Cased 142 feet to limestone.

Typical wells of Mahaska County—Continued

Owner	Location	Depth	Depth to rock	Source of supply	Head below curb	Remarks: (Logs given in feet)
		Feet	Feet		Feet	
W. R. Lacey	NE. ¼ sec. 1	198		Saint Louis	120	Strong well, test 348+ gallons per minute. Surface, 50; blue clay, 6; slate, gray, 8; sand, 2; sandstone, 1½; coal, ½; bowlder, (?), ⅔; coal, ⅝; fire clay, 1; gray slate, 9; fire clay, ¼; slate, black, 50; sandstone, 2; limestone, 27; sandstone, 39.
Wm. Velthuzen	NW. ¼ sec. 1	102		Drift sand		Plenty of good water.
Abe Bartlows	SW. ¼ sec. 23	145	21	Saint Louis		
T. 74 N., R. 14 W. (Cedar).						
R. Parsell	NW. ¼ sec. 5	207		Sandstone (Saint Louis)		Base of Des Moines at 97 feet.
T. 74 N., R. 16 W.						
D. W. Covey (Des Moines).	SE. ¼ sec. 3	215	40	Sandstone (Saint Louis)		Good soft water.
Fred Oswandle	SW. ¼ sec. 2	250	38	Osage (?)		Soil and clay, 38; slate, 22; limestone, 20; slate and soapstone, 110; hard blue limestone, 60; sand. Water very salty and mineral. Head varies with rainfall and pumps down rapidly. "White water rock" (sandstone in Saint Louis).
D. D. Davis	SW. ¼ sec. 29	118	32	Sandstone (Saint Louis)	95	Surface, 32; slate, 8; coal, 2; slate, 28; limestone, 25; sandstone, 23. Water stands at top of sandstone. Cased to limestone.
Williams Bros.	Sec. 18	317	42	Osage (?)		Surface, 42; slate, 58; coal, 5; slate, limestone, and shale alternating, 212. Gradual increase of water in limestone layers. Weak head, may be pumped out.
T. 77 N., R. 16 W. (Prairie).						
Town of New Sharon.		155	80	Sandstone (Des Moines)	80	Test, 35 gallons per minute. Soil, 2½; clay, yellow above, blue below, 77½; sandstone, red and white, 70; shale, black and gray, 5. Test 35 gallons per minute, 9-inch casing to sandstone.
Minneapolis & Saint Louis R. R. Co.	New Sharon	246	123	Drift sand		Water scanty.
New Sharon Electric Light Co.	New Sharon	150	110	Sandstone (Des Moines)	54	Soil and yellow clay, 25; sand, 50; shales, 22; coal, 2; fire clay, 3; shales, 8; light shales, 25; sandstone, white shales, 40. Pumped 23½ hours per day for six weeks during drought, yielding constantly 5 gallons per minute without lowering. Water from white sandstone at 135 feet. Used chiefly for boilers.

Typical wells of Mahaska County—Concluded

Owner	Location	Depth	Depth to rock	Source of supply	Head below curb	Remarks: (Logs given in feet)
O. G. Tice	Sec. 19	170		do		White sandstone with FeS_2 concretions.
W. Hite	Southwest of New Sharon.	256	100+	Drift sand		Plenty of water in sand over shale.
T. 77 N., R. 15 W. (Union).						
Allan Bros.	NE. ¼ sec. 22	222	75	Osage (?)	58	Clay and sand, 75; limestone, solid, 20; slate, 12; limestone, thin layers, 100; sandstone, 15. Tastes very strongly of mineral salts. Pouring in test; 7 barrels without rise of head.

VAN BUREN COUNTY

BY W. H. NORTON.

TOPOGRAPHY.

Van Buren county consists of a once continuous and well-nigh level plain modeled by glacial ice, now deeply and intricately carved by running water so that only remnants of the initial surface remain in the broad, flat and imperfectly drained prairies of the northern part of the county and in the narrow flat-topped divides which separate the more closely spaced streamways of the south.

Des Moines river has trenched the upland to a depth of 100 feet or more, crossing the county diagonally from northwest to southeast. Fox and Little Fox rivers hold courses parallel with that of the Des Moines and have widened their valleys to a greater degree proportionately than has the larger river.

GEOLOGY.

The lowest beds exposed in the county belong to the Osage stage of the Mississippian series. They include at the base the upper part of the Burlington limestone, consisting of chert with a few thin beds of limestone or of limy shale (the Montrose Chert of Iowa Survey reports). The chert, although too hard to be cut by the drill, is fortunately brittle and is readily broken by the impact of its blows. On this chert rests the lower division of the Keokuk limestone, a blue-gray, coarse, subcrystalline, and thinly bedded limestone. Next in ascending order comes a bed of shale 40 feet thick, distinguished by the geodes which it carries. Broken by the drill, these hollow balls furnish to the slush bucket crystals of quartz or calcite and chips of milky white translucent chalcedony. Hardly to be distinguished from the geode-bearing shales in well records is a bed of overlying blue shale and interbedded limestone layers.

The Osage stage is overlain by the Saint Louis limestone, which consists of sandy magnesian limestones, shattered limestones made up of sharp angular fragments, and compact granular limestones, the total thickness reaching nearly 90 feet. The larger part of the county is covered by the Pennsylvanian series, with its beds of shale, sandstone, and coal, underlying fine clay.

Not exposed within the county, but underlying the Montrose Chert is the lower part of the Burlington limestone, which forms a valuable water bed. This limestone rests on heavy shales (Kinderhook stage), which are entered by some of the deeper wells. Near Utica these shales lie about 400 feet below the surface of the upland.

Resting on bedrock or separated from it by stratified sands and gravels lies a massive, tough, blue, stony clay, known as the Nebraskan drift. Upon the Nebraskan lies another stony clay, known as the Kansan drift. These two drifts may be parted by sands and gravels belonging to the Aftonian. The Kansan in its unweathered portions is a blue hard till hardly to be told in drillings from the Nebraskan, except that the latter is usually of a darker tint. In its weathered portions the Kansan is a yellow or reddish stony clay, in places 40 to 50 feet thick. Both drift sheets contain lenses of sand and gravel laid down by water from the melting ice.

The entire county, with the exception of the present flood plains of the rivers, is covered with loess, a yellow or gray silt 2 to 10 feet thick.

UNDERGROUND WATER.

SOURCES.

Sheet water is found so near the surface in river sands and gravels on the flood plains of the larger streams that it is tapped by driven and open wells. Such wells form the chief domestic supply for the towns located on the Des Moines river. On Fox river the alluvial area is still more extensive in proportion to the size of the stream.

In places the base of the loess supplies house wells. The chief water beds of the drift, however, are sands interbedded between the successive sheets of stony clay, and one beneath the earliest till, parting it from bedrock. These beds supply very many wells on the more level uplands

Where drift sands fail to furnish sufficient water there is a good prospect of finding it at moderate depths in some of the Mississippian limestones or cherts. A number of wells to the Mississippian are reported, however, which range from 270 to something more than 400 feet in depth. The deepest of these are sunk a few feet into the Kinderhook, but so far as known no wells in the county have failed to find water above this heavy shale.

CITY AND VILLAGE SUPPLIES.

Bonaparte.—The waterworks at Bonaparte (population, 597), owned by the town, are used for fire protection and street sprinkling only. Water is pumped from Des Moines river to a standpipe. The pressure is from 65 to 125 pounds. There are two miles of mains and 28 fire hydrants.

Bonaparte (and also Keosauqua) is about 644 feet above sea level and the base of the Kinderhook should be reached at from 275 to 300 feet above sea level. The drill will then pass into 200 to 300 feet of Devonian and Silurian limestones, the latter possibly including a water-bearing sandstone near its base. The underlying dry Maquoketa shale rests on heavy limestones (Galena and Platteville), in which water should be obtained above the bituminous shales which here occur near the base of the Platteville limestone. The Saint Peter sandstone should be reached at about 500 feet below sea level or 1,100 feet below the surface. A well 1,300 feet in depth should obtain an adequate supply of water of fair quality with a head of perhaps 50 feet. As security against the possibility of the Saint Peter sandstone failing to yield enough for a city supply, the contract should provide for drilling, if necessary, to 1,600 feet.

Farmington.—Farmington (population, 1,165) draws its public supply from Des Moines river. Water is pumped raw into a reservoir with a capacity of 300,000 gallons and distributed thence under a pressure of 80 pounds. There are 16 fire hydrants and two miles of mains. The water is not used for domestic purposes, open or driven house wells being still utilized for this purpose. The waterworks are owned by the town.

A flowing well, 705 feet deep, is reported by C. A. White[1] at Farmington (elevation, 567 feet). Its depth would take it to the Silurian sandstone beds, and it was probably from these that the flow occurred. Large flows may be expected here from about 350 feet below sea level or about 920 feet below the surface and a well for city supply should be sunk to this depth, not only to get more water but also to improve its quality. This depth would take it to either the crystalline Galena dolomite (which in this area is often erroneously called by drillers the Saint Peter sandstone) or to the Saint Peter sandstone. The water should head at from 670 to 700 feet above sea level, and should be entirely potable, although its mineral content will not be low.

Keosauqua.—Keosauqua (population, 1,009) obtains its public water supply from Des Moines river. A standpipe gives gravity pressure of 55 pounds and the pumps can increase the pressure to 200 pounds direct. There are 17 double hydrants and 1¾ miles of mains.

[1]White, C. A., Rept. Iowa Geol. Survey, vol. 2, 1870, pp. 272, 355.

Minor supplies.—Supplies of minor villages are summarized below:

Town and village supplies of Van Buren County.

Town	Nature of supply	Depth	Depth to rock	Depth to water bed	Head below curb	
					Shallow wells	Deep wells
		Feet	Feet	Feet	Feet	Feet
Birmingham	Wells	20-65	150-200	60		25
Cantril	Wells and cisterns	20-60		30		
Douds Leando	Driven, bored and open wells	15-20	20	20	12	
Kilbourne	Cisterns, open, and drilled wells	20-112	40	112	15	6
Milton	Open wells	15-30			15	
Mount Sterling	Cisterns and bored wells	15-60			8	
Mount Zion	Wells and cisterns	70-100	100		40	60
Stockport	Wells	10-40	45	40		

WELL DATA.

The following table gives data of typical wells in Van Buren county:

Typical wells in Van Buren County.

Owner	Location	Depth	Diameter	Depth to rock	Depth to water bed	Source of supply	Head below curb	Remarks: (Logs given in feet)
T. 67 N., R. 10 W. (Part of Des Moines).		Feet	In.	Feet	Feet		Feet	
William Teter	Sec. 8	83	12		65	Gravel and sand.	35	Yields 50 barrels a day.
W. C. Fritz	5 miles southeast of Cantril.	82	4		62	Sand	40	Yields 20 barrels a day; water iron bearing.
T. 67 N., R. 11 W. (Part of Jackson)								
A. U. Benson	NW. ¼ sec. 12	290	4	280(?)	290	Sandstone	40	Yields 2 gallons a minute; water sulphur bearing.
T. 68 N., R. 10 W. (Part of Des Moines).								
Edwin De Ford	Sec. 27	350	4	200	270	Limestone	80	Yields 5 gallons per minute.
J. M. Silver	NW. ¼ sec. 29	290	5	240	250	do	80	Yields 2 gallons per minute.

Typical wells in Van Buren County—Continued

Owner	Location	Depth	Diameter	Depth to rock	Depth to water bed	Source of supply	Head below curb	Remarks: (Logs given in feet)
		Feet	In.	Feet	Feet		Feet	
—— Manning	NW. ¼ sec. 31	151			110	Gravel and sand.		Yellow clay, 50; blue till, 60; water-bearing gravel and sand 41.
T. 69 N., R. 10 W. (Part of Van Buren).								
L. R. Plowman	Kilbourne	112	6	(?)			4	Hill slope; water salty, flowing when first drilled.
Siegel	SE. ¼ sec. 28	153	6	63	150	Limestone	60	Upland. Yellow clay, reddish clay, light blue clay, dark blue clay, all without sand, 63; limestone, 87; shale, 3.
	NW. ¼ sec. 13	213		60		do		A little caving yellow sand under yellow clay, with a little water. Rock hard limestone with some flint.
—— Britt	SE. ¼ sec. 32	409		90		do	60	Drift clays, 80; black sand with foul water, 10; shale, black, 30; limestone and shale, 100; limestone, shale at bottom. Water pumps down 6 to 200 feet.
—— Drummond	Pittsburg	110		16		do	15	Des Moines river bottoms. Alluvium, 16; shale, 10; limestone, shale at bottom.
T. 70 N., R. 10 W. (Lick Creek).								
	SE. ¼ NW. ¼ sec. 26.	194		110		Limestone		Creek bottom. Drift, 110; limestone, 84.
T. 70 N., R. 11 W. (Village).								
S. E. McGrew	SW. ¼ sec. 21	405	5	40			25	Water lowers under pumping to 47 below curb.
James Elerick	Sec. 20	400	4	100	375	Siliceous rock.	75	Upland. Yields 5 gallons per minute. Mostly limestone, except 4 feet of water-bearing stone at 250, and siliceous rock ("quartz rock") near bottom.
T. 68 N., R. 11 W. (Part of Jackson).								
—— Holland	SW. ¼ sec. 8	217½			205½	Gravel	52	Yellow clay, 23; dark blue clay with some sand 65 feet from top, 181; "rock," rather soft, 1½; water-bearing clay and sand with some gravel, 12.

Typical wells in Van Buren County—Concluded

Owner	Location	Depth	Diameter	Depth to rock	Depth to water bed	Source of supply	Head below curb	Remarks: (Logs given in feet)
T. 69 N., R. 8 W. (Harrisburg).		Feet	In.	Feet	Feet		Feet	
—— Cresswell	SW. ¼ sec. 11	132		92		Limestone		Yellow clay, 92; limestone, yellowish to white, 6; limestone, white, in thin strata water bearing, 34.
Enderby	SE. ¼ sec. 12	121		120				Yellow clay, 50; blue clay with gravel 90 feet below curb, 70; limestone, 1.
C. Davis	Sec. 8	318		85				Yellow clay with some sand, 35; blue joint clay, 5; yellow clay with layers of sand and some water, 16; hard blue till, 29; Coal Measure shales 17; white limestone, 15; blue limestone with some pyrite, 70; shale, 58; limestone, cherty and sandy, 3; limestone, gray, pink, and black, 38; rock, hard, gray, cuts the drill, 32.
T. 69 N., R. 9 W. (Washington, pts of Henry and Van Buren).								
C. Miller	1½ miles northeast of Keosauqua.	162		42				Gray clay, 8; sand, 32; gravel with water, 2; coal, 3; white limestone, 8; lime and sand, 8; gray limestone, 30; reddish sandstone, 3; gray sandstone, 12; blue shale, 56.
H. B. Edmundson	SE. ¼ sec. 26	224		111				Yellow clay, no sand, 90; blue clay into 3 inches of sand at base, 21; blue shale, 55; ocher, 3; brown limestone, 10; shales alternating with limestone, 41; rock, very hard, dark, could not penetrate it (most all chert ?), 4.
T. 70 N., R. 8 W. (Cedar).								
George Watson	1½ miles north of McVeigh.	50				Sand		Water from white sand beneath light blue clay.
William Brooks	Utica	400					65	Yellow clay, 56; light blue clay, 23; dark blue clay, 29; limestone, 257; alternate shale and limestone, 25; shale (Kinderhook), 10.

WAPELLO COUNTY

BY HOWARD E. SIMPSON AND W. H. NORTON.

TOPOGRAPHY.

Wapello county lies about midway between the center and the southeast corner of the state. Owing to the deep dissection of the Kansan till plain by the tributaries of Des Moines river the surface is generally rough and irregular, the only notable exception being in the northeast quarter, where the upland plain is but slightly rolling. This area is drained by Cedar creek and its tributaries into Skunk river. These master streams conform to the general southeasterly trend of the more important streams in the eastern part of the state. The Des Moines enters at Eddyville, in the northwest corner of the county, and leaves just below Eldon, in the southeast corner, flowing the entire distance through a broad, deep valley of preglacial origin, on the floor of which it has developed a flood plain a mile or two in width. The drainage is complete. The relief, though broken, varies only from about 625 feet in the Des Moines valley at its point of exit from the county to about 900 feet near the southwest corner.

GEOLOGY.

Save where removed by stream erosion, the surface of the entire county is covered with a fine light gray clay, in few places more than a few feet thick, which is easily identifiable with the southern loess. On the floors of the deeper stream valleys this loess is replaced by darker alluvial silts. These are especially prominent on the bottoms of the Des Moines valley, where they cover not only the present flood plain, known as the "bottom," but also form several terraces, the most conspicuous of which is known as the "second bottom."

Underneath the loess and resting unconformably on the country rock is a thicker layer of Kansan drift, composed of mixed clay, sand and gravel.

The country rock consists chiefly of Carboniferous shale, including some beds of sandstone and coal, and belongs to the Des Moines stage of the Pennsylvanian series. (See Pl. X, p. 448.) In the deeper valleys in the northeast corner of the county, and in the Des Moines valley for more than half the distance across the county, the streams have cut through the Pennsylvanian shales and sandstones to the Saint Louis limestone of the Mississippian series. Below the upper limestones of the Saint Louis a soft sandstone, belonging to the same division and popularly known in this region as the "white water sand rock," occurs in a few places. All the strata have a very slight southern dip, and in working for coal gentle folds and a few small faults have been noted.

UNDERGROUND WATER.

SOURCE.

Water in Wapello county is obtained from the alluvium, the drift, the Des Moines stage, the Saint Louis limestone, and from deeper rock. Each is an important source of water in some localities, though the first three vary greatly in both quantity and quality. The only distinct water province is that formed by alluvial deposits of the Des Moines valley and its chief tributaries.

In the belt of alluvium half a mile to two miles wide lying along the Des Moines river valley floor and in very much narrower strips in the lower ends of the tributary valleys bands or belts occur, in which water may be found in sandy or gravelly layers, usually within a few feet of the surface. Such water is commonly obtained by means of drive points, though dug and bored wells are numerous.

The most common source of water in the county is the drift. Rarely are any wells now found which secure a supply of water from the loess, though in earlier years the sand near the base of the deeper portions of loess yielded a supply sufficient for the scanty needs of the pioneer. The drift wells are generally dug or bored to 20 to 30 feet, though some reach 120 to 130 feet before striking abundant water. The shallower wells find a meager supply in sand pockets and small veins in the bowlder clay. The most prolific source is, however, in a heavy layer of sand and gravel at or near the base of the drift. This layer, when found directly overlying the shale, is in some places cemented into a ferruginous conglomerate and is so similar to the Aftonian gravel as to suggest an older drift sheet.

The drift waters, when uncontaminated, are of good quality and, being comparatively easy of access and comparatively free from deleterious mineral matter, are generally used for domestic purposes. Most of them contain carbonate of lime, and occasionally a ferruginous precipitate forms in them when they are exposed to the air, but neither of these is particularly baneful.

In villages and in the vicinity of the coal mines these shallow waters are subject to pollution and should be used with caution. The quantity supplied from the gravel bed at the base of the drift is in some places sufficient for all demands of even large stock farms, but generally the drift wells are insufficient except for household use or for small farm supplies. Large open wells must be dug to increase inflow, and to form suitable storage reservoirs, or the drill must be resorted to and a rock well be tried.

The Des Moines stage (or Lower Coal Measures, as it is popularly called) is composed chiefly of shales with a few beds of sandstone and coal. The shales are of no value as water bearers, since they are very impermeable and therefore comparatively dry. Water is commonly found in the coal beds, but it is not potable, owing to the abundance of iron and sulphur compounds it carries in solution, this being characteristic of most of the waters of this stage. Some sandstone lenses are so free from mineral as to afford satisfactory supplies, but these are local and uncertain.

Many of the best farm wells of the northern and western portions of the county penetrate the Coal Measures and enter the Saint Louis limestone, the upper part of which consists of a compact, even-bedded white limestone 20 to 30 feet thick, with cherty and marly layers. In some wells a good supply of hard water is found in the joints, and in the underlying calcareous sandstone of the Saint Louis, known as the "white water sand rock," a supply of good hard water is obtained in quantities sufficient for all wells for stock. This water is rarely mineralized, and it will probably prove to be the most satisfactory source in the county. It is not much used except in the northwest corner on account of the depth at which it lies and the expense of drilling to it.

Whatever doubt may exist as to the proper correlation of the deeper sandstones there is fortunately no doubt as to the abundant store of water in the upper of the two. It supplies the wells of the Ottumuwa Iron Works and the first well drilled by the Morrell Company, whose initial flow is reported at 800 gallons per minute with a 5⅝-inch bore through the water bed. The Young Men's Christian Association well did not reach this horizon if its depth is correctly reported. In the Morrell well No. 4 a small flow was obtained from 975 to 1,190 feet; when the well pierced the lower strata of this aquifer from 1,190 to 1,240 (1,260?) a flow of 1,100 gallons was tested.

DISTRIBUTION.

At Larson (formerly Marysville) bored wells draw their supply from the sand and gravel layers of the drift at depths ranging from 20 to 40 feet, though at one point a mile south of the village a drift well 130 feet deep is reported.

A typical deep drilled well is reported by J. P. Hawthorne, two miles southeast of Larson. This well penetrates about 100 feet of drift and at 200 feet found a strong water-bearing sandstone. The water tastes of sulphur, but is a good stock water, yielding strongly to windmill with only slight lowering below the 30-foot level. It probably draws from a sandstone lens in the Des Moines stage.

One of the deepest stock wells of the county is on the farm of Norman Reese, four miles south and two miles east of Larson.

The record as reported by A. G. Leonard is given to show the relations of the drift, the Des Moines stage and the Saint Louis limestone.

Record of well of Norman Reese.

	Thickness.	Depth.
	Feet	Feet
Drift clay	60	60
Sand	3	63
"Soapstone"	15	78
Shale, gray	30	108
"Soapstone"	20	128
Shale, black, carbonaceous	7	135
Coal	3½	138½
Shale, blue	15	153½
"Soapstone"	10 to 15	167
Shale	8	175
"Soapstone"	10 to 14	188
Shale, black	100	288
Limestone (Saint Louis) alternating with thin, blue layers of "sandstone"	182	470

The record shows the characteristic sand horizon at the base of a 60-foot layer of drift. No sandstone lenses are reported in the Des Moines stage (Coal Measures), of which 222 feet were penetrated; the Mississippian was entered to a depth of 182 feet.

Highland wells about Dahlonega are chiefly bored and dug in the drift from 20 to 40 feet. The well of George D. Robertson (section 19) is typical. It is 40 feet deep and four feet in diameter and does not reach bedrock. The water enters from sand at 18 feet and stands ordinarily about 10 feet below the surface, but in dry weather may be pumped out by the windmill. The best drift aquifer evidently lies very deep here, for in several places in the northeastern part of the township the heavy sand layer at the base of the drift is reached only at 120 feet.

On the farm of F. J. Remir, two miles northeast of Dahlonega, several wells indicate two quite persistent water beds. The composite section follows:

Record of wells on farm of F. J. Remir, near Dahlonega.

	Thickness.	Depth.
	Feet	Feet
Soil	2- 3	2- 3
Clay, yellow, and loess with light colored sand	10-12	12-15
Clay, black, with gravel; drift	10-20	22-35
Sand and gravel		

Temporary hillside springs not uncommonly issue from the sand at the base of the loess.

A few wells are drilled into rock. Among these the most noted is that at the County Farm in the SE. 1/4 sec. 32, Highland township (T. 73 N., R. 13 W.), 462 feet in depth, which reached limestone of the Saint Louis at 200 feet and its water-bearing sandstone at about 230 feet. The head is very low, standing about 200 feet below the surface and requiring a gasoline engine and force pump.

The J. Haines farm well, a mile southwest of the village of Kirkville, draws its supply from the Saint Louis at a depth of 177 feet. A strong flow of water was procured in sandstone of the Des Moines stage at a depth of 110 feet, though caving prevented its utilization. The average well about Kirkville is 20 to 40 feet in drift, though wells are drilled deeper on stock farms.

Shallow drift wells are common in the vicinity of Eddyville and many in the valley utilize the sand and gravel underneath the alluvium. Good rock wells are, however, more common than in any other part of the county, owing to the proximity to the surface of the sandstone of the Saint Louis, the best water bed of this region. The limestone of the Saint Louis is quarried in the bluffs a mile south of Eddyville and the sandstone is exposed immediately underneath.

Among these rock wells may be mentioned that of A. J. Gardiner on the upland (SW. 1/4 sec. 19, T. 73 N., R. 15 W.), 220 feet in depth, which enters the rock at 55 feet and the sandstone at 214. The well of G. F. Glass, three miles southeast of Eddyville on the river bottom, enters rock at 25 feet and the sand rock at 50 feet, the total depth being 75 feet. The C. H. Leander well, three miles north of Dudley, 185 feet deep, reached Coal Measures at 24 feet and the sandstone of the Saint Louis at 157, after passing but seven feet of limestone. The well of George Stevens, two miles northwest of Dudley, is 205 feet in depth; that of James Harris, 1½ miles southwest of Kirkville, is 177 feet; and that of Joe Johnson, 2½ miles south of Eddyville on the river bluff, is but 120 feet.

One of the most interesting wells in this vicinity is that of Stephen Lewis, just south of Eddyville (section 7, Columbia township). It is a characteristic blowing well. As stormy weather approaches the water becomes roily and the well rumbles and roars with a rush of air which jars and rattles the pump. Although the water is derived from the sandstone of the Saint Louis at a depth of 80 feet, the air apparently issues from the limestone at a depth of perhaps 60 feet. The well was drilled in 1903, and at that time the phenomenon was most pronounced, but it has gradually decreased since.

A. J. Leonard, two miles northeast of Munterville, (section 9, Polk), reports water at a depth of 124 feet, beneath 24 feet of limestone. Another well 1½ miles east of Munterville reached the Saint Louis at 210 feet and penetrated it 20 feet, when an abundant supply was found. Near Blakesville the limestone was struck at a depth of 360 feet. A well in the NW. ¼ sec. 27, Green township, reached the Saint Louis at 350 feet and its water-bearing sandstone at 370 feet.

Owing to the thickness of the drift, the slight probability of securing satisfactory water in the Coal Measures, and the depth to the Saint Louis, few wells have been drilled in the southeastern part of the county. In the vicinity of Agency some bored wells reach a depth of 100 feet or over, though depths of 20 to 35 feet are most common. A small flowing well was secured in the SE. ¼ sec. 24, Agency township, the flow coming from the Des Moines stage at 44 feet.

CITY AND VILLAGE SUPPLIES.

Eddyville.—Eddyville is 676 feet above sea level and wells there should find the same artesian waters as at Ottumwa, but at greater depths. The water-bearing sandstone found at 417 feet below sea level at Ottumwa was presumably the Saint Peter and should be found at Eddyville at about 550 feet below sea level or about 1,225 feet below the surface. The logs of the Ottumwa wells are conflicting and no set of drillings has ever been preserved. It is possible that the lower sandstone is the Saint Peter, and this would be found at Eddyville at about 1,375 feet from the surface. It is quite probable that a well 1,500 feet deep would suffice for the town, but more copious flows can be had by drilling deeper, the supply increasing to 2,000 feet at least.

The static level is such as to bring the water to the surface with a probable pressure of 20 pounds. In quality it should be a good potable water of the sodic-magnesic sulphated class, provided that the upper waters of the Carboniferous and Silurian are cased out. In all probability gypsum or anhydrite will be found in the Silurian, and water-tight casing should be driven to the Galena.

Eldon.—The location of Eldon (elevation, 630 feet) in the Des Moines valley gives it an elevation so low that artesian water will be found within moderate distance of the surface and will rise to the curb under a good pressure. The Des Moines valley extends here approximately along the line of strike of the strata, and the Ordovician dome of southeastern Iowa causes a slight rise toward the southeast, the dip from Keokuk to Ottumwa measured on the Saint Peter being 1.6 feet to the mile. At this rate the water bed supposed to be the Saint Peter at Ottumwa (Pl. X) would be encountered at Eldon at 400 feet below sea level, or about 1,030 feet below the surface; but the absence of complete and reliable data both at Ottumwa and at Keokuk makes accurate estimates impossible. Above the supposed Saint Peter, water may be expected in the limestones of the Devonian and Silurian; below the Saint Peter, for several hundred feet, the flow should be largely increased from creviced and porous dolomitic beds and intercalated sandstones.

If the upper Mississippian waters are cased out the well should supply a potable water of fair quality of the sodic-magnesic sulphated class. Sodium sulphate may be the chief mineral in solution, but some sodium chloride, or common salt, will also be found. The pressure of the water at the curb may reach 20 to 25 pounds.

Ottumwa.—The public water-supply franchise for Ottumwa (population, 22,012) was granted to the Public Water Company in December, 1903, for a period of 25 years. The water was formerly drawn from a power canal leading from Des Moines river opposite Turkey Island down past the main pump house in the city, 1½ miles below. Dams across the two channels of the river connected with a levee divert the water into the canal. and this still furnishes the greater part of the power necessary to operate the plant.

The water is now obtained in part from a well 20 feet in diameter and 25 feet deep, sunk on the island just above the levee. An infiltration gallery, 250 feet long and seven by eight feet in cross section leads into the well. As this supply is inadequate the additional amount necessary is taken direct from the river through an eight-inch intake pipe.

A pumping station at the well on the island is equipped with two electrically driven pumps, each having a capacity of 5,000,000 gallons a day, which force the water against a head of 44 pounds through the two 24-inch pipes leading to the main pumping station. To avoid danger of accident during high water these pumps are set in a steel tank 18 feet square and 15 feet deep, the top being well above high-water level, and the suction of both connected with a header through which the water may be drawn from the well, the river, the sedimentation basin, or all of them.

The main pumping plant is in a modern fireproof station, 67 by 90 feet. Water and steam are both provided for power, the former through the canal, which operates five turbines under a head of 7½ feet. These furnish sufficient power for most of the year. Four horizontal boilers supply the steam power. Two water-power pumps, one having a capacity of 2,000,000 and the other of 3,000,000 gallons, are connected with a 125-horsepower Corliss engine in such a way that they may be operated by steam if necessary. There is also a steam turbine pump having a capacity of 5,000,000 gallons. Two electric generators, one driven by water and the other by steam, generate the current needed to operate the pumps on Turkey Island and the pumps at the auxiliary station at the reservoir and light the company's buildings.

The city is built on two levels, the business district being on the "second bottom" of Des Moines river and the modern residential district on the bluffs, about 180 feet above. It therefore requires two waterworks systems. The lower level is supplied with water under a head of 210 feet, from a reservoir of 2,000,000 gallons capacity, receiving its supply directly from the pumps of the main station. The higher part of the city is supplied with water under the same head by a motor-driven pump located at the reservoirs.

Two standpipes, each 56 feet in height and six feet in diameter, located on the 24-inch mains, one at either pumping station, regulate the flow in the pipes and give head to operate an old series of Jewell filters when the condition of the river water is such as to necessitate its being filtered.

A new sedimentation basin at the island station and a clear-water reservoir at the nearer station are contemplated at an early date.[1]

On the "second bottom" of Des Moines river, a terrace about 20 feet above low water, driven wells have generally replaced the older open dug wells. These average between 15 and 20 feet in depth between Main Street and the river and have a maximum of about 30 feet in the vicinity of the fair ground. The water occurs in alluvial sand so fine that ordinary screens are of no use, and 60 to 120 gauze is required with large exposure.

Between Main Street and the foot of the bluffs bored wells fitted with six-inch drain tiles are common. The fineness of the alluvial silt and sand causes the water to be somewhat roily.

On the bluff dug wells are still used though the supply there is from the drift and is meager and of poor quality. Cisterns are frequently used for domestic supply.

A spring worthy of mention is that of William Wheaton in the northeast portion of the city, from which 75 to 100 barrels per day flow. The water is stored in a tank by means of wind and gas engines and sold for household use throughout the city.

On the south side of the river practically all the wells are driven, the only exceptions being in the west end where the sandstone of the Saint Louis is found within 15 or 20 feet of the surface and is occasionally utilized; the well of B. A. Williams

[1] Eng. Record, vol. 53, 1906, No. 13, p. 430. Fire and Water Eng., Feb. 3, 1906, p. 54.

enters it to a depth of 80 feet. The average well is about 24 feet in depth. The water-bearing sand is here overlain by 10 to 12 feet of yellow clay and is generally coarser than on the north side. The water is generally good though hard, and is inexhaustible. After a time the point is coated over with sand cemented into a conglomerate with lime and iron. The fact that but a few feet of loamy clay separates the city from its water supply makes this sand a questionable source of supply.

The Wabash Railroad Company uses for boiler supply a battery of 17 driven wells which reach the rock. The water is pumped into a 30,000-gallon tank, from which about 10,000 gallons a day are used without ever running short. Though somewhat hard, the thin scale which forms breaks easily and the water does not cause foaming.

Similar results are obtained at the Dain Manufacturing Company's plant, where all of the water used comes from the alluvial sands. In the open heater a slight yellow iron precipitate is formed and a thin flaky scale forms. The water stands 10 to 12 feet below the surface.

The country rock at Ottumwa is the Des Moines. (See Pl. X, p. 448.) For the nature and thickness of the deeper formations dependence must be placed entirely on the identifications of the drillers' logs, in the absence of any drillings from any of the wells. In a number of important points these logs are in substantial agreement, and correlations may be made with considerable assurance. But the real natures of several strata and their places in the geologic column remain in doubt because of the total lack of direct lithologic evidence.

After passing through thin superficial deposits the drill penetrates the rapidly alternating limestones, cherts, shales, and sandstones of the Saint Louis limestone and the Osage stage. The shales of the Kinderhook are reached at about 200 feet above sea level and apparently extend to about 40 feet above sea level or even lower. Leaving the Kinderhook, the drill passes into a complex of limestones with more less shales interbedded at different horizons, the whole attaining a thickness of 300 to 375 feet. The lower 125 to 150 feet of this complex is described by one log as "limestone," as "caving rock" by a second, and as "shale" by a third. The drill next encounters a sandy limestone from 75 to 125 feet thick. As at least some of the drillers seem to have had wide experience, and as they speak of the arenaceous dolomites of the Prairie du Chien stage in the same terms it is quite probable that it is here a true arenaceous limestone rather than a limestone which crushes under the drill into crystalline sand. All logs agree that this sandy limestone rests on a water-bearing sandstone from 75 to 100 feet thick, whose top may be reckoned at about 430 feet below sea level by an average of probabilities, although variously placed in the logs. Below this lies 100 feet of limestone from which the drill passes into 20 feet of green shale overlying a white sandstone 40 feet thick whose summit stands at about 630 feet below sea level.

Either the first or the second of these sandstones is the Saint Peter, but which of the two it is must be left in doubt, although the question could be settled at once by inspection of cuttings if these had been preserved. Favoring the theory that the lower sandstone is the Saint Peter is the fact that it is called a white sandstone and that it is overlain by a shale definitely stated to be green. We seem to have here the assocation of the Saint Peter sandstone and the green shale of the Platteville found in all near-by deep wells, as indeed it is found in almost all the deep wells of the state. The fact that no shale is reported overlying the upper sandstone favors this reference. The upper sandstone and the sandy limestone which rests upon it, then, fall to the Silurian and may be taken as the equivalent of the water-bearing Silurian sandstones found at Centerville and Washington and certified at these two stations by cuttings of the strata.

Bearing against this reference is the thinness of the beds intervening between the two sandstones, which must represent the entire thickness of the Maquoketa, Galena, and Platteville. At Centerville these beds are about 290 feet thick, at Washington about 450, and at Pella upward of 500 feet thick, and at Ottumwa the logs allow for them only about 120 feet. (See Pl. X, p. 448.) The fact that the Maquoketa is absent from the section, as no shale underlies the upper sandstone, is not decisive, since it is also absent at Centerville, although present in force at points north and west of Ottumwa.

If the upper sandstone is assumed to be the Saint Peter, the shale reported in one well at from 137 to 307 feet below tide must be referred to the Maquoketa, but as this rests directly upon the "sandy limestone" and as less than 150 feet intervene between the shale and the sandstone the same difficulty recurs as to the thinning out of the Galena and Platteville.

If it be assumed that the lower of the two sandstones is the Saint Peter, the drill at about 1,300 feet passes out of it into the Prairie du Chien stage, with perhaps still lower terranes undistinguished from it with the evidence at hand, the whole forming a complex of limestones, sandy limestones, and sandstones extending, according to the logs, to the bottom of the deepest well, 1,562 feet below sea level. The description of these strata as given in the Ottumwa well logs is altogether similar to that given of the Prairie du Chien wherever found. In a general way the Prairie du Chien at Ottumwa tallies with the beds below the Saint Peter at Centerville. From 800 to 1,250 feet below sea level these beds are generous in their yield.

The Ottumwa Iron Works well is 1,150 feet deep and six inches in diameter; casing to 600 feet packed with lead at bottom. The curb is 648 feet above sea level. The original head was 50 feet above curb; the present head is above curb. Water comes from 1,040 feet. Temperature, 62° F. The well was completed in 1888, at a cost of $3,000.

This well has shown loss of pressure. It still overflows and is used to supply water-closets at the works. The lessened flow is attributed to defective packing and to the loss in the well of a smaller pipe that was being inserted. The sinking of other wells has not affected the discharge. The strata penetrated are said to be mostly limestone to the water bed at 1,040 feet, and below that sandstone.

The Artesian Well Company well No. 1 has a depth of 2,047 feet and a diameter of eight inches; cased to 1,200 feet. The curb is about 648 feet above sea level. The original head was 108 feet above curb by pressure; the present head is 103 feet above curb. The original and present flow is about 700 gallons per minute. Water comes from 1,015 feet. The temperature is variously reported as 70° F. and 67° F. Date of completion, 1889. In 1904 the well was repaired by recasing to 30 feet below the curb, where a leakage was found to occur.

Driller's log of Artesian Well Company well No. 1 at Ottumwa.

	Thickness.	Depth.
	Feet	Feet
Loam	21	21
Limestone	21	42
Shale	14	56
Sandstone	30	86
Limestone	60	146
Shale	19	165
Sandstone, flinty	41	206
Sandstone	30	236
Limestone	195	431
Shale	160	591
Limestone	380	971
Limestone, mixed with sand	96	1,067
Sandstone, white	110	1,177
Shale and limestone	200	1,377
Slate	19	1,396
Limestone	319	1,715
Limestone, water bearing	332	2,047

The Artesian Well Company well No. 2 is 1,552 feet deep and eight inches in diameter; cased to 1,200 feet; packed down 100 feet with concrete. The curb is about 648 feet above sea level and the head about 76 feet above curb. The flow is about 300 gallons a minute, the water coming from 1,250 feet. Temperature, 70° F. The well was completed in 1897 by J. F. Kearns, of Ottumwa.

The Young Men's Christian Association building well is 800 feet deep. The curb is about 648 feet above sea level and the head, by pressure, nine feet above curb. The flow is 33 gallons a minute; temperature, 65° F. The well is used to supply a swimming pool and baths.

The packing house well No. 1 of John Morrell & Company (Ltd.) has a depth of 1,110 feet. The curb is 643 feet above sea level. The first flow came in at 280 feet, and increased at 710 feet, the main flow being struck at 1,015 feet. The well was completed in 1888. It was reamed out in 1892 by the original drillers, J. P. Miller & Company, to a diameter of 12 inches to 19 feet, 8 inches to 518 feet, and 5⅝ inches to bottom. The flow was then 800 gallons a minute. The pumping capacity in 1908 was 207 gallons a minute. The head in 1895 was 35 feet above curb; in 1896, 32 feet above curb. The loss of flow was gradual and was attributed to filling with sediment. No repairs have been made since 1892.

Driller's log of packing-house well No. 1 of John Morrell & Company, Ottumwa.

	Depth in feet.
Surface	80
Slate	100
Slate and lime	110
Lime and sand	215
Solid lime	255
Water flowed	280
Lime	312
Lime and streaks of sand	330
Lime	360
Shale	440
Solid rock	625
Flow increased	710
Sandstone, water bearing	1,015
Sandstone	1,100

Packing-house well No. 2 of John Morrell & Company (Ltd.) has a depth of 1,554 feet and a diameter of 10 inches to 25 feet, 9⅝ inches to 97 feet, 8 inches to 540 feet, 6 inches to 994 feet, 5 inches to 1,320 feet, and 4 inches to bottom; casing, from surface to 25 feet, from 437 to 540 feet, from 842 to 994 feet, from 1,244 to 1,320 feet. The curb is 643 feet above sea level. The original head was 57 feet above curb; the head in 1893, 49 feet above curb. The original flow was 1,000 gallons a minute, and the tested capacity in 1908, 214 gallons a minute. Repairs none. Loss attributed to filling with sediment. The water comes from 1,085 feet. Temperature, 64° F. The well was completed in 1892 by J. P. Miller & Company, of Chicago.

Driller's log of packing-house well No. 2 of John Morrell & Company, at Ottumwa.

	Thickness.	Depth.
	Feet	Feet
Surface	17	17
Limestone	8	25
Shale	71	96
Limestone	344	440
Caving rock	90	530
Sandy limestone	150	680
Shale	35	715
Limestone	140	855
Caving rock	130	985
Limestone	65	1,050
Sandstone	65	1,115
Limestone	110	1,225
Sandstone	15	1,240
Shale and sand	70	1,310
Limestone	170	1,480
Sandstone	50	1,530
Sandy limestone	24	1,554

Packing-house well No. 3 of John Morrell & Company (Ltd.) has a depth of 1,702 feet and a diameter of 10 to 6⅝ inches; casing, 8 inches from surface to 1,360 feet, later, 10 inches from surface to 76 feet, 1,360 to 1,702 feet uncased. The curb is 643 feet above sea level and the original head was 50 feet above curb. The original flow was 1,500 gallons a minute; pumping capacity in 1908, 244 gallons a minute. Repairs none. Temperature, 67° F. The well was completed in 1898 by J. P. Kearns, of Forrestville, N. Y. It was first bored to 1,702 feet with a diameter of eight inches below 425 feet. As some trouble was experienced with caving rock from 1,210 to 1,360 feet, and as the well yielded only 900 gallons a minute, it was reamed to 10 inches to a depth of 1,360 feet and an eight-inch pipe inserted to this depth, when the discharge was increased to 1,500 gallons a minute.

Packing-house well No. 4 of John Morrell & Company (Ltd.) has a depth of 2,205 feet and a diameter of 12 to 6⅝ inches; casing to 1,310 feet; with hemp packer. The curb is 643 feet above sea level. The head, in 1905, was 46 feet above curb. The original flow was 1,450 gallons a minute; tested capacity in 1908, 1,500 gallons a minute. A small flow came in at 1,190 feet; a flow of 1,100 gallons, tested, at 1,260 feet, and of 1,450 gallons, tested, at 1,896 feet; all rocks were water bearing between 1,451 and 1,896 feet, no increase at 2,205 feet. Temperature, 70° F. The well was completed in 1905, by J. P. Miller & Company, of Chicago.

Driller's log[a] of packing-house well No. 4 of John Morrell & Company, at Ottumwa.

[a] Log below 1,240 feet sent by driller to the survey. Log above this depth supplied by the company, probably from the log of another driller.

	Thickness.	Depth.
	Feet	Feet
Surface	22½	22½
Small stone and rock	63½	96
Limestone and shale, mixed	334	430
Shale and limestone	205	635
Limestone, solid	35	670
Streaks of shale and stone	50	720
Limestone	60	780
Shale	170	950
Sandy limestone	125	1,075
Sandstone and limestone, small flow	115	1,190
Water rock (1,100 gallons flow)	50	1,240

Driller's log of packing-house well No. 4 of John Morrell & Company, at Ottumwa.—Concluded.

	Thickness	Depth
Limestone, water bearing	20	1,260
Shale, green	16	1,276
Sandstone, white	38	1,314
Limestone, with streaks of shale	11	1,325
Sandstone, white	5	1,330
Limestone	25	1,355
Sandstone	10	1,365
Limestone	58	1,423
Sand or sandy limestone	28	1,451
Limestone with crevices	34	1,485
Sandstone, white	58	1,543
Limestone with streaks of sandstone	22	1,565
Limestone	57	1,622
Limestone, sandy	10	1,632
Limestone	33	1,665
Sandstone, white	15	1,680
Limestone, sandy, with crevices	65	1,745
Limestone	45	1,790
Limestone, sandy, or hard sandstone	45	1,835
Limestone	15	1,850
Limestone, sandy, or hard sandstone	27	1,877
Sandstone	19	1,896
Limestone, hard	129	2,025
Sandstone, with streaks of limestone	73	2,098
Same as above, but thicker streaks (15 to 20 feet)	62	2,160
Limestone, hard	30	2,190
Limestone, sandy	15	2,205

WELL DATA.

The following table gives data of typical wells in Wapello county:

Typical wells of Wapello County.

Owner	Location	Depth	Depth to rock	Source of supply	Head below curb	Remarks
John Curtis	3½ miles east of Eddyville.	165	91	Sandstone (Saint Louis).	100	Hard water.
James Harris	1½ miles southwest of Kirkville.	177	9	do	125	
George Stevens	2 miles northwest of Dudley.	205	20	do		A good well.
C. H. Leander	3 miles north of Dudley.	185	40	do		Good soft water
Joe Johnson	2½ miles south of Eddyville.	120	16	Sandstone (Des Moines?).	60	Good water.
S. H. Lamis	2½ miles east of Eddyville.	80	25	Sandstone (Saint Louis).	40	A blowing well.
A. J. Gardiner	3½ miles south of Eddyville.	220	55	Sandstone (Des Moines).		Hard water.
J. P. Hawthorne	2 miles south of Farson.	217	100	do	80	"Sulphur taste."
G. F. Glass	3 miles southeast of Eddyville.	75	25	Sandstone (Saint Louis).	8	

WASHINGTON COUNTY

BY W. H. NORTON.

TOPOGRAPHY.

Washington county is situated in the third row of counties north of the Missouri line and in the second west of the Mississippi river. Its relief is due almost wholly to the dissection of an ancient plain of glacial drift molded by a continental glacier to a well-nigh flat and even surface. The rivers of the area have cut their valleys in this once continuous upland to depths of 175 feet and more. Bordering the larger streams the country is "broken" into a succession of ridges and closely spaced ravines. The interstream areas, however, are still largely uncarved by any sharp or well-marked channels and form tabular divides traversed by shallow swales that mark the beginnings of the tributary streams. The area may thus be divided into flat uplands called "prairies," and slopes, called "breaks," where somewhat rugged. Iowa river forms part of the eastern boundary of the county, but as it saps the right-hand valley bluffs its bottom lands lie outside the county limits. Skunk river flows over a wide alluvial floor. English river has developed a flood plain 1½ miles wide for nearly six miles from the western county line.

GEOLOGY.

Washington county lies wholly within the area of outcrop of the Mississippian series, of which the Kinderhook stage, the Osage stage, and the Saint Louis limestone are exposed to view. The lowest stage, the Kinderhook, includes heavy shales overlain by earthy magnesian limestones and gritstones, the total thickness being estimated at 200 feet. Upon the Kinderhook rests the Osage stage, made up of massive, coarsely crystalline limestones. In the southern and southwestern parts of the county the Osage is overlain by the Saint Louis limestone, consisting of limestones, shale, and sandstones. Some of the limestone is a breccia; that is, it is composed of angular fragments cemented together. Small isolated patches of Coal Measures are also found in this county—outliers of the coal fields of the Des Moines stage. (See Pls. X, p. 448, XIV, p. 660.)

The Pleistocene of Washington county includes but two drift sheets. Immediately upon the country rock lies the Nebraskan drift sheet—a tough, hard, dark blue stony clay, in many places containing small fragments of coal and bits of wood, and in some places at its base glacial gravels. Directly upon the Nebraskan or separated from it by stratified sands and gravels and in a few places by an old soil or forest beds—interglacial deposits known as the Aftonian—lies the Kansan drift sheet. This stony clay is normally blue in color, but is oxidized and turned yellow for a considerable distance below its surface. Upon the Kansan lies the loess—a thin, yellow, or gray gritless silt or dust deposit, which everywhere mantles the uplands of the county. The average depth of the Pleistocene over the county probably exceeds 100 feet.

UNDERGROUND WATER.

SOURCE AND DISTRIBUTION.

The water-bearing beds of Washington county consist of the alluvial sands and gravels of the flood plains of the rivers, the glacial sands and gravels of the Pleistocene, and the limestones of the Mississippian. The first named are limited to portions of the valleys of Skunk and English rivers and their larger affluents. The second forms a province as wide as the entire county. The third, or Mississippian, also includes all the county with the exception of a deep buried river channel extending from northwest to southeast through the town of Washington, and hence designated the Washington channel. Along the line of this ancient river valley the limestones have been cut away to great depth and water is sought and found in glacial sands.

On the flat uplands ground water stands high, and house wells and wells adequate for small farms with little live stock may be obtained in many places within 50 feet of the surface.

A soft gray silt, underlying the yellow loess and attaining in places a thickness of 15 feet, supplies many shallow wells. A second water bed, consisting of streaks of reddish sand and gravel varying in thickness from two to three feet up to 20 and even 30 feet underlies the yellow pebbly clay of the area. A portion of this sand is often cemented to "hardpan"; and a good roof of hardpan overlying water-bearing sand and gravel may be reckoned as distinct good fortune to the well maker.

A third water bed is found in layers of reddish sand and gravel underlying the blue pebbly clay of the drift (either the Nebraskan or the unaltered Kansan) and resting on the country rock. This sand is said by drillers to be thin and seldom supplies water in adequate amount.

Washington channel supplies many deep wells from its buried sands. In the town well of Washington a large amount of water was struck at 235 feet in these sands, and a number of farm wells tap them at depths exceeding 200 feet.

The chief water beds of the county are those of the bedrock. The upper rock layers broken by preglacial weathering into spalls, called "shelly rock" by drillers, constitute a waterway of much importance.

The limestone of the Osage stage, which is found immediately underlying the drift over the larger part of the county yields copious supplies from porous layers and from seams separating massive beds. Some drillers report that the cherts and flinty beds interleaved with the limestones of the Osage are especially reliable as water carriers. Water-bearing crevices, where the drill drops a foot or more, are said not to be uncommon in this easily soluble limestone.

Water may also be found in the Saint Louis limestone which forms the country rock over the southwestern part of the county.

The thick shales of the Kinderhook stage will be found dry. When they are reached without obtaining a sufficient supply of water the question of going deeper should be carefully considered. If this is decided against, the well may be shot with nitroglycerin at the top of the shale, the well having been filled up to this height if the drilling has been continued below it. The well of Mr. L. Stout, in Brighton township, reached a depth of

425 feet, having been sunk 215 feet in the Kinderhook. The well was then plugged at the top of the shale and shot with nitroglycerin, the flow being trebled in amount by the operation. In case this heroic treament is not successful, the only course remaining is to abandon the drill hole and drill again in some other place, since torpedoing a well makes it impossible to sink it deeper.

Some notes may be added as to conditions in different townships. In Brighton township wells about Verdi are from 80 to 120 feet in depth and draw their water from a blue flinty limestone with some streaks of shale which may be referred to the Osage. In Marion township a highly mineralized corrosive water is found in drift sands and gravels, rock not being reached. In West Franklin, Duck Creek and Seventy Six townships wells find the rock usually at about 100 feet, and obtain water in the "shelly rock" immediately beneath the drift. In the latter township, however, a strip of "deep country" extends from the Keokuk county line for five or six miles on the north side of Crooked creek and parallel with it. There rock is said to lie from 200 to 400 feet from the surface and most wells are "sand wells."

CITY AND VILLAGE SUPPLIES.

Ainsworth.—At Ainsworth (population, 408) the waterworks are owned by the town. Distribution is made by compressed air under a pressure of 65 pounds. There are three-fourths of a mile of mains, seven fire hydrants and 60 taps. The capacity of the system is 12,000 gallons daily and the consumption is but 4,000 gallons.

Washington.—The town of Washington (population, 4,489) draws its supply from deep wells. The consumption per diem is 200,000 gallons. The domestic pressure is 47 pounds and the fire pressure from 90 to 100 pounds There are 9 miles of mains, 73 fire hydrants, and 600 taps. The waterworks are the property of the city.

City well No. 1 has a depth of 1,611 feet and a diameter of 10 to 4½ inches; casing, 10-inch to 244 feet, 6¼-inch to 461 feet, 5½-inch from 563 to 818 feet, 4½-inch from 1,400 to 1,468 feet.

The original head was 44 feet below curb; head in 1896, 54 feet below curb; head in 1907, 133 feet below curb. The well is now pumped with air lift; capacity, 95 gallons per minute. The temperature is variously reported as 72° and 74° F. The well was completed in 1891 by J. P. Miller & Company of Chicago.

City well No. 2 (Pls. X, XIV) has a depth of 1,217 feet and a diameter of 12 to 6 inches. The head is 58 feet below curb. Water was found at 300 feet, but was cased out, the present supply coming from 1,105 feet; capacity, 62 gallons per minute. The well was completed in 1897 by O. G. Wilson.

City well No. 3 has a depth of 1,808 feet; casing, 14 inches to 256 feet, 10 inches to 610 feet, and 8 inches to 1,470 feet. The curb is 738 feet above sea level; the initial head was 100 feet below the curb; head in 1911, 70 feet below curb. The capacity under compressed air is 300 gallons per minute. The water comes chiefly from 1,808 feet. The well was completed in 1908 by C. B. Brant of Indianapolis, Indiana, at a cost of $10,000.

Water levels in Washington City well No. 3 while well was being drilled.

Geologic division	Depth	Head below curb
	Feet	Feet
Devonian	500	200
Silurian	563	120
Saint Peter sandstone	1,215	110
New Richmond sandstone	1,365	95
Jordan sandstone	1,670	83
Saint Lawrence formation	1,808	80

Description of strata of city well No. 3 at Washington.

	Depth in feet
Quaternary (235 feet thick; top, 738 feet above sea level)	235
Carboniferous (Mississippian?):	
Sandstone, buff and reddish buff; microscopic angular grains; flint of same color	242
Carboniferous (Mississippian):	
Kinderhook stage (198 feet thick; top, 503 feet above sea level)—	
Shale, light blue, plastic, gritless	265
Shale, hard, brownish drab, fissile	360
Shale, hard, green-gray, calcareous; in rounded chips; washed	385
Devonian (101 feet thick; top, 305 feet above sea level):	
Silurian (29 feet thick; top, 204 feet above sea level):	
Dolomite, light buff; siliceous, with microscopic quartzose particles, and cherty, with white calciferous sandstone; grains fine, imperfectly rounded; chips show microscopic quartz crystals	534
Dolomite, dark drab mottled; light gray, pyritiferous, slightly quartzose residue; with white chert; some quartz,	

as above 563

Ordovician:

Maquoketa shale (147 feet thick; top, 175 feet above sea level)—

Shale, light green, plastic; noncalcareous; in molded masses 563

Shale, drab, hard, noncalcareous 615

Shale, green, hard, noncalcareous 620

Galena dolomite to Platteville limestone (398 feet thick; top, 28 feet above sea level)—

Dolomite, dark brown, granular crystalline, argillaceous, of Galena facies; and yellow, earthy; three samples 710-790

Limestone, light gray; rapid effervescence; cherty; seven samples 900-980

Limestone, light drab and yellow-gray; with brown, and highly inflammable shale 1,030

Shale; as above; with light brown and gray limestone 1,037

Shale, hard, green; and limestone as above 1,043

Limestone, light yellow-gray and brown; rapid effervescence; four samples 1,050-1,085

Dolomite, brown, hard, crystalline .....

Shale, hard, green, fissile; and sandstone; white rolled noncalcareous grains; larger grains about 0.8 millimeter diameter (in log of earlier well this horizon is given as sandstone 2 feet, arenaceous shale 16 feet) 1,090

Saint Peter sandstone (103 feet thick; top, 370 feet below sea level)—

Sandstone, white; well rounded grains, larger up to 1 millimeter diameter; two samples 1,115-1,117

Sandstone, fine; grains imperfectly rounded, rusted, native color, white; seven samples 1,150-1,208

Prairie du Chien stage—

Shakopee dolomite (142 feet thick; top, 473 feet below sea level)—

Shale, light green; in hard molded masses; some quartz sand 1,211

Dolomite, gray, cherty; some oolitic, highly arenaceous chert; drillings largely sand; grains reach 1 millimeter iu diameter; two samples 1,215-1,230

Dolomite, light yellow-gray, crystalline; considerable quartz sand and green shale 1,235

Dolomite, gray-buff, arenaceous; some chips show embedded grains 1,250

Dolomite, light gray, arenaceous; some embedded grains; some sand 1,280

Sandstone; as at 1,165 feet; sample misplaced 1,310

Dolomite, light drab, arenaceous; some sand and embedded grains 1,320

New Richmond sandstone (27 feet thick; top, 615 feet below sea level)—

Sandstone, white; grains imperfectly rounded, secondary enlargements; larger grains of 0.8 millimeter diameter 1,360

Dolomite, pink; considerable quartz sand in drillings 1,370

Sandstone; as at 1,360 feet; cherty; some oolitic chert 1,380

Oneota dolomite (210 feet thick; top, 642 feet below sea level)—

Dolomite, pink and buff; a large part of drillings quartz sand 1,390

Dolomite, light gray-buff 1,415

Chert, white; in large chips, some oolitic; two samples 1,420-1,425

Dolomite, light gray, clean of sand; and whitish, pink and brown; with siliceous oolite in places; two samples 1,445-1,590

Cambrian:

Jordan sandstone (150 feet thick; top, 852 feet below sea level)—

Sandstone, white, fine; grains imperfectly rounded; two samples 1,595-1,600

Sandstone, white; larger grains reach 1 and 1.2 millimeters diameter 1,612

Sandstone, fine, white 1,620

Sandstone, white, hard; in chips and detached grains; secondary enlargements; two samples 1,625-1,650

Dolomite, gray; much sand 1,670

Sandstone, white, fine 1,705

Sandstone; as above; and light gray dolomite 1,730

Saint Lawrence formation (68 feet penetrated; top, 1,002 feet below sea level)—

Dolomite, light gray and whitish; drusy pyrite at 1,745; two samples 1,745-1,770

Dolomite, light pink 1,808

Driller's log of city well No. 3 at Washington.

	Thickness.	Depth.
	Feet	Feet
Subsoil, white and blue clay	65	65
Quicksand	5	70
Clay, blue	35	105
Quicksand	12	117
Clay, blue	118	235
Quicksand	7	242
Shale, white	118	360
Shale, brown	25	385
Shale, blue	50	435
Limestone, brown	40	475
Limestone, gray	52	527
Limestone, brown	7	534
Limestone, gray	29	563
Shale, blue	42	605
Shale, brown	15	620
Shale, blue	80	700
Shale, brown, sandy	35	735
Shale, blue	28	763
Limestone, brown, shelly	27	790
Limestone, brown, hard	10	800
Limestone, gray	228	1,028
Limestone, brown, hard	22	1,050
Limestone, gray	40	1,090
Limestone, blue, and sandstone	18	1,108
Sandstone, white, hard	103	1,211
Shale, blue	4	1,215
Limestone, red, shelly, hard	15	1,230
Limestone, gray, hard	123	1,353
Sandstone, white, soft	12	1,365
Limestone, red	10	1,375
Sandstone, white, soft	5	1,380
Limestone, gray	20	1,400
Limestone, gray, soft	80	1,480
Limestone, white, hard	110	1,590
Sandstone, white, soft	80	1,670
Limestone, gray, hard	30	1,700
Sandstone, white, soft	40	1,740
Limestone, gray, hard	63	1,803
Limestone, pink, hard	5	1,808

Record of strata of a well drilled in Washington previous to 1888 (Pls. X, p. 448, XIV, p. 660).

Adapted from report by Calvin: Am. Geologist, Vol. 1, 1888, pp. 28-31.

	Depth in feet
Pleistocene (350 feet thick; top, 738 feet above sea level):	
Sand, gravel, blue clay; forest bed with peaty matter and cones of Abies nigra at 115 feet	115
Carboniferous (Mississippian):	
Kinderhook stage (108 feet thick; top, 388 feet above sea level)—	
Shales, dark; in part calcareous; samples to	432
Devonian (74 feet thick; top, 280 feet above sea level):	
Limestones and shales; at 458 feet, limestone light colored, magnsian; with fragments of Atrypa reticularis Linn and Athyris vittata, Hall; samples to	500
Silurian (170 feet thick; top, 206 feet above sea level):	
Sandstone; calciferous at 532 feet; purer at 585 feet; continuing to	632
Ordovician:	
Maquoketa shale (101 feet thick; top, 36 feet above sea level)—	
Shale; bluish or greenish, some with sand; some with calcareous matter; samples continuing to	793
Galena and Platteville limestones (297 feet thick; top, 65 feet below sea level)—	
Limestone, grayish; samples	803-963
Limestone and dark, fine-grained, carbonaceous shale	1,020
Limestone; facies of Platteville	1,059

Sandstone	1,082
Shale, arenaceous	1,084-1,095
Saint Peter sandstone (128 feet thick; top, 362 feet below sea level)—	
Sandstone, pure white, granular; resembling refined sugar; some drillings changed to reddish or brownish by atmosphere and moisture; samples from	1,100-1,200
Shale, bluish	1,228
Prairie du Chien stage—	
Shakopee dolomite (2 feet penetrated; top, 490 feet below sea level)—	
Sandstone, gray	1,230

Wellman.—The public supply of Wellman (population, 724) is drawn from eight 3-inch wells 70 feet deep, located 50 feet apart and joined to a single steam pump. Their combined yield more than equals the capacity of the pump—225 gallons per minute. The two best wells yield 149 gallons per minute and one of these alone can supply 80 gallons. The wells are situated about ten feet above the level of Smith creek and head four inches below the curb. Rock was here reached at 30 feet from the surface. Water is distributed from a tank, whose capacity is 3,500 gallons, through more than a mile of mains. There are 12 fire hydrants and 54 taps. The domestic pressure is 60 pounds and the fire pressure 100 pounds. The daily consumption is 6,500 gallons. The works are the property of the town.

Minor supplies.—The water supplies of minor villages are described in the following table:

Minor village supplies in Washington County.

Town	Nature of supply	Depth	Depth to water bed	Depth to rock	Head above or below curb	
					Shallow wells	Deep wells
		Feet	Feet	Feet	Feet	Feet
Crawfordsville	Dug, bored and drilled wells	15-140		60-100	—10	—20
Haskins	Bored wells	20-150	100	55	— 6	
Nira	Wells	20- 62				+ 6
Rubio	Driven, bored and drilled wells	30-190		50	—20	
Riverside	Open wells	18- 55		25	—35	—30 to —60
West Chester	Dug wells	18- 50		35	—10	—30

WELL DATA

The following table gives data of typical wells in Washington county:

Typical wells in Washington County.

Owner	Location	Depth	Depth to rock	Source of supply	Remarks: (Logs given in feet)
T. 77 N., R. 9 W. (Part of Lime Creek).					
		Feet	Feet		
George G. Sigler	SW. ¼ NW. ¼ sec. 25	92	78	Limestone	Valley. Diameter, 2½ inches. Water also in sand at 60 feet; discharge ½ gallon per minute. Heads 2 feet above curb.
—— Carris	NW. ¼ sec. 32	168	140	Sandstone	
	1½ miles south of Nira.	180	179		Ends in shale.
	1 mile south of Nira	90	89		Creek bottom. Flowing well: now failing.
T. 76 N., R. 9 W. (Seventy-Six).					
O. K. Stoutner	Northeast of Keota		100		
—— Stamp	Northeast of Keota		125		
	SE. ¼ sec 18	450			"Depth of drift, 450 feet."
—— Tallman	SW. ¼ sec. 17	450			Do.
P. H. Tallman	Sec. 19	551			Joint and dark brown clay, 60; sand, 10; clay, 70; rock, ½; clay, yellow and brown, and changeable mixed with some gravel, 60; shale light gray, gritless, with a bed of bluish rock 30 feet thick, and bed of rock in the middle, 250; sulphur, very hard, 4; rock, softer, to 551 feet; where water was struck; water salty and laxative.
—— Mickle	SW. ¼ sec. 34	136	100		
D. Monroe	SE. ¼ sec. 35	113	100		
D. Fisher	SE. ¼ sec. 27	270	170	Limestone	Heads 70 feet below curb.
D. Fisher	NE. ¼ sec. 27	130	114	do	Same level as preceding well. Heads 30 feet below curb.
	2½ miles southwest of Lexington.	330			No rock except a shell of soapstone at 100. No water.
Charles Kreger	NW. ¼ sec. 31	130	105		
A. S. Tuft	SW. ¼ sec. 30	90	75		
William Stoutner	SW. ¼ sec. 5	160	120	Limestone	
	2 miles southwest of Lexington.	100	100		Plenty of water in shell rock.
T. 75 N., R. 9 W. (Part of Dutch Creek).					
Curtis Wells	S. ½ sec. 12	140			
James Brinning	NW. ¼ sec. 35	220	130		
W. Horning	About 2 miles southwest of Grace Hill.	230	80		Drift, limestone; shale; limestone. Heads 90 feet below curb.
B. Engle	About 1 mile southwest of Grace Hill.	130	100		
W. W. Wells	Sec. 13		220		

Typical wells in Washington County—Continued.

Owner	Location	Depth	Depth to rock	Source of supply	Remarks: (Logs given in feet)
T. 76 N., R. 8 W. (Cedar, part of Franklin).		Feet	Feet		
D. Monroe	NW. ¼ sec. 31	90		Gravel	
—— McCurdy	NE. ¼ sec. 31	162	161		
T. 75 N., R. 8 W. (Parts of Franklin and Washington).					
Charles Guy	SW. ¼ sec. 6				Drift, 190.
Alexander Houk	3 miles west of Washington.		110		
T. 75 N., R. 7 W. (Part of Washington).					
County Farm	Sec. 7	236			Wood and seeds at 236; below blue clay.
John Graham	1½ miles east of Washington.		250		
T. 74 N., R. 8 W. (Brighton; part of Marion).					
L. Stout	Sec. 22	425	20	Limestone	Foot of bluff, Skunk river bottoms; clay, 20; limestone, 190; shale, 215.
T. 74 N., R. 7 W. (Part of Marion).					
William Hamilton	Sec. 6	150		Sand and Gravel.	Upland. Red clay, 30; bastard shale, a blue clay with few if any pebbles, 100; sand and gravel, 20.
T. 76 N., R. 7 W. (Jackson).					
George Foster	Sec. 23	313		Sand	Ends in sand under 200 feet of soft blue clay.
	Sec. 26		125		Same altitude and place as preceding.
T. 75 N., R. 6 W. (Oregon).					
Livery stable	Ainsworth		50		20 feet above railway station.
C. Pearsons	2 miles south of Ainsworth.		113		
T. 74 N., R. 9 W. (Clay; part of Dutch Creek.).					
John Fleig	Richland	168	37	Limestone	Water in rock at 165. Heads 120 feet below curb.
Henry Lewers	NW. ¼ sec. 3	240	160		Heads 100 feet below curb.

CHAPTER XI.

UNDERGROUND WATERS OF THE NORTH-CENTRAL DISTRICT.

INTRODUCTION

BY W. H. NORTON.

The north-central district comprises the eleven counties of Butler, Cerro Gordo, Floyd, Franklin, Hancock, Humboldt, Kossuth, Mitchell, Winnebago, Worth and Wright. The predominant dip of the Paleozoic strata is southward. (See Pl. VII, p. 324.) In the northern part of the area the strata dip gently toward the east, the axis of the trough lying apparently in Floyd county. In Floyd and Butler counties a strong southwestward dip is evident. The gradient of the Saint Peter southwest from Osage to Fort Dodge is about 9.5 feet per mile and from Mason City south to Hampton is nearly 20 feet per mile.

The rocks immediately underlying the drift in Mitchell, Worth, and Floyd and most of Butler and Cerro Gordo counties are Devonian; in the remainder of the area, except in western Kossuth county, where Cretaceous formations appear, the rocks are Mississippian.

The geologic and artesian conditions in the eastern half of the area are fairly well known through the records of wells at Osage (Pl. VII, p. 324), Charles City, Mason City (Pl. V, p. 280), and Hampton; but in the western half the only well reaching the Paleozoic sandstones is that at Algona, and of this well practically nothing is known.

The Paleozoic rocks thin rapidly toward the west and north, and some of the formations probably disappear. Thus, at Emmetsburg, a few miles beyond the western boundary of the area, from the bottom of the Cretaceous to the top of a rock called granite by the drillers, is but 632 feet. (See Pl. XVI, p. 814.) If the Algonkian or Archean rocks were really reached at this depth, the entire Paleozoic is here comprised within little more than 600 feet, though at Des Moines it exceeds 3,000 feet; if the bottom of the well is in dolomite, as the drillings indicate, and this belongs to the Prairie du Chien stage, the same narrow limit is set to a body of rock which in eastern and central Iowa ranges in thickness from 1,700 to 2,000 feet.

Pennsylvanian rocks appear only in a few townships of Humboldt county. The Niagaran is probably present only in greatly attenuated beds, and the Devonian may thin out before it reaches Kossuth county. The Maquoketa may persist throughout the area, and the Galena and Platteville probably underlie it all, although they seem to become increasingly shaly toward the west. If the deeper sandstones have been correctly correlated, the Saint Peter maintains a thickness of about 100 feet to the extreme northern and western boundaries of the area—a fact of prime importance in the matter of artesian supplies. In the eastern counties the divisions of the Prairie du Chien stage are well marked, and the Jordan, Saint Lawrence, and Dresbach formations are also distinguishable. In the southwestern counties the dolomites of the Prairie du Chien stage may become increasingly arenaceous and give place in part to sandstones.

If the Minnesota well records are correctly interpreted, the Saint Peter sandstone should be found in the northern tier of counties at about 600 feet above sea level, and in the southern tier, along the south line of Wright and Franklin counties, at about 300 feet below sea level. Thus, it is so near the surface that its waters, together with those of the limestones and sandstones immediately below, can be exploited at no very great expense over the entire area with fair chances of success. Wells carried 400 or 500 feet below the base of the Saint Peter will in most places tap the water beds of the Prairie du Chien and Jordan or their western equivalents, and should reach the shales of the Saint Lawrence formation. It will hardly be advisable to drill through these shales to the Dresbach sandstone.

The red clastic beds (Algonkian ?) found in Minnesota may occur also in this area, but as these beds yield little water their exploitation is hardly more warranted than is that of granite or quartzite.

The artesian waters of this area are of high grade. (See pp. 164-167, 171-173.)

BUTLER COUNTY

BY MELVIN F. AREY.

TOPOGRAPHY.

In Butler county the soil is everywhere fertile and tillable and agriculture is the principal occupation. There is no large city in this county, but there are eight or nine towns and villages, with population ranging from 400 to about 1,150. With two exceptions, Allison and Bristow, which are on the prairie level, the towns are in the valleys of the principal streams.

The area is crossed from the north and west by three tributaries of Cedar river. Shell Rock river traverses the northeast portion for a distance of 20 miles or more, its drainage area comprising about three-eighths of the county. West Fork of Cedar, draining an equal area, flows in a somewhat more easterly course through the south-central part of the county for more than 30 miles. The rest of the county, embracing principally the south row of townships, is drained to Beaver creek. These streams and their larger tributaries, with two or three minor exceptions, have broad flood plains of alluvium, which constitute fully one-third of the area of the county.

Between West Fork of Cedar and the Beaver is a ridge of Kansan drift, which begins in the southern part of Madison township (T. 91 N., R. 18 W.) and the northern part of Washington township (T. 90 N., R. 18 W.), and extends to nearly the central part of Monroe township (T. 90 N., R. 17 W.). Another ridge begins in the west-central part of Albion township (T. 90 N., R. 16 W.) and extends east on through Beaver township (T. 90 N., R. 15 W.), reaching its maximum height about 80 feet above the valley of the Beaver, not far from New Hartford. There is also a beautiful cluster of wood-crowned hills of Kansan drift in sections 26, 27, and 35, Madison township.

The Iowan drift plain is 10 to 15 feet above the valleys of the smaller streams and 30 to 40 feet above the valleys of the larger streams. The natural drainage is better developed than in most counties where Iowan drift prevails.

GEOLOGY.

Throughout the north and east portions of the county, comprising three-fourths of its entire area, the drift rests on the Cedar Valley limestone of the Middle Devonian series (Pl. VII, p. 324); in nearly three-fourths of the remainder it lies on the Lime Creek shale of the Upper Devonian; in scarcely more than one township in the southwest corner is it shown by outcrops to rest on the Kinderhook stage of the Mississippian series.

The Cedar Valley limestone in this county shows at the top a layer characterized by thin plates with conchoidal surfaces. Predominantly and characteristically, however, it consists of an inferior lithographic rock which is much jointed, shows numerous thin clay partings, and usually yields no water. At the base of the lithographic layers is a soft, earthy limestone which shows water-worn channels of considerable size.

The outcrops of the Lime Creek shale, so far as observed in the county, belong chiefly to its upper beds, described by Calvin as the Owen substage,[1] the lower part (Hackberry substage of Calvin) being seen in but one locality. The upper beds in the main are readily pervious to water, as are the sandstone and much-jointed limestone of the Kinderhook stage.

[1]Ann. Rept. Iowa Geol. Survey, vol. 7, 1897, pp. 162-166.

UNDERGROUND WATER.

SOURCE.

Water is obtained from the Buchanan gravel, from the sandstone of the Kinderhook stage, from the base of the upper division of the Lime Creek shale (Owen substage of Calvin), from the shelly rock layers of the Cedar Valley limestone, and from the earthy limestone just below the lithographic beds of the Cedar Valley limestone.

DISTRIBUTION.

In the part of the county northeast of the valley of the Shell Rock, and including all of Fremont and the northeast halves of Butler and Dayton townships, the drift is everywhere thin and rock reaches the surface in many places. Several kettle holes and small ponds occur along the northern border. Little trustworthy information concerning the wells of this district could be obtained, but a drilled well in the north half of Fremont (sec. 22, T. 93 N., R. 15 W.), which was completed in 1904, is believed to be typical. The well is five inches in diameter and 87 feet deep and ends in soft limestone underlying the lithographic beds. The water is medium hard and plentiful.

Log of well in Fremont township.

Material.	Thickness.	Depth.
	Feet	Feet
Soil and drift (Iowan), followed by gravel (Buchanan)	7	7
Clay, yellow, and shelly stone	20	27
Limestone (Cedar Valley); some clay partings	60	87

In the valley of Shell Rock river, a tract about 20 miles long and two to three miles wide, the wells range in depth from 10 to 30 feet, are dug or driven, and obtain an abundance of good water in the Buchanan gravel, which everywhere and to an unusual depth underlies the alluvium. The towns of Greene, Clarksville, and Shell Rock are in this district. Part of Greene is on an elevated bench where the wells are about 50 feet deep, but the wells in the plain have an average depth of 25 feet and are mostly driven. Greene has a public well located one-half mile north of the railroad station, on top of a gravel ridge 30 feet or more above the river plain; this well is wholly in sand and gravel and is 25 feet deep; water stands in it constantly to a depth of 10 or 12 feet. At Clarksville many wells enter the shelly rock about five feet, although many stop in the gravel. At Shell Rock, at a point where rock is found in the river bed, wells are drilled to a depth of 50 to 80 feet, 50 to 60 feet being in rock, and the water is hard as compared with that in the driven wells in the southeast part of the town, which are 20 to 30 feet deep. The water is of excellent quality.

In the northeastern part of the elevated Iowan plain lying between the Shell Rock and West Fork of Cedar the drift is thin, but in the southwestern part it ranges from 100 to 200 feet. The wells on this upland range in depth from 65 to 207 feet. The shallower wells end in drift, the deeper penetrate rock to distances ranging from 15 to 140 feet.

In West Point township (sec. 32, T. 92 N., R. 17 W.) a well 200 feet deep is 40 feet in rock; water is plentiful but hard. Most wells in this vicinity are 160 to 180 feet deep. In east half of section 22, same township, a well 80 feet deep wholly in drift, yields good water in abundance.

In Bennezette township in the NE. ¼ sec. 19, T. 93 N., R. 18 W., is a well 207 feet deep. The owner reported 60 feet of drift, 39 feet of loose rock, and bottom of well in solid rock. The loose rock is believed to belong to the upper division of the Lime Creek shale. The owner reports a little water in this material. A part of the material below this is believed to belong to the lower division of the Lime Creek shale, the well ending in Cedar Valley limestone. Another well one-half mile south, gives good water at a depth of 189 feet. Another a mile north is but 75 feet deep.

In Pittsford township, in the NE. ¼ sec. 5, T. 92 N., R. 18 W., is a well 106 feet deep, the lowest six feet of which is in loose rock, believed to be the Cedar Valley limestone. At Dumont driven wells find water at 15 to 50 feet. Rock occurs at 60 feet in the town, but on a hill to the north the drift is 95 feet deep.

On the alluvial plain of West Fork of Cedar river is a tract 2 to 3½ or 4 miles wide and about 30 miles long, on which water is obtained by driven or dug wells ranging in depth from 10 to 30 feet, the differences being due largely to the great thickness of the Buchanan gravel, any part of which ordinarily yields water.

The western end of the upland region between the plain of the West Fork of Cedar and that of Beaver creek is wide and is more varied in elevation and character than are other parts of the county. This district narrows toward the east until it is occupied almost exclusively by the Kansan morainic hills. Accurate data for wells in the western part were not generally obtained, but it is reported that most wells in this region are shallow and end in gravel. Two miles north of Austinville, in sec. 10, T. 90 N., R. 18 W., a well 40 feet deep, three feet in limestone of the Kinderhook stage, yields a plentiful supply of hard water. A broad valley of a tributary of the Beaver shares with the latter the most of the northern area of Monroe township (T. 90 N., R. 17 W.) in which the wells are all driven and shallow.

In the eastern third of this district the ridge of loess-crowned Kansan drift hills dominates the topography almost wholly. Wells in this area range in depth from 55 to 190 feet and most of them end in gravel.

Near the center of section 27, Beaver township, a drilled well, 101 feet deep, penetrates rock to an unknown extent. In the NW. ¼ section 27 a drilled well on top of a hill 70 feet above the creek valley is 190 feet deep and obtains a plentiful supply of water in gravel beneath blue clay. In section 15 a drilled well 122 feet deep passes 10 feet into limestone.

The alluvial plain of Beaver creek is narrower than the other valley plains but is in other respects similar, except that in the first two or three miles of the course of the creek through the southwest corner of the county it is much constricted by steep stony bluffs which are held up by limestone of the Kinderhook stage. Most of the wells in this valley are driven to depths of 10 to 16 feet. The deeper gravels are more heavily stained with iron and give to the water a taste so disagreeable that many prefer the shallower wells. New Hartford, Parkersburg, Aplington and Austinville, towns on the Illinois Central railroad, are situated wholly or in part in this valley, and obtain their water supply largely from the gravels just below the alluvium.

In the narrow strip of upland south of Beaver creek water is obtained by drilled or driven wells.

In the southeast part of Parkersburg, at an elevation of 30 or 40 feet above the railroad station, a well 142 feet deep ends in gravel just above the rock. In South Parkersburg a drilled well gives the following section:

Section of drilled well in South Parkersburg.

	Thickness.	Depth.
	Feet	Feet
Drift	142	142
Limestone; water bearing, but not sufficiently so	28	170
Soapstone; described by driller as a greasy, solid clay	87	257
Limestone; firm; water plentiful, good, but hard	5	262

No rock outcrops in this vicinity. The nearest exposure is a limestone belonging to the upper division of the Lime Creek shale (Owen substage of Calvin), three miles northeast. It is believed that the limestone above the "soapstone" belongs to this upper division and that the soapstone belongs to the lower division of the Lime Creek shale (Hackberry substage of Calvin). The limestone in which the well ends must be the Cedar Valley limestone.

Three miles due west of Parkersburg a drilled well is 65 feet deep, the last five feet being in rock, undoubtedly the upper division of the Lime Creek shale.

In the east half of section 32, Washington township, a drilled well 30 feet deep is 14 feet in rock. This well is in the Kinderhook area and the surface is at least 40 feet above the creek level. The water is somewhat iron-tainted. The nature of the rock could not be ascertained.

SPRINGS.

Small springs are not uncommon in some portions of the county, many having their source in the drift and issuing from slopes where the interglacial gravels or sands chance to be exposed. A few springs issue from limestone or sandstone beds, exposed by stream erosion. Such a spring is in the SE. 1/4 sec. 11, Pittsford township, near a quarry in the Cedar Valley limestone. Another is near the center of section 31, Washington township. The rock is limestone of the Kinderhook stage. Yet another spring is in the SW. 1/4 sec. 28 of the same township. The rock is sandstone of the Kinderhook stage. Springs of the type first mentioned are in the SW. 1/4 sec. 29, Fremont township, and in the NE. 1/4 sec. 11 and the SW. 1/4 sec. 15, West Point township. Several springs in Shell Rock township afford water for the stock in the pastures. Annias Best, Clarksville, obtains a good supply of excellent water from a hillside spring piped to his buildings.

CITY AND VILLAGE SUPPLIES.

Allison.—Allison (population, 495) pumps its supply by gas engine from an 8-inch well drilled to 180 feet, reaching rock at 40 feet. The water bed is limestone. The well was completed in 1899. A deep well would probably reach the Saint Peter sandstone at 1,000 feet (50 feet below sea level), and a well 1,100 feet deep should give a supply ample for the town.

Greene.—Greene (population, 1,150) pumps by steam from a dug well 20 feet in diameter and 25 feet deep, all in sand and gravel. The well is walled with limestone. The head is 10 feet below the curb and does not lower on pumping. The well was completed in 1900.

New Hartford.—New Hartford (population, 482) obtains a supply by windmill from a driven well 2½ inches in diameter and 28 feet deep, wholly in gravel. The curb is on a slope 10 feet above the river. The well was completed in 1896.

Shell Rock.—The town of Shell Rock (population, 741) obtains its supply from a dug well 10 feet in diameter and 15 feet deep, five of which is in limestone. A force pump run by water power is used. The water is used for washing and for stock. There are 35 taps. The curb of the well is 10 feet above the river level. It was completed in 1900.

WELL DATA.

The following table gives data of typical wells in Butler County:

Typical wells of Butler County.

Owner	Location	Date of completion	Elevation of curb	Diameter	Depth
			Feet	Inches	Feet
R. H. Stewart	Bristow; on Iowan drift plain	1906		5	122
Chicago Great Western Railway	do	1906		10	300
Private	Dumont; on alluvial plain				15-50
Electric Light, Heat & Power Co.	Parkersburg; in valley	1898	10 feet below railway station.	8	90

Owner	Depth to rock	Source of supply	Casing	Head below curb	Pumped by	Use
	Feet		Feet	Feet		
R. H. Stewart	48½	Limestone	48.5	52	Hand	Domestic.
Chicago Great Western Railway	40				Gasoline	Locomotives.
Private						
Electric Light, Heat & Power Co.	14	Limestone	20	76	Steam; Bell pump; lowers slightly.	General; 120 taps.

CERRO GORDO COUNTY

BY O. E. MEINZER AND W. H. NORTON.

TOPOGRAPHY AND GEOLOGY.

Gerro Gordo county is divisible into two distinct topographic provinces. An area nearly coextensive with the western tier of townships shows a thick deposit of Wisconsin drift, typical morainic topography, poor drainage, and numerous lakes, ponds, and swamps; the rest of the county shows a much thinner layer of drift (Iowan) and a smoother topography. The drainage system in the Iowan area is, however, well developed, many of the streams having cut into the bedrock.

The formations exposed in the county[1] include glacial drift (Wisconsin and older), Mississippian limestone, and Devonian strata consisting of limestone at the top, shale in the middle, and limestone at the base. The rock formations dip gently toward the southwest; hence, if the drift were removed, they would outcrop in parallel bands crossing the county with a northwest-southeast trend. Thus the Devonian shale lies next below the drift in a belt that extends through Mason City (Pl. V, p. 280); toward the southwest it passes beneath younger strata of limestone, and farther northeast it is absent and the underlying older Devonian strata are found immediately below the drift.

UNDERGROUND WATER.

SOURCES.

Water is obtained from the glacial drift, the limestone above the Devonian shale, the limestone immediately below the shale and deeper limestone and sandstone formations. The Wisconsin drift is so imperfectly drained that where it occurs the ground-water table is near the surface and nearly all the porous

[1]Calvin, Samuel, Geology of Cerro Gordo County: Ann. Rept. Iowa Geol. Survey, vol. 7, 1897, pp. 144 et seq.

beds are saturated. Many of the wells are very shallow, but some draw from beds of sand and gravel at greater depths. Where the Wisconsin drift sheet is absent (Pl. III) the drift is too thin and well drained to be a reliable aquifer. In the western part of the county, the limestones above the Devonian shale will furnish large supplies, but farther northeast, where the shale is near the surface, these limestones fail as a source of water, and the Devonian limestone that lies stratigraphically below the shale constitutes the most important water bearer.

In the western tier of townships dug and bored wells are common but there are also numerous drilled wells, which either end in drift or enter rock. Elsewhere in the county drilled wells are the dominant type, and several have been sunk to considerable depths.

HEAD.

Water from the Galena dolomite and the Saint Peter sandstone rises at Mason City to a little over 1,100 feet above the sea, which is slightly above river level at that point, but 140 feet below Clear Lake, 130 feet below Burchinal, and 90 feet below Thornton. Drilling by the municipality and by the Chicago, Milwaukee & St. Paul Railway at Mason City seems to show that the water in the still deeper sandstones is under less head.

In the west, the water from the limestone immediately underlying the drift will probably rise considerably higher than 1,100 feet above sea level, but if a deep well were drilled the head would probably be lowered as greater depths would be reached. In the relatively low area at the east base of the high morainic belt, the water from drift and from the limestone below the drift is under good pressure and will flow in certain tracts, as along West Fork of Beaver creek.

CITY AND VILLAGE SUPPLIES.

Clear Lake.—At Clear Lake (population, 2,014) about one-half of the residents depend on the city waterworks, the supply for which is taken from the lake; the rest use private wells, most of which are shallow and end in drift. The distribution system consists of a standpipe, more than 3 miles of mains, 35 fire hydrants, and about 140 taps. The average daily consumption is estimated at 60,000 gallons.

Dougherty.—The railway well at Dougherty (population, 171) is 417 feet deep and ends in shale which probably is the Maquoketa. It is reported to have been pumped at 90 gallons a minute and to have a normal water level of 135 feet below the surface.

Emery.—The well at Emery, owned by the electric railway company, was drilled into shale, but gets its supply from higher horizons. In this well the water stands only five feet below the surface and the yield is large.

Section of electric railway well at Emery.

	Thickness.	Depth.
	Feet	Feet
Drift	25	25
Limestone	30	55
Sandy transition bed	5	60
Shale (entered)	15	75

Mason City.—The public supply in Mason City (population, 11,230) is furnished by flowing wells that discharge into two large underground reservoirs. City well No. 1, which was drilled in 1892 by Henry F. Miller, of Chicago, is 1,350 feet deep and eight inches in diameter. The elevation of the curb is 1,077 feet above sea level, water level at curb. The water beds are variously reported at 426 and at 537 feet above sea level. As the supply at 426 feet above sea level was far from sufficient, drilling was continued to 1,350 feet, where the drill encountered a crevice in the Saint Lawrence formation and the flow was lost. The well was then plugged at 651 feet.

City wells Nos. 2, 3, and 4 are 651 feet deep and five inches in diameter. The curb is 1,077 feet above sea level and the water level is at curb. Water is obtained at a depth of about 600 feet in a porous limestone, said to be 40 inches thick, lying above the Decorah shale. The temperature of the water is 49° F.

City wells Nos. 5 and 6, located about 500 feet from the reservoir, are 616 feet deep and 10 inches in diameter, and are cased to a depth of 50 feet. Normally the water flows above the surface, but is lowered 80 feet by pumping.

City wells Nos. 2, 3, and 4 were drilled in 1892 at the corners of a parallelogram 60 feet long and 40 feet wide, the other corner being occupied by city well No. 1. This space, excavated in rock to the depth of 16 feet, forms the reservoir into which the wells discharge. The natural flow of wells 1 to 4 combined was 60 gallons a minute. In 1894 the wells were cased and an air lift was installed, 200 feet below the surface, increasing the discharge to 150 gallons a minute from the four wells. All six wells still flow and furnish under compressed air an average of 400,000 gallons a day with a maximum of 650,000 gallons.

The water is pumped from the reservoir directly into the mains, the combined capacity of the three pumps being 2,100 gallons a minute. There are 15½ miles of mains, 108 fire hydrants, and about 1,000 taps. Approximately one-half of the people are supplied from the city waterworks; the other half depend on private wells, most of which are drilled only a short distance into rock and furnish only small amounts of water.

Record of strata in Mason City waterworks well No. 6.

	Thickness	Depth
Devonian and Silurian (?):	Feet	Feet
Dolomite, light yellow-gray, subcrystalline; in sand	10	10
Dolomite, brown, crystalline; in small chips	40	50
Limestone, blue-gray, rapid effervescence; crystalline; much yellow-gray flint	30	80
Dolomite, brown, crystalline; considerable calcite	30	110
Limestone, light gray and blue mottled; rather slow effervescence; some brown dolomite	30	140
Limestone, brown; rather slow effervescence; considerable calcite	10	150
Dolomite, light gray, crystalline, vesicular, fossiliferous	17	167
Limestone, blue-gray, crystalline, of rapid effervescence; and dolomite, light yellow, hard, in small chips and sand	8	175
Dolomite, crystalline, brown; 2 samples	25	200
Ordovician:		
Maquoketa shale—		
Limestone, brown; of rapid effervescence; dark brown inflammable shale and blue-gray limestone of rather slow effervescence	15	215
Shale, medium dark blue-gray, highly calcareous; in large chips	5	220
Limestone, blue-gray, argillaceous; rather slow effervescence; some brown dolomite	6	226
Limestone, medium dark blue-gray, argillaceous; in fine chips; 2 samples	39	265
Shale, medium dark blue-gray, highly calcareous; in chips; 2 samples	35	300
Galena dolomite to Platteville limestone—		
Limestone, light gray and whitish, dense, fine-grained; rapid effervescence; in large flakes	15	315
Dolomite, gray, crystalline; chips of drab clay shale	5	320
Dolomite, dark brown, vesicular, cherty; 2 samples	25	345
Chert and dark gray dolomite	15	360
Limestone, as at 315 feet	4	364
Chert, gray; and dark gray dolomite; 2 samples	21	385
Dolomite, brown; much chert	33	418
Limestone, yellow-gray, earthy; rapid effervescence	15	433
Limestone, blue-gray; and chert	7	440
Limestone, earthy, whitish, and light yellow; Trenton facies; 16 samples	140	580

City well No. 7 has a depth of 865 feet and a diameter of 10 inches; casing, 10 inches from surface to 50 feet, 8 inches from 620 to 750 feet. The curb is 1,109 feet above sea level; the head at a depth of 220 feet was 40 feet above the curb; after passing the Saint Peter it was about the same as in the wells in the reservoir. The only water bed mentioned is at 70 feet. The well is 470 feet from the wells in reservoir and 700 feet from well No. 6. It was completed in 1910 at a cost of $2,579 by W. L. Thorn, of Platteville, Wisconsin.

Description of strata in well No. 7, Mason City waterworks.

	Depth in feet
Devonian (and Silurian?) (210 feet thick; top, 1,109 feet above sea level):	
Limestone, cream-yellow, finest grain; subconchoidal fracture; rapid effervescence; in large chips	25
Limestone; as above; and dark blue-gray, compact, nonmagnesian limestone; in small chips	50
Dolomite, drab, crystalline; in flaky chips; light gray limestone of rapid effervescence; some dark blue fissile shale	75
Limestone, brown-gray; subcrystalline; rather slow effervescence; in large chips	100
Limestone, light gray; rather slow effervescence; in sand	110
Limestone, drab, subcrystalline, vesicular; rather slow effervescence; 3 samples	140
Dolomite, light brown-gray; in sand	150
Limestone, buff, vesicular, with molds of fossils; rather slow effervescence, with lighter nonmagnesian limestone	160
Dolomite, buff, compact	170
Limestone, drab, brownish, compact; rather slow effervescence; with limestone of lighter tint and rapid effervescence	190
Dolomite, drab and brown; in coarse sand	200
Ordovician:	
Maquoketa shale (90 feet thick; top, 899 feet above sea level)—	
Shale, light blue-gray, calcareous, laminated; in large chips; also some buff dolomite	210
Dolomite, buff, saccharoidal	220
Shale, light blue-gray, calcareous; in chips; 2 samples	240
Dolomite, drab and brown, vesicular; some brown inflammable shale	250
Shale, blue-gray, highly calcareous; in large chips; 4 samples	290
Galena dolomite to Platteville limestone (450 feet thick; top, 809 feet above sea level)—	
Dolomite, gray; in coarse sand	300
Limestone, gray and buff; considerable calcite; rapid effervescence	310
Limestone, gray, soft; in large chips; rapid effervescence	320
Limestone, fine saccharoidal, greenish gray; rapid effervescence; in sand with powder of shale	330
Dolomite, gray, vesicular; in places cherty, crystalline; 5 samples	380
Chert, light gray; and blue-gray shale	390
Chert, light gray; shale; and hard argillaceous dark gray limestone	400
Dolomite, dark gray, vesicular; and chert	410
Dolomite, dark buff-gray; disk of crinoids	420
Limestone, dark gray, saccharoidal; moderately rapid effervescence; in large flakes; 3 samples	450
Limestone and shale; limestone of Trenton facies, earthy, grayish buff; in chips; fossiliferous; effervescence rapid	460
Limestone, buff, nonmagnesian	470
Limestone, whitish or light gray, earthy, nonmagnesian; in flaky chips often of considerable size; in places fossiliferous; 12 samples	590

Description of strata in well No. 7, Mason City waterworks.—Continued

Limestone, as above, but blue-gray	600
Limestone, green-gray; and shale	610
Limestone, cream-colored	620
Limestone, blue-gray; crystalline; in coarse sand	630
Limestone, blue and yellow-gray; in flaky chips; 2 samples	650
Shale, green; in molded masses, calcareous; 2 samples	670
Shale, as above; some chips of hard dark limestone of rapid effervescence	680
Shale, green; in molded masses; 2 samples	710
Shale, green; fine, gritless, noncalcareous; in splintery chips	720
Limestone, blue-gray; rapid effervescence; some hard, noncalcareous green shale	730
Shale, hard, green, noncalcareous; in large chips; some limestone	740
Saint Peter sandstone (77 feet thick, top, 359 feet above sea level)—	
Sandstone, white; rounded grains, rarely exceeding 0.7 millimeter in diameter; 2 samples	760
Sandstone, as above, but slightly finer; 2 samples	780
Sandstone, as above; largest grains attain 0.8 millimeters in diameter; some light yellow limestone and green shale; 2 samples	800
Sandstone, clean; as at 780 feet	810
Sandstone, white; with calcareous cement	820
Prairie du Chien stage—	
Shakopee dolomite (40 feet penetrated; top, 282 feet above sea level)—	
Dolomite, light gray and light brown; in fine sand; considerable quartz sand; 3 samples	824-850
Sandstone, calciferous; or limestone, highly arenaceous; grains fine, about 0.6 millimeter in diameter; white, well rounded	860

Driller's log of city well No. 7, Mason City.

	Thickness.	Depth.
	Feet	Feet
Sand	4	4
Lime, white	26	30
Lime, blue and white	19	49
Lime, gray	40	89
Lime, white	6	95
Lime, brown	5	100
Lime, brown, and shale	5	105
Lime, gray bluish	10	115
Lime, brown and gray	8	123
Shale in soft thin layers		
Lime, brown	22	145
Lime, brown, and shale	15	160
Lime, gray	22	182
Lime, brown and gray	28	210
Lime, brown and gray, and shale	15	225
Lime, blue	13	238
Lime, blue, with shale	7	245
Lime, blue	64	309
Lime, blue and gray	14	323
Lime, gray and white	23	346
Lime, gray, and shale	61	407
Rock, gray-brown	135	542
Rock, gray and white	46	588
Lime, gray and white	6	594
Lime, gray and bluish	31	625
Shale and clay	93	718
Shale, clay, and brown lime	20	738
Shale and clay	9	747
Sandstone (Saint Peter)	73	820
Lime, gray and white	44	864

The Lehigh Portland Cement Company has two wells located in section 33, Lime Creek township, just north of city limits. They have a depth of 405½ feet and a diameter of 12 inches to 14½ feet and 10 inches to 405½ feet. The head is within 10 feet of the surface. On bailing with sand pump for 1 hour at a rate of about 45 gallons a minute the water fell to 30 feet below surface. The well was completed in 1911 by J. B. Lowe & Company, of Mason City. These wells were sunk as a reserve supply in case the Calamus creek reservoir supply proved inadequate.

Description of strata, well No. 2, Lehigh Portland Cement Company, at Mason City.

	Depth in feet
Soil, black; no sample	4
Devonian (and Silurian?):	
Limestone, light colored; no sample	20
Limestone, light buff and blue-gray, compact; rapid effervescence; in large chips	20
Limestone, light gray, dense; earthy luster; rapid effervescence	30
Dolomite, crystalline, buff; in sand	40
Dolomite, drab, crystalline: in small chips	50
Dolomite, darker drab; rather slow effervescence; with drab fissile shale and some nonmagnesian light colored limestone; 2 samples	70-80
Dolomite, dark gray, hard, vesicular; with casts of fossils; in large chips	90
Limestone, nonmagnesian, yellow-gray, compact, lithographic; conchoidal fracture	100
Limestone, gray-buff, hard; rather slow effervescence; subcrystalline; in sand and small chips	110
Dolomite, blue-gray, crystalline; in small chips	120
Limestone, light brown-gray; in thin flakes; moderately rapid effervescence	130
Limestone, light brown-gray; in sand at 140 feet; in large flakes at 150 feet; rather slow effervescence; 2 samples	150
Limestone; rather slow effervescence; gray-buff at 169, 180, and 190 feet; drab at 170 feet; hard; in small chips; 4 samples	190
Dolomite, brown, crystalline; 2 samples	210
Limestone, light yellow, lithographic; nonmagnesian, conchoidal fracture	220
Ordovician:	
Maquoketa shale—	
Limestone, brown; moderately rapid effervescence; considerable brown and black inflammable shale	230
Dolomite, drab, hard; some blue shale; 2 samples	250
Shale, blue, pyritiferous; highly calcareous; in sand; 4 samples	290
Limestone, highly argillaceous; or shale, highly calcareous, blue	300
Galena and Platteville limestones—	
Limestone, drab; rapid effervescence; 2 samples	320
Limestone, light buff, saccharoidal, minutely vesicular; moderately slow effervescence; in large chips	330
Limestone, as above, but cherty; 3 samples	360
Chert, white	370
Chert, white, with hard drab dolomite; 3 samples	400

The well of Jacob E. Decker & Sons has a depth of 604 feet and a diameter of 10 inches. The elevation is about 1,092 feet above sea level and the head eight feet below the curb; cased to 18½ feet. The capacity is 225 gallons a minute and the water comes from a depth of 100 feet; temperature, 50° F. The well was completed in 1911 at a cost of $1,850 by W. L. Thorn, of Platteville, Wisconsin.

Description of strata in Jacob E. Decker & Sons' well at Mason City.

	Depth in feet
No samples	220
Limestone, hard, fine-grained, brown, nonmagnesian	220
Maquoketa shale:	
Shale, blue-gray, laminated; in large chips; some brown inflammable shale	230
Limestone, light blue-gray, argillaceous; 2 samples	250
Shale, and highly argillaceous blue-gray limestone; 5 samples	300
Galena dolomite to Platteville limestone:	
Limestone, brown, crystalline, nonmagnesian	310
Shale, blue; some white macrocrystalline nonmagnesian limestone	320
Dolomite, blue-gray; 3 samples	350
Chert; some limestone and shale; 5 samples	400
Limestone, yellow-gray, crystalline; mostly of slow effervescence, with chert and shale; 2 samples	420
Limestone, nonmagnesian, yellow-gray and whitish, earthy; 16 samples	600

The Chicago & North Western Railway well, located one mile north of the station, has a depth of 862 feet and a diameter of 10 inches to 53 feet, 8 inches to 650 feet, and 6 inches to bottom; casing, over the shale of the Platteville from 660 to 749 feet. The curb is 1,124 feet above sea level and the head 24 feet below the curb. The tested capacity is 6,500 gallons an hour after 10 hours' continuous pumping with cylinder set 200 feet below the surface. Water comes from 650 feet above the shale, rising within 16 feet of the surface and supplying 1,000 gallons an hour, and from 746 feet, with rise of water 2 feet in tube and testing (at 756 feet) 1,440 gallons an hour. The main supply is in the Saint Peter at 862 feet. The head of this lower water is reported at 117 feet below the curb. Date of completion, 1900.

Driller's log of railway well, near Mason City.

	Thickness.	Depth.
	Feet	Feet
Loam, clay, and gravel	16	16
Limestone	660	676
Shale	89	765
Sandstone	94	859
Mud	3	862

The Chicago, Milwaukee & St. Paul Railway well No. 1 has a depth of 1,473 feet and diameter of 8 to 6 inches. The curb is 1,128 feet above sea level. The original head was 2 feet below curb and the head in 1896 was variously reported at 30 and 75 feet below curb. The capacity is small, being insufficient to keep a small steam pump running. The well was completed about 1879 by Swan Bros., of Minneapolis. The well has long been abandoned; in 1896 it was used—or misused—as a depot sewer. The water was not found inadequate in quantity, but its quality as a boiler water was inferior to that supplied by the city.

Record of strata in Chicago, Milwaukee & St. Paul Railway well No. 1 (Pl. V, p. 280).

	Thickness.	Depth.
Pleistocene and Recent (28 feet thick; top, 1,128 feet above sea level):	Feet	Feet
Black loam	2	2
Clay	26	28
Devonian and Silurian (276 feet thick; top, 1,100 feet above sea level):		
Limestone, brown, soft, argillaceous	70	98
Dolomite, hard, light bluish gray, granular, subcrystalline; some lighter and softer, briskly effervescent limestone	119	217
Dolomite or magnesian limestone, hard, brown	87	304
Ordovician:		
Maquoketa shale (57 feet thick; top, 824 feet above sea level)—		
Shale, blue	57	361
Galena dolomite (350 feet thick; top, 767 feet above sea level)—		
Limestone, magnesian, hard, pale buff	50	411
Limestone, magnesian, flinty, impure, bluish gray; earthy luster	300	711
Platteville limestone (75 feet thick; top, 417 feet above sea level)—		
Shale, green, slightly gritty; with chert and particles of magnesian limestone	55	766
Dolomite, highly arenaceous; yellow	20	786
Saint Peter sandstone (85 feet thick; top, 342 feet above sea level)—		
Sandstone, fine, white; grains rounded and ground	85	871
Prairie du Chien stage (308 feet thick; top, 257 feet above sea level)—		
Shakopee dolomite—		
Dolomite, white	113	984
New Richmond sandstone—		
"Mixed lime and sandstone", (no sample)	50	1,034
Oneota dolomite—		
Dolomite, light gray	145	1,179
Cambrian:		
Jordan sandstone (70 feet thick; top, 51 feet below sea level)—		
Sandstone, buff and white	70	1,249
Saint Lawrence formation (174 feet thick; top, 121 feet below sea level)—		
Dolomite, hard, gray; flakes of rather hard, green shale	116	1,365
Shale, greenish, highly arenaceous; fragments of dolomite	58	1,423
Dresbach sandstone (45 feet thick; top, 295 feet below sea level)—		
Sandstone, gray; larger grains, rounded; many smaller angular fragments; with some greenish shale	45	1,468
Cambrian or pre-Cambrian (?) (5 feet penetrated; top 340 feet below sea level):		
"Granite." The sample so labeled consists of sandstone similar to the above, rounded grains about 0.25–0.35 millimeter in diameter, with some dolomite, chert, and shale; none of the constituents of granite are present except quartz	5	1,473

The Chicago, Milwaukee & St. Paul Railway well No. 2 has a depth of 816 feet and a diameter of 6 inches. The curb is 1,135 feet above sea level. The original head was 30 feet below curb; head in 1908, 126 feet below curb. The tested capacity is 120 gallons a minute.

Driller's log of Chicago, Milwaukee & St. Paul Railway well No. 2. near Mason City.

	Thickness.	Depth.
	Feet	Feet
Clay	36	36
Limestone	659	695
Shale	30	725
Limestone	35	760
Sandstone	56	816
Shale.		

The American Brick & Tile factory has a well 207 feet deep, and the Mason City Brick & Tile factory one 304 feet deep. The water rises within about 20 feet of the surface in the former and within about 30 feet in the latter, or to about 1,100 feet above sea level in each. Both wells yield large supplies.

Rockwell. The city well at Rockwell (population, 700) passes through glacial drift, limestone, and shale, and ends at a depth of 236 feet in limestone beneath the shale. The water stands 20 feet below the surface, or 1,110 feet above the sea, lowering about 25 feet on pumping for 12 hours at 60 gallons a minute. The water is pumped into an air-tight cylinder from which it is delivered by air pressure. The total length of mains is one-half mile, and there are 10 fire hydrants. Only a few homes have service connections, and the total daily consumption probably does not exceed 5,000 gallons.

FLOYD COUNTY

BY O. E. MEINZER AND W. H. NORTON.

TOPOGRAPHY AND GEOLOGY.

The smooth surface of the Iowan drift plain extends over Floyd county but is moderately dissected by a number of small parallel streams which flow southeastward. The thickest drift is found in the northeast in an area which includes the eastern and central parts of Cedar, nearly all of Niles, and the extreme eastern or northeastern part of Saint Charles townships. Here many wells have penetrated more than 200 feet of drift, and in one well (NW. ¼ sec. 29, T. 97 N., R. 15 W.) a thickness of 365 feet is reported. Throughout most of the remainder of the county the drift is relatively thin, the average thickness probably being less than 50 feet, and along the streams rock outcrops are common. The numerous irregularities in the rock surface on which the drift rests account for the radical differences in the thickness of the latter noted in drilling wells at points not far apart and on nearly the same level.

The rock which lies immediately below the drift is probably all Devonian in age and consists for the most part of indurated but somewhat cavernous limestone. (See Pl. V, p. 280; Pl. VII, p. 324.) In the southwest part of the county, including the southern part of Scott and the southwestern part of Union township, the distance to limestone is commonly 75 to 100 feet, but it is not clear from the data at hand whether this depth is due entirely to glacial drift or in part to the Devonian shale, which is known to be well developed in the next county to the west.

UNDERGROUND WATER.

SOURCE AND DISTRIBUTION.

Water is obtained from (1) alluvial and outwash gravels, which are practically restricted to the valleys, where they yield freely to some shallow wells; (2) glacial drift, which in most parts of the county is too thin and well drained to be a satisfactory source of supply; (3) Devonian limestone, which constitutes the best and most largely utilized aquifer; and (4) lower formations reached in at least one well—the deep well at Charles City.

In Cedar and Niles townships there are many shallow open wells that end in the upper part of the drift, and perhaps even more drilled wells that extend to an average depth of nearly 200 feet and draw unfailing supplies of good water from the lower part of the drift or from the limestone. In many of the deepest wells the water level is low, in some standing 100 feet below the surface. In Saint Charles and Floyd townships some wells end in alluvial sand and gravel and some in porous drift beds, but the best penetrate the limestone and have an average depth of more than 100 feet. In Riverton township, where the drift rarely exceeds 60 feet in thickness and is in some localities very thin, most of the satisfactory wells penetrate limestone and are commonly between 120 and 160 feet in depth. In Pleasant Grove township, where the drift ranges in thickness from less than 10 feet to more than 140 feet, the wells are generally drilled into limestone and have an average depth of perhaps 100 feet. In Rock Grove and Rudd townships the rock is near the surface and is penetrated by practically all wells. The most common depths are between 50 and 150 feet, but in the northern part of Rock Grove township wells approaching 300 feet in depth are reported. Many of the shallowest wells, such as those common in the village of Nora Springs, do not yield much water, but abundant supplies are usually found if the rock is penetrated some distance. In Rockford and Ulster townships the drift is also thin and in many places wells must be sunk many feet into the rock before obtaining large and dependable supplies. Depths ranging from 30 to 180 feet were reported. In the northern parts of Scott and Union townships, where the limestone is generally near the surface, most of the wells are between 50 and 125 feet deep, but in the southern parts, where the distance to limestone is greater, most of them are between 100 and 200 feet deep.

From the head of water in the deep wells at Mason City and at Charles City it appears probable that flows with slight pressure could be obtained from deep wells on the lowest levels in the valley at Marble Rock, Rockford, Nora Springs and elsewhere, but so much excellent water can be obtained by drilling a few hundred feet into the limestone that it would seem unnecessary to sink to greater depths even for municipal or industrial supplies.

SPRINGS.

The largest springs issue from crevices in the limestone at places where the streams have removed the overlying drift. A good example is afforded by the spring of C. F. Beelar, in the valley of Shell Rock river, at the south edge of the village of Marble Rock, where a stream of several hundred gallons per minute pours from a solution channel in the limestone.

CITY AND VILLAGE SUPPLIES.

Charles City.—The city water supply of Charles City (population, 5,892) is obtained from a well 1,587 feet deep (Pl. V, p. 280; Pl. VII, p. 324), drilled by J. F. McCarthy, of Minneapolis, in 1906, at a cost of $3,591. The well is 10 inches in diameter to 800 feet, 8 inches to bottom, and is cased from top to 250 feet and from 600 to 800 feet; no packing was used. The curb is about 1,013 feet above sea level and the head of water 10 feet above curb. The natural flow is 200 gallons per minute; with vacuum of 7 pounds, 900 gallons a minute. Temperature, 53° F. The strata penetrated are shown in the following table:

Record of strata of deep well at Charles City.

	Thickness	Depth
Devonian (120 feet thick; top, 1,013 feet above sea level):	Feet	Feet
Limestone	14	14
Limestone, yellow; rapid effervescence	36	50
Limestone, light brown-gray, rather soft, finely granular, crystalline; moderately rapid effervescence	10	60
Limestone, yellow; rapid effervescence	10	70
Limestone, like that at 50-60 feet; some fragments of yellow, soft, argillaceous limestone, probably fallen in	10	80
Limestone, highly argillaceous, in light blue chips; and limestone, hard, gray, of moderately slow effervescence; 2 samples	20	100
Shale, blue, plastic, calcareous; 2 samples	20	120
Silurian? (180 feet thick; top, 893 feet above sea level):		
Limestone, gray, soft, granular, argillaceous; earthy luster; slow effervescence	10	130
Limestone, blue-gray, argillaceous; some nodules of pyrite; moderately slow effervescence; 3 samples	30	160
Shale, and soft, gray argillaceous limestone	10	170
Limestone, blue-gray, argillaceous; rapid effervescence; 3 samples	30	200
Limestone and shale, limestone yellow with slight quartzose residue, shale blue, calcareous, in chips	10	210
Dolomite, gray, porous, rather hard, with blue-gray shale; in chips	10	220
Dolomite, gray, hard, in part vesicular; with molds of fossils	20	240
Shale, blue, calcareous; in chips and powder; and limestone, blue-gray, some crystalline and of rapid effervescence, some hard, compact, and of slow effervescence	10	250
Limestone, blue-gray, rather hard; moderately slow effervescence; earthy luster	10	260
Limestone and shale, blue-gray; limestone varying in rate of effervescence	10	270
Dolomite, gray; earthy luster; 2 samples	20	290
Dolomite, gray, minutely saccharoidal; some yellow limestone, probably fallen from above	10	300
Ordovician:		
Maquoketa shale (110 feet thick; top, 713 feet above sea level)—		
Shale, blue, calcareous, in powder	10	310
Shale and limestone; shale blue; limestone gray; cherty; slow effervescence	20	330
Limestone, gray; moderately slow effervescence, rather hard; in sand	20	350
Shale, light blue-gray; calcareous; in powder with sand of gray dolomite; 4 samples	40	390
Limestone, light gray, hard; rapid effervescence; somewhat siliceous	10	400
Shale; blue-gray; with limestone of rapid effervescence	10	410
Galena limestone to Platteville limestone (380 feet thick; top, 603 feet above sea level)—		
Limestone, argillaceous, yellow-gray, somewhat siliceous; rapid effervescence	10	420
Limestone, gray, earthy luster; rapid effervescence; in thin flaky chips; 5 samples	50	470
Limestone, light yellow-gray, hard, somewhat siliceous, magnesian; cherty at 500 feet; 4 samples	40	510
Shale and limestone, gray	10	520
Limestone, light yellow-gray, crystalline, minutely porous, somewhat siliceous; slow effervescence	20	540
Limestone, yellow-gray and blue mottled; crystalline; rapid effervescence	10	550
Limestone, gray; moderately slow effervescence	10	560
Limestone, gray, soft; earthy luster; argillaceous; rapid effervescence; 4 samples	40	600
Dolomite, hard, crystalline, light gray; effervescence slow; cherty	10	610
Limestone, light gray; rapid effervescence; 2 samples	20	630
Shale, blue, calcareous; in masses of concreted powder; 3 samples	30	660
Shale, buff, calcareous; residue, ocherous, cherty, and minutely arenaceous	10	670
Shale, blue; as at 630 to 660 feet	20	690
Shale, hard, green, fossiliferous; in chips	30	720
Sandstone, highly argillaceous, gray, slightly calcareous; grains fine, rounded, of considerable diversity of size; the largest more than 0.5 millimeter in diameter; 8 samples	70	790
Saint Peter sandstone (80 feet thick; top, 223 feet above sea level)—		
Sandstone, white; clean quartz sand grains well rounded and sorted; largest 1 millimeter in diameter	10	800
Sandstone and dolomite; quartz sand of rounded grains with much white chert and gray siliceous dolomite and green shale; granular; 4 samples	40	840
Sandstone, white; clean grains of quartz; fine-grained	10	850
Sandstone, white; grains mostly 0.75 millimeter in diameter; calcareous cement	10	860
Sandstone, white	10	870
Prairie du Chien stage (300 feet thick; top 143 feet above sea level)—		
Shakopee dolomite—		
Dolomite, light yellow-gray; in meal; little quartz sand in drillings	10	880

Record of strata of deep well at Charles City.—Concluded

	Thickness	Depth
Dolomite, blue-gray and yellow-gray; 2 samples	20	900
Sandstone and dolomite; sandstone white, moderately fine-grained; dolomite blue-gray; in fine sand	10	910
Dolomite, blue; shale, white, in powder; and sandstone, white; largest grains 1.2 millimeters in diameter	10	920
New Richmond sandstone—		
Sandstone, white; finer than above; with admixture of dolomite in lower part; 2 samples	20	940
Sandstone; white; largest grains 1 millimeter diameter; 2 samples	20	960
Oneota dolomite—		
Dolomite, blue, and sandstone; drillings largely quartz sand; 2 samples	20	980
Dolomite, brown, drab, and gray; finely arenaceous and cherty; 7 samples	70	1,050
Marl, white, calcareous; residue argillaceous and quartzose	10	1,060
Dolomite, white and gray; highly cherty at 1,070 feet; 11 samples	110	1,170
Cambrian:		
Jordan sandstone (80 feet thick; top, 157 feet below sea level)—		
Sandstone, clean, white; well rounded grains; many 1 millimeter in diameter	30	1,200
Sandstone, as above, but finer	10	1,210
Sandstone; as above, coarser; largest grains 1.5 millimeters; passing at bottom into highly arenaceous dolomite represented in drillings by blue-gray chips	10	1,220
Sandstone; as above; clean quartz sand; 2 samples	20	1,240
Sandstone, finer, calciferous	10	1,250
Saint Lawrence formation (337 feet penetrated; top, 237 feet below sea level)—		
Shale, green-gray, calciferous, arenaceous; 2 samples	20	1,270
Sandstone, white, moderately fine-grained; chips of dolomite	10	1,280
No samples	120	1,400
Shale, greenish, calcareous, glauconiferous, arenaceous; fine rounded grains of quartz; 4 samples	50	1,450
Shale, blue-gray, calcareous, glauconiferous; in easily friable concreted masses; arenaceous; 2 samples	20	1,470
Shale; as above; and greenish, fine-grained, argillaceous, and glauconiferous sandstone; 7 samples	70	1,540
Shale, green-gray, glauconiferous, calcareous, and arenaceous	10	1,550
Shale; as above; with flakes of hard, dark, greenish drab shale, noncalcareous and nonglauconiferous; very slightly siliceous; 2 samples	20	1,570
Shale; green-gray, glauconiferous, calcareous, and arenaceous	17	1,587

The following chemical analyses of drillings from the deep well at Charles City were made in chemical laboratory of Cornell College, Mount Vernon, Iowa:

Analyses of drillings from Charles City well.

	270–280 Feet	600–610 Feet
$MgCO_3$	39.45	35.29
$CaCO_3$	53.42	53.28
Fe_2O_3	.21	.75
Al_2O_3	.99	.23
SiO_2	4.50	9.89
H_2O	.54	.50
$CaSO_4$	.29	.11
Total	99.40	100.05

The waterworks system consists of a standpipe, 6 miles of mains, 56 fire hydrants, and about 450 taps. The water is used for domestic purposes by perhaps 1,800 people, or one-third of the population, and for boiler supplies by both railway companies and by other industrial concerns. The average daily consumption is estimated at 200,000 gallons.

Marble Rock.—The village well at Marble Rock (population, 480) is 154 feet deep, nearly all of which is in rock. It has been pumped for 12 hours at the rate of 65 gallons a minute without noticeable effect. The water normally stands about 60 feet below the surface. The system comprises an elevated tank, half a mile of mains, six fire hydrants, and about 35 taps. About one-fifth of the people use the public supply.

Nora Springs.—The public well at Nora Springs (population, 985) is eight inches in diameter and 197 feet deep, nearly the entire depth being in limestone. It is pumped at the rate of 45 gallons per minute without appreciable effect. The water rises to a level 20 feet below the surface, or about 1,050 feet above the sea, and is pumped to an elevated tank, from which it is distributed through three-fourths of a mile of mains. There are 14 fire hydrants. Only a few of the inhabitants use the public supply; about 4,000 gallons are said to be consumed daily. According to Norton, a supply of good water could probably be obtained from a deep well sunk to the Galena and Platteville limestones, or from these and the Saint Peter sandstone combined. The summit of the Saint Peter should be found at about 300 feet above sea level, or at about 775 feet below the surface. A well 800 or 900 feet deep should be ample.

FRANKLIN COUNTY

BY O. E. MEINZER AND W. H. NORTON.

TOPOGRAPHY AND GEOLOGY.

Franklin county is divisible into two distinct topographic, geologic, and ground-water provinces, the area of Wisconsin drift occupying the western part, and the area of Iowan drift occupying the eastern part. The former has deep drift, a morainic topography, many undrained swamps and ponds, and numerous drift wells; the latter has thin drift, a nearly level but well-drained surface, and a predominance of rock wells. Except in certain localities, the dividing line between these two areas is well defined. It crosses the north boundary about nine miles east of the west margin, trends southeast, and crosses the south boundary about four miles west of the east margin of the county.

The rocks upon which the drift rests are chiefly limestones belonging to the upper part of the Devonian and the lower part (Mississippian series) of the Carboniferous. Apparently they dip gently toward the southwest, so that the oldest formations are found in the northeastern and the youngest in the southwestern part of the county. In the northeastern part of Franklin county and also in Cerro Gordo county a shale formation is interbedded between Devonian limestones.

UNDERGROUND WATER.

SOURCES.

Water is obtained from the glacial drift and underlying limestone, and in the deep well at Hampton from the lower sandstone formations. In the western morainic area the drift is in general between 65 and 150 feet thick, and because of the poor drainage the pervious portions are filled with water nearly to the surface. When this area was first settled, the water supply was nearly all obtained from shallow wells that ended in the upper part of the drift, but many wells have recently been sunk to the lower part of the drift and into the subjacent limestone, thus obtaining more sanitary, more plentiful and more reliable supplies. In the eastern area, where the drift is thinner and a little more dissected by streams, it is generally necessary to drill into rock in order to obtain supplies that are at all dependable. Most of the wells end in the upper limestone at depths ranging from 30 to 100 feet, but a few pass through the Devonian shale and end in the underlying limestone at depths between 200 and 400 feet. In all wells that are sufficiently deep the supply is abundant and permanent. The water from all beds is hard, but is otherwise of good quality unless polluted from the surface.

SPRINGS AND FLOWING WELLS.

In the valley of Iowa river in the southwestern part of the county, in the valley of West Fork of Red Cedar river in the northeast and in a number of low tracts, especially at the east base of the high morainic area, the water in the ordinary drilled wells rises nearly to the surface or, in a few wells, overflows. In other localities east of the morainic belt, the water-bearing beds have been exposed by erosion or otherwise, allowing the water to escape in rather large springs. The head of the city well at Hampton indicates that the water from the deeply buried formations will remain at a lower level than that from the formations reached in ordinary drilling.

CITY AND VILLAGE SUPPLIES.

Hampton.—The public supply of Hampton (population, 2,617) comes from a group of springs and from a deep well. The springs discharge into two reservoirs at about 100 gallons a minute; and the well has been tested at 160 gallons a minute.

There are a standpipe and system of mains with about 225 taps. The average daily consumption is about 150,000 gallons, the water being used for domestic purposes by over 1,000 people and for boiler supplies by both railway companies and by several industrial concerns.

The well is 1,709 feet deep, is cased with 10-inch pipe from surface to 190 feet, 8-inch from 588 to 642 feet, 7-inch from 196 to 1,139 feet, and 6-inch from 1,139 to 1,191 feet; the casing is split to let in water. The curb is 995 feet above sea level. The normal head is 50 feet below curb; under pump the water stands 160 feet below curb. The principal water supply is obtained from a depth of 1,100 feet. The well was drilled in 1900 by J. P. Miller & Company of Chicago. The strata penetrated are indicated by the following log and section:

Driller's log of city well at Hampton.

	Thickness	Depth
	Feet	Feet
Surface	52	52
Shale	153	205
Lime, hard	393	598
Shale, caving	77	675
Limestone	65	740
Shale	60	800
Mixture of lime and shale and coating material	40	840
Very hard rock, which batters drill	35	875
Mixture of rock and soapstone	140	1,015
Limestone	85	1,100
Sandy material	35	1,135
Shale	53	1,188
Sandstone	60	1,248
Limestone	152	1,400
Sandy limestone	75	1,475
Hard limestone	160	1,635
Sandstone	74	1,709

Description of strata in city well at Hampton.

	Depth in feet
Pleistocene (52 feet thick; top, 995 feet above sea level):	
Till, pale yellow	20
Sand, ocher-yellow; with ocherous clay	40
Carboniferous (Mississippian):	
Kinderhook stage (108 feet thick; top, 943 feet above sea level)—	
Shale, blue	60
Limestone, bluish gray, subcrystalline; of rapid effervescence; in coarse chips; fragments of calc spar and sparry surfaces indicate that the rock is geodiferous; platy fragments of drusy pyrite, in some of which the pyrite alternates with laminae of black coaly shale	80
Shale, blue; 3 samples	100-140
Devonian (360 feet thick; top, 835 feet above sea level):	
Limestone, dark green-gray, earthy; brisk effervescence; argillaceous residue; in large chips; some fragments of white, fine-grained, crystalline limestone	160
Limestone, dark drab, fine-grained, crystalline, hard; residue black; moderately brisk effervescence; microscopic grains of crystalline quartz	180
Limestone, white, compact; earthy luster; also gray and cream-colored; saccharoidal, in small chips; much argillaceous admixture; effervescence moderate; residue large, argillaceous, and microscopically quartzose	200
Shale, greenish	220
Limestone, white, earthy; brisk effervescence; in fine sand; some cuttings of shale	240
Shale, greenish; 2 samples	260-280

Description of strata in city well at Hampton.—Continued.

Limestone, white; brisk effervescence; crystalline, in fine sand masked by argillo-calcareous powder	300
Limestone, varicolored, dark bluish, saccharoidal, with moderate effervescence, and argillaceous residue; and buff, subcrystalline, fine-grained, compact, with brisk effervescence and little residue	320
Limestone, light gray, fine-grained, subcrystalline, subtranslucent; rapid effervescence; in large flakes	340
Limestone, drab; large dark argillaceous residue; effervescence moderate	360
Limestone, light gray, dense, fine-grained, subcrystalline; brisk effervescence; some chips of soft greenish saccharoidal limestone	380
Limestone, light buff, soft, compact, earthy; effervescence brisk	400
Limestone, light blue and light buff; hard, brisk effervescence	420
Limestone, light brownish, soft; earthy; brisk effervescence; argillaceous residue	440
Limestone, blue-gray; earthy luster; fine-grained, compact; brisk effervescence, dark argillaceous residue	460
Limestone, blue-gray; effervescence rather slow; large clayey residue; fragments of fossiliferous green shale	480
Limestone, gray, subcrystalline; in angular sand; effervescence brisk	500
Silurian (78 feet thick; top, 475 feet above sea level):	
Limestone, cream-colored, very soft; earthy; effervescence moderate; some drab, argillaceous	520
Limestone, light blue-gray, soft; rather large clayey residue; effervescence moderate	540
Limestone; as above, but with chips of chert, siliceous limestone, and drab argillaceous limestone	560
Limestone, white, soft; rapid effervescence; subtranslucent	580
Ordovician:	
Maquoketa shale (172 feet thick; top, 397 feet above sea level)—	
Shale, light chocolate-brown, calcareous	600
Shale, reddish; no reaction for carbons or hydrocarbons in closed tube	620
Shale, light greenish, calcareous	640
Limestone; moderate effervescence; much argillaceous powder	660
Gray chert, greenish shale, and red calcareous shale; probably fallen from above	700
Shale, greenish	720
Limestone, varicolored, in sand; brisk effervescence; much greenish shale	740
Shale, dark greenish, calcareous	760
Galena limestone to Platteville limestone (410 feet thick; top, 225 feet above sea level)—	
Limestone, white; brisk effervescence; much shale	780
Limestone, buff, and shale, chocolate-brown; considerable yellow chert	800
Limestone, gray and white; brisk effervescence; much white chert and argillaceous powder; 2 samples	820-840
Shale, green and brown; gray chert	860
Limestone, gray; brisk effervescence	880
Limestone, cream-colored; brisk effervescence; in fine sand; much argillaceous powder	900
Limestone, light yellow; highly argillaceous; 2 samples	920-940
Shale, light brownish, calcareous	960
Limestone, light gray; some fossiliferous; cherty; brisk effervescence; in chips; much argillaceous powder in some samples; 6 samples	980-1,080
Limestone, gray, brisk effervescence; 2 samples	1,130
Shale, green; and gray limestone	1,140
Shale, green; indurated; in fine chips	1,160
Saint Peter sandstone (68 feet thick; top, 185 feet below sea level)—	
Sandstone; white grains of clear quartz, well rounded, comparatively uniform in size, surfaces smooth, with green shale from above; 4 samples	1,180-1,240
Prairie du Chien stage—	
Shakopee dolomite (172 feet thick; top, 253 feet below sea level)—	
Dolomite, gray, hard, cherty	1,260
Dolomite, gray, cherty, arenaceous	1,280
Sandstone, fine-grained, white	1,300
Dolomite, light buff and gray, cherty; 2 samples	1,320-1,340

Description of strata in city well at Hampton.—Concluded

Dolomite, light buff, arenaceous; considerable quartz sand in drillings	1,360
Dolomite, blue-gray	1,400
New Richmond sandstone (70 feet thick; top, 425 feet below sea level)—	
Dolomite, blue-gray, and sandstone; large part of drillings quartz sand	1,420
Dolomite, gray; small fragments of arenaceous dolomite and some quartz sand	1,440
Sandstone and dolomite; sandstone of Saint Peter facies; dolomite gray	1,460
Sandstone, white, fine-grained, hard	1,480
Oneota dolomite (145 feet thick; top, 495 feet below sea level)—	
Dolomite, gray and white, cherty; 2 samples	1,500-1,520
Dolomite, gray; residue of crytocrystalline quartz	1,540
Dolomite, blue-gray; residue as above	1,560
Dolomite, gray; 3 samples	1,580-1,620
Cambrian:	
Jordan sandstone (74 feet penetrated; top, 640 feet below sea level)—	
Sandstone; of clean, white, well-rounded grains of pure quartz, of moderate size; 3 samples	1,640-1,680
Sandstone; as above, but somewhat harder, as indicated by larger number of fractured grains; 2 samples	1,700-1,709

Latimer.—The village well at Latimer (population, 378) is six inches in diameter and 150 feet deep, the last 50 being in limestone. The water rises within 45 feet of the surface, and the well is reported to have yielded 300 gallons a minute continuously during a 12-hour test.

The water is brought out of the well by an air lift and is then forced by a rotary pump into a cylindrical air-tight tank, from which it is carried through the mains by air pressure. The total length of the mains is less than half a mile, the number of fire hydrants six, number of taps fourteen, and the average daily consumption is estimated at 6,000 gallons. Only a small proportion of the inhabitants use the public supply.

HANCOCK COUNTY

BY O. E. MEINZER.

TOPOGRAPHY AND GEOLOGY.

The drift-covered surface of Hancock county is in most localities only gently undulating. It has been but little modified by stream erosion and consequently its natural drainage is imperfect. The glacial material forms a continuous blanket, 75 to 250 feet thick, beneath which the older rock formations are completely concealed. In the northwestern part of the county (Bingham, Crystal, Orthel and part of Britt townships) the drift has its greatest development, depths of 200 to 250 feet being common; and in the southern tier of townships (Major, Amsterdam, Twin Lake and Avery,) it is also rather deep, ranging in general between 125 and 200 feet and averaging deeper in Twin Lake than in Avery township; in parts of Britt, Garfield, Concord, Ell, German, Erwin and Boone townships it is relatively thin, depths of 75 to 125 feet being common.

The bedrock upon which the drift rests consists of indurated limestone with a minor amount of interstratified shale, and probably belongs in part to the Mississippian series of the Carboniferous and in part to the Devonian system. The general succession of the upper formations is indicated by the following section of the village well at Britt:

Section of village well at Britt.

	Thickness	Depth
	Feet	Feet
Drift	127½	127½
Limestone	40½	168
Shale	17	185
Limestone (entered)	15	200

UNDERGROUND WATER.

SOURCES.

The water supply is derived from the glacial drift and the underlying limestones. On account of the poor drainage, the porous parts of the drift are usually filled with water nearly to the surface; hence there are many shallow wells which are liable to fail in dry seasons when the water level lowers. Better wells are drilled to deeper parts of the drift where they receive more dependable supplies from sand and gravel beds that contain water under pressure. The best drilled wells, however, pass through the sand and gravel beds and tap the limestones, from which are obtained copious supplies of water that is lifted by artesian pressure nearly or quite to the surface. The water from both drift and limestone is hard, but is otherwise good.

Throughout the county the blanket of drift, with its undrained surface and its water-bearing beds of sand and gravel, rests on the same kind of bedrock, with its large water supplies under good pressure. The two variable factors are (1) the thickness of the drift and consequent depth to rock, and (2) the altitude of the surface and the resulting depth at which the water remains in the wells.

HEAD.

In most of the county the water in drilled wells rises nearly to the surface and in some areas it overflows. The following table shows the head at several points:

Head of water in and near Hancock County.

Locality	u de of surface above sea level	Height to which the water rises	
		Above or below surface	Above sea level
	Feet	Feet	Feet
Forest City (Winnebago county)	1,180	Above	1,180
Garner	1,220	—14	1,206
Klemme	*a*1,210	—10	*a*1,200
Belmond (Wright county)	1,180	Above	1,180
Britt	1,230	—18	1,212
Hutchins	1,208	—18	1,190
Wesley (Kossuth county)	1,246	—80	1,166
Corwith	1,178	—20	1,158

a Approximately.

Flowing wells have been obtained along the several branches of Boone river in Magor, Amsterdam, Boone and Erin townships, and also in the low tracts adjoining several creeks in Bingham and Orthel townships. They have also been obtained in the valley of Iowa river near the south line of the county, and, judging from the flowing well at Forest City, it seems not improbable that they could be obtained in parts of Lime creek valley near the Winnebago county line.

The deepest well reported is the Chicago, Milwaukee & St. Paul Railway well at Britt, which extends to a depth of 684 feet, and in which the water rises to sixteen feet below the surface, or 1,220 feet above the sea level, this being practically the same head that is found in the ordinary drilled wells of the vicinity. At Algona to the west and Mason City to the east the water from the deeply buried formations does not rise much higher than 1,100 feet above sea level, and the general experience in deep drilling in this region indicates that the head tends to become lower with increasing depth. In view of the generous yield and good head of wells sunk relatively short distances into the rock, probably little or nothing would be gained by deep drilling.

In certain areas where the water in rock wells stands some distance below the surface, it may be feasible to drain small swampy tracts, remote from streams and large ditches, by conducting the water through wells into the cavities of the rock, but throughout the greater part of the county the head of the well water is too high to permit this method of drainage.

CITY AND VILLAGE SUPPLIES.

Britt.—The public well at Britt (population, 1,303), a section of which is given on page 780, is 8 inches in diameter and 200 feet deep. It is reported that the first limestone yielded 60 gallons a minute and that the finished well, ending in the limestone beneath the shale, has been tested at the rate of 400 gallons a minute. The waterworks consist of an elevated tank, about two miles of mains, 16 fire hydrants, and approximately 200 taps. A majority of the people use the water, the average daily consumption being estimated as 30,000 gallons.

The Chicago, Milwaukee & St. Paul Railway well has a depth of 684 feet and a diameter of seven inches. The curb is 1,236 feet above sea level. The head is 16 feet below the curb and the tested capacity is 125 gallons a minute.

Corwith.—The village well at Corwith (population, 455) is 125 feet deep and ends in limestone. The water stands 20 feet below the surface, or 1,158 feet above sea level, and has been pumped at the rate of 70 gallons a minute.

The distribution system comprises an elevated tank, somewhat more than half a mile of mains, 8 fire hydrants, and 17 taps. Only a small portion of the total population uses the public supply. The average daily consumption is reported to be approximately 10,000 gallons.

Garner.—The public water supply of Garner (population, 1,028) comes from two wells, one of which was dug to a bed of gravel at 48 feet, and the other was dug to 55 feet and thence drilled to 145 feet, where it ends in limestone. The water in each well rises within 14 feet of the surface, but pumping at the rate of 80 gallons a minute from the two combined lowers the water level about 25 feet.

The system comprises an elevated tank, about one-half mile of mains, 11 fire hydrants, and approximately 75 taps. It is estimated that less than one-fourth of the people are supplied from this source and that the average daily consumption is about 13,000 gallons.

HUMBOLDT COUNTY

BY O. E. MEINZER.

TOPOGRAPHY AND GEOLOGY.

Nearly all of Humboldt county is drift covered and much of it is poorly drained, but the East and West Forks of the Des Moines river, which cross the county and unite near the south line, have in many localities cut into the bedrock, and, with their numerous short tributaries, have drained some of the swampy tracts. In the eastern part of the county the glacial drift forms an uninterrupted sheet, commonly between 100 and 200 feet thick, but in most of the central and western parts it is thinner and in some places is only a veneer over the rock surface. Near the northwest and southwest corners (Pl. XVI, p. 814) beds of loose sand, which are believed to represent the basal Cretaceous deposit, appear to lie immediately below the drift, but elsewhere, as far as is known, the drift rests on Carboniferous rocks which, according to T. H. Macbride,[1] consist of shale and sandstone belonging to the Des Moines stage of the Pennsylvanian and of the Saint Louis limestone and the Kinderhook stage of the Mississippian. The shale and sandstone are probably not widely distributed, for in most sections limestone constitutes the first rock recognized by drillers. The succession is indicated by the following section of the Chicago & North Western Railway well at Renwick:

Section of railway well at Renwick.

	Thickness	Depth
	Feet	Feet
Soil, yellow and blue clay	40	40
Clay, hard, blue	100	140
Sand	10	150
Shale, red	20	170
Shale, white	4	174
Limestone	88	212

[1]Geology of Humboldt County: Ann. Rept. Iowa Geol. Survey, vol. 9, 1899, pp. 122 et seq.

UNDERGROUND WATER.

SOURCES.

Most of the water used in Humboldt county is obtained from the glacial drift and the Carboniferous limestones. In the eastern tier of townships relatively few wells have been sunk to rock, but many end in the lower part of the drift at depths of more than 100 feet. In the vicinity of Livermore the drilled wells average perhaps 100 feet in depth, and possibly half of them end in rock; in the vicinity of Humboldt they average somewhat deeper and a larger proportion enter rock. In the west-central part of the county limestone wells are also numerous, but in certain localities, especially near the northwest and southwest corners, all drilled wells end in sand.

In general the rock wells are the most satisfactory and yield the largest supplies, but where the drift is thin and the water level is low it is in some places necessary to drill considerable distances in the rock, and even where the latter lies entirely below the water level a generous yield is obtained only after a good crevice has been tapped. Although the upper part of the limestone is the most broken and fissured it occasionally happens that compact rock must be penetrated for many feet before an opening is found which will freely conduct water to the drill hole.

HEAD.

In the eastern part of the county water in the drilled wells rises nearly to the surface, and several flows have been struck in the valley of Prairie creek and elsewhere. In Boone valley, immediately east of Humboldt county, flows are obtained over an extensive area, but in Des Moines valley, which lies at a lower level, none exist. The difference is due to the fact that in the first valley there is a continuous thick blanket of bowlder clay which is so impervious that it acts as a confining bed, holding under pressure the water in the porous beds beneath; whereas in the second valley the stream has cut through the confining bed into the water-bearing strata, thus allowing the water to escape freely. The result is that one valley has flowing wells but practically no springs, and the other has numerous springs but no flowing wells.

In some localities in the western part of the county the water in the drilled wells remains at rather greater depths and the conditions are unusually favorable for draining swamps into the underlying limestone.

No deep drilling has been done in Humboldt county, but the wells in Algona, Mallard and Webster City indicate that the water from the deep formations will rise to approximately 1,100 feet above the sea and that wells may possibly flow with slight pressure in the Des Moines valley. The highest head would probably be obtained within a few hundred feet of the surface; no additional pressure would be gained by sinking to still lower horizons.

SPRINGS.

Springs are abundant in the valley of West Fork of Des Moines river, and also in that of East Fork near the junction of the two streams. They issue mainly from the limestone, where the impervious cover of bowlder clay has been removed by erosion.

CITY AND VILLAGE SUPPLIES.

Humboldt.—About half of the people of Humboldt (population, 1,809) are said to use the public supply. The water comes from a spring that flows into a reservoir, from which the water is carried, by gravity, through a pipe that passes under the river into a second reservoir, and is then pumped into a standpipe and system of mains. The total length of mains is 3½ miles, the number of fire hydrants is 21, and the number of taps is about 180. Approximately 60,000 gallons of water are consumed daily.

At Humboldt the drill (according to Norton), after passing the Mississippian limestone and shales, will enter the limestones and shales of the Devonian, below which some Silurian limestones may possibly be found. Next are shales 100 to 200 feet thick, correlated with the Maquoketa, although they may in part represent the Galena. Probably some water will be found in the Galena limestone. Below the Decorah shale and the Platteville limestone the drill will enter the Saint Peter sandstone, about 1,300 feet below the surface. This sandstone may easily reach 100 feet in thickness and should afford a good yield of excellent water. The supply may be largely increased by going deeper, say to 1,700 feet, to tap the stores held by the limestones and sandstones lying beneath the Saint Peter.

Livermore.—The village well at Livermore (population, 578) is 163 feet deep, the last 31 feet of which are in limestone. The water is said to stand about 55 feet below the surface (or about 1,080 feet above sea level) and to have been pumped at the rate of 60 gallons a minute.

KOSSUTH COUNTY

BY O. E. MEINZER.

TOPOGRAPHY.

The surface of Kossuth county forms a north-south trough, the southern and central portions of which are drained southward through East Fork of Des Moines river and the northern portion northward through Blue Earth river. These two rivers are connected across the divide between the Des Moines and Minnesota river basins by a swampy area known as Union Slough. The entire area is covered with glacial drift and exhibits a typical ground-moraine topography. The drainage is imperfect and swamps and ponds are numerous.

GEOLOGY.

If the layer of drift, which in most localities is over 100 feet thick, could be removed the surface on which it rests would probably comprise an erosional topography exposing a geologic section of considerable thickness and diversity. In the eastern and most of the central part of the county and also in a small area in the extreme southwest the drift lies upon indurated Paleozoic limestone, the age of which can not be definitely ascertained because outcrops are lacking. In a tract adjoining Des Moines river and throughout most of the western third of the county a wedge of soft shale and sandstone with a maximum known thickness of about 200 feet intervenes between the drift and the limestone. The upper beds of shale and sandstone are believed to be Cretaceous, but some of the lower beds probably belong to the Pennsylvanian series and possibly in part to the Permian. The following well sections, as reported by the drillers, show to some extent the character and relations of these strata:

Generalized well section for the vicinity of Wesley.

	Thickness.	Depth.
	Feet	Feet
Soil and yellow clay	8	8
Clay, blue	45	53
Clay, brick, sand and gravel with fragments of wood	5	58
Clay, blue	45	103
Clay, black, with fragments of wood	2	105
Clay, yellow, sandy	7	112
Clay, blue	83	195
Clay, yellow, and broken limestone	2	197
Limestone (entered).		

Section of well immediately north of Luverne.

	Thickness.	Depth.
	Feet	Feet
Clay, blue	80	80
Sand	10	90
Clay, red	50	140
"Flint"	6	146
Sandstone	20	166
Shale	10	176
Limestone (entered)	2	178

Section of well at the Algona steam laundry.

	Thickness.	Depth.
	Feet	Feet
Clay, blue	90	90
Sand		
Shale, or clay, yellow		
Shale or clay, red	125	215
Shale or clay, blue		
Limestone	5	220
Sandstone	7	227
Limestone (entered).		

Section of abandoned village well at Whittemore.

	Thickness.	Depth.
	Feet	Feet
Clay, etc.	115	115
Sand, etc.	40	155
Shale	3	158
Sandstone (entered).		

The section at Wesley suggests three distinct drift sheets whose deposition occurred at intervals sufficiently long to enable a soil to form and some weathering to occur at the top of each before it was covered by the next. The section at Bancroft (page 792) likewise suggests either two or three distinct drift sheets. The red clay or shale reported in a number of the sections in Kossuth, Humboldt and Palo Alto counties may represent the red shale found in the vicinity of Fort Dodge.

UNDERGROUND WATER.

SOURCE AND DISTRIBUTION.

Water is obtained from glacial drift, Cretaceous sandstone and Paleozoic limestones and sandstones.

In the northeastern part of the county, where the drift rests upon limestone at depths ranging from about 100 feet in the vicinity of Germania to much more in certain other localities, many drilled wells pass through the entire thickness of drift and find water after penetrating only a short distance into the limestone. Farther west, in the vicinity of Swea City, a few wells reach limestone at about 200 feet, but in general the rock lies much farther below the surface and the wells are finished either in the drift or in the Cretaceous sand.

Similar conditions prevail in the central portion of the county. Thus, at Ramsey postoffice, near Union Slough, limestone occurs and is reached by many drilled wells at about 100 feet; at Bancroft it lies 240 feet below the surface and is reached by only a few wells; and at Ringsted, three miles west of the county line, it occurs at 364 feet and is almost never reached in drilling.

In the southeastern part of the county many bored wells end in the drift at depths of less than 100 feet, but a large proportion of the drilled wells enter rock, although in some localities this lies at considerable depths. In a very general way it may be said that the most common depths of the drilled wells are between 150 and 190 feet in the region south of Titonka, between 200 and 230 feet in the vicinity of Wesley, about 175 feet in the vicinity of Sexton, between 200 and 260 feet in the high area surrounding Saint Benedict, and between 75 and 200 feet in the vicinity of Luverne. In much of the region south of Wesley and east of Luverne the drift is deep and drilled rock wells are proportionately rare.

In the vicinity of Algona there is a wide range in the depth of wells, some of the drift wells being very shallow and some of the rock wells going down more than 300 feet. An average for drilled wells is probably between 150 and 200 feet. In the high area north of Whittemore the drilled wells range in general between 200 and 330 feet and end either in the drift or in the subjacent beds of sand. South of Whittemore the range in depth of wells is between 70 and 200 feet and most of the wells end in sand, except in a small area near the southwest corner of the county, where limestone is sometimes reached by the drill.

Of the several sources of water in this county the limestone is the most satisfactory. Its upper portion is generally creviced—a condition probably due to preglacial weathering—and hence it supplies water very freely. On the other hand, sand at higher levels causes much trouble by rising in the wells or by clogging screens. Only 6-inch wells should be sunk and, except in those areas where the depth to rock is great, drilling should be continued until limestone is reached or a satisfactory sand or gravel bed is encountered. As the ordinary rock wells yield generous quantities of good water little if anything is to be gained by drilling to the deeper formations.

HEAD.

The upper part of the glacial drift is more or less porous and as a rule is saturated almost to the surface, the water table closely following the topographic irregularities. But the bulk of the drift consists of dense bowlder clay which appears to be quite impervious to water and which serves in a sense as a confining bed that holds under pressure the water in the creviced limestone, in the sand strata, or in the sand and gravel deposits within the drift itself. Hence, when a hole is drilled through the bowlder clay, the water from the underlying formations rises under pressure to a certain definite level, which is generally higher (above the sea) in elevated than in depressed regions, but which does not follow the topographic irregularities nearly as closely as does the surficial ground-water table. Hence it is that in the highest areas the water remains far below the surface and in the lowest areas it may rise above the surface.

The following table shows the head of the water at several points in or near this county:

Head of water in and near Kossuth County.

Locality	Altitude of surface above sea level	Height to which water rises	
		Above or below surface	Above sea level
	Feet	Feet	Feet
Buffalo Center (Winnebago county)	1,183	— 14	1,169
Germania		Above	1,145
Swea City	1,174	— 15	1,159
Armstrong (Emmet county)	1,240	— 68	1,172
Bancroft	1,210	— 60	1,150
Burt	1,170	— 30	1,140
Ringsted (Emmet county)	1,251	— 76	1,175
Wesley	1,246	— 80	1,166
Sexton	1,218	— 70	1,148
Saint Benedict	1,266	—125	1,141
Algona	1,193	— 53	1,140
Whittemore	1,200	— 35	1,165
Corwith (Hancock county)	1,178	— 20	1,158
Luverne	1,169	— 40	1,129
Livermore (Humboldt county)	1,140	— 55	1,085
West Bend (Palo Alto county)		Above	1,156

Wells obtain flowing water in a tract of considerable extent adjacent to Blue Earth river, chiefly in Hebron, Springfield, Ledyard, and Lincoln townships, and also in the valleys of Buffalo, Mud, Prairie, and Lotts creeks, all of which drain into Des Moines river. Throughout the entire northeastern part of the county the water rises nearly to the surface, but in the high areas in the northwestern and west-central parts, and in the region about St. Benedict, it remains at considerable depths. To the south the head is lowered by the leakage that takes place farther south where the rocks outcrop along both forks of Des Moines river.

CITY AND VILLAGE SUPPLIES.

Algona.—The public supply of Algona (population, 2,908) is obtained from two deep wells: City well No. 1, drilled by S. Swanson, of Minneapolis, which is 1,050 feet deep, and City well No. 2, which is 818 feet deep. The curb of well No. 1 is approximately 1,202 feet above sea level, and the water level is 69 feet below curb. The driller's logs follow:

Driller's log of city well No. 1, Algona.

	Thickness	Depth
	Feet	Feet
Material	235	235
Sand rock	75	310
Lime rock	125	435
Sand rock	300	735
Shale and streaks of sand rock	315	1,050

Log of city well No. 2.

	Thickness.	Depth.
	Feet	Feet
Soil	4	4
Clay, yellow	10	14
Clay, blue	77	91
Sand	50	141
Shale, blue; shale, white; flint shale, light blue	169	310
Limestone	508	818

The water level in the first well lowers notably when pumped 50 gallons a minute, but the second yields 150 gallons by the use of an air lift. There are a standpipe, about five miles of mains, and 39 fire hydrants. It is reported that about 1,600 people are supplied and that an average of 60,000 gallons is consumed daily.

Bancroft.—The public supply of Bancroft (population, 830) is taken from a rock well, 242 feet deep, which has been tested at 40 gallons a minute. The system comprises an elevated tank, about one-half mile of mains, eight fire hydrants, and 28 taps. Approximately 5,000 gallons of water are used daily and perhaps 125 people are supplied.

A well at one time drilled for the railroad company is said to be 500 feet deep with the water rising within 2 feet of the surface, which would be 1,187 feet above sea level. The well stood a good test, but the water is so hard that it is not used in locomotives.

Section of village well at Bancroft.

	Thickness.	Depth.
	Feet	Feet
Soil and yellow clay	15	15
Clay, blue	50	65
Sand containing wood, snails, etc.	6	71
Clay, blue	20	91
Sand	5	96
Clay, red and yellow	138	234
Gravel	6	240
Limestone, entered	2	242

Burt.—The village well at Burt (population, 495) is 175 feet deep and has been pumped at the rate of 40 gallons a minute. The water rises within 30 feet of the surface.

Waterworks with nearly a mile of mains and 10 fire hydrants have been installed.

Swea City.—The public well at Swea City (population, 402) is 117 feet deep and ends in sand from which the water rises within 15 feet of the surface (1,160 feet above sea level). It has been pumped at the rate of 30 gallons a minute. The water is pumped to an elevated tank and is to be distributed through a system of mains.

MITCHELL COUNTY

BY O. E. MEINZER.

TOPOGRAPHY AND GEOLOGY.

Mitchell county exhibits few topographic irregularities. The deep-drift area, however, is higher than the shallow-drift area, a fact that has an important bearing on ground-water conditions.

The bedrock in all parts of the county probably consists of limestone of Devonian age, upon the irregular surface of which rests a mantle of glacial drift. In the southwest the average thickness of the drift is perhaps 200 feet, and in certain localities it exceeds 300 feet. In much of the northeastern part it is also thick, but its average is less. Thus in the northern part of Jenkins township and in much of Wayne township the drift is only about 50 feet thick, though in the southern part of Jenkins and in some places in the northeastern sections of Wayne it is much heavier, locally exceeding 200 feet. In the second tier of townships from the east the drift is thinner than in the first tier; in most places in the western half of the county it is less than 25 feet thick and limestone outcrops are abundant, especially along Red Cedar river.

UNDERGROUND WATER.

SOURCE AND DISTRIBUTION.

Water is derived from alluvial and outwash deposits, glacial drift, Devonian limestone, limestone below the Devonian, and Saint Peter sandstone.

Deposits of alluvial sand and gravel occur locally in the valleys of the principal streams and afford large quantities of water to wells from 15 to 25 feet deep. Within the body of the glacial drift there are many water-bearing beds of sand and gravel, the shallowest of which can not, however, be relied on to yield water in dry years. The limestone everywhere yields an unfailing supply and is the most valuable water bed in the county. The city well at Osage extends through the Saint Peter sandstone, which was encountered at a depth of 715 feet.

In the southeastern townships most of the drilled wells end in beds of gravel and sand far down in the drift, many wells being more than 200 feet and a few more than 300 feet deep. In the northeastern townships most of the drilled wells end in limestone at depths averaging about 100 feet in the localities of thinnest drift and about 200 feet in the localities of thickest drift. In the second tier of townships from the east drilled wells commonly range in depth between 100 and 150 feet, some ending in limestone and others in drift. In the western half of the county by far the greater number of good wells are drilled into rock and obtain an abundance of water at depths ranging from about 50 to 150 feet.

SPRINGS AND FLOWING WELLS.

In the western part of Mitchell county, especially in the valley of Red Cedar river, some rather large springs issue from the limestone, the spring in the park south of Osage being typical. In the eastern part of the county smaller seeps come from gravelly beds in the drift; the spring at Riceville may be cited as an example.

In a belt running north and south through the western part of Wayne, Jenkins, and Burr Oak townships the water in the drilled wells rises nearly to the surface and in some wells overflows with slight pressure; farther west it does not flow, even though the altitude is lower. The explanation of this distribution of flowing wells appears to be as follows:

Along the east margin of Mitchell county and the adjoining parts of Howard county the surface is relatively high and the pervious portions of the drift are filled with water nearly to the surface. To some extent these pervious members are in communication with the underlying limestone, which they thus keep supplied with water under considerable head. The limestone may be regarded as a continuous water-bearing formation, and consequently, if farther west, where the altitude is lower, a well is drilled into the limestone or into sand or gravel in communication with it the water will rise under pressure and a flowing well may result. The drift thus plays the double part of a porous formation through which the water enters and an impervious layer under which it is confined. A short distance farther west, however, no flows are obtained, although the surface is still lower, the rapid reduction of the artesian pressure evidently being due to leakage through the thin drift cover and through rock outcrops.

Altogether there are in this belt probably several dozen flowing wells grouped in clusters along streams or in depressions. The well on the farm of James McCarthy, in the SW. 1/4 sec. 9, T. 98 N., R. 15 W., is locally famous for its unusually strong pressure and flow. It ends in gravel at the depth of 174 feet and is reported to flow about 300 gallons a minute.

In the Osage deep well the water from the Saint Peter sandstone rises to about 1,110 feet above sea level. According to the railway surveys the altitude at Osage is 1,168 feet above sea level; at Riceville, 1.229 feet; at McIntyre, 1,279 feet; at Stacyville, 1,208 feet, and at Saint Ansgar, 1,175 feet.

CITY AND VILLAGE SUPPLIES.

Osage.—At Osage (population, 2,445) it is reported that 40,-000 gallons are pumped from the city well daily and about 1,500 people are supplied. The water is lifted into an elevated tank and thence distributed through nearly four miles of mains to 42 fire hydrants and about 400 taps.

The city well (Pl. VII, p. 324) is 780 feet deep, 12 to 10 inches in diameter, and is cased to a depth of 192 feet without packing; the curb is 1,168 feet above sea level, and the water stands 60 feet below curb. The tested capacity is 200 gallons a minute. Water horizons are reported at 110 feet, with water heading 70 feet below curb; and at 650 feet, heading 60 feet below curb; water is also reported at 780 feet. The temperature of the water is 48° F. The well was drilled in 1899 by J. F. McCarthy, of Minneapolis, and cost $2,400.

Driller's log of city well at Osage.

	Thickness.	Depth.
	Feet	Feet
Drift	20	20
Limestone	160	180
Gumbo shale	20	200
Limestone (water at 650 feet)	460	660
Shale and sandstone mixed	60	720
Sandstone	60	780

Record of strata in Osage city well.[a]

	Thickness.	Depth.
	Feet	Feet
No sample	490	490
Dolomite, light buff, crystalline; beginning at 490 feet; 4 samples	50	540
Limestone, light gray; effervescing freely in cold hydrochloric acid; 6 samples	85	625
Limestone, yellowish; with pyritic crystals and small nodules; 2 samples	15	640
Limestone, light gray; with pyrite; 1 sample	5	645
Limestone, dark gray; small chips of lighter gray from above; some grains of pyrite; 1 sample	10	655
Limestone, dark gray, shaly, pyritic; 1 sample	5	660
Limestone, dark gray; chips of green shale	10	670
Shale, greenish	5	675
Shale, slaty gray; some small flakes of limestone and crystals of pyrite; 2 samples	20	695
Shale, dark green; a few small bits of limestone and grains of clean water-worked quartz sand	20	715
Quartz sand, clean, clear, water worn; some chips of green shale from above; 3 samples; sand at 750 feet a little finer than that above	35	750
Sand, yellowish; finer than any in the above	10	760
Shale, greenish, marly; some sand grains and small chips of limestone	10	770
Sand, fine, gray; well rounded grains; some shale	10	780

[a]Calvin, Samuel: Ann. Rept. Geol. Survey of Iowa, vol. 13, 1903, p. 336.

Calvin refers the sandstones from 725 feet to the bottom of the well to the Saint Peter, and all the rocks above it to the Galena, Decorah, and Platteville formations. The occurrence of water above the Decorah shale—the source of powerful springs in the northeastern counties of the state—should be noted.

Riceville.—The public supply of Riceville (population, 844) is taken from a spring which issues from a seam of sand in the drift at the bank of the river and yields about 20 gallons a minute. The water is allowed to flow into a reservoir from which it is pumped into an elevated tank and thence distributed through a small system of mains to four fire hydrants and 15 taps.

St. Ansgar.—The city well at St. Ansgar (population, 747), put down in 1902 by Emil Sedlack, of Thief River Falls, Minnesota, is 240 feet deep and 10 inches in diameter. (See Pl. VII, p. 324.) The curb is 1,175 feet above sea level and the water stands 20 feet below the curb.

This well was in process of boring when the county was surveyed by the Iowa Geological Survey. The drill had then reached a depth of 160 feet, the last 60 feet being in the Maquoketa shale.

WINNEBAGO COUNTY

BY O. E. MEINZER.

TOPOGRAPHY AND GEOLOGY.

Winnebago county is covered with glacial drift to a depth, in most localities, of 100 to 200 feet. The upper layer is of Wisconsin age and has a gently undulating and poorly drained surface. The highest land and the deepest drift are found in a north-south belt which passes through the central part of the county. Beneath the drift is an irregular limestone surface not known to outcrop within the county.

UNDERGROUND WATER.

SOURCES.

Water is obtained from the glacial drift and from the underlying limestone. The drift is tapped by a large number of dug, bored, driven, and drilled wells, and furnishes the greater part of the supply; the limestone is reached by a smaller number of drilled wells, but the supplies are very satisfactory.

Driven wells are successful only over small tracts where coarse material has been deposited at the surface. Bored wells are common throughout the county, but many of them are filthy and their yield is frequently small and uncertain. Drilled drift wells penetrate deeper and reach beds of sand and gravel from which water is delivered under pressure. Where the water-bearing material is sufficiently coarse, they are satisfactory, but in some of them the sand is so fine that it rises when the water is pumped. Drilled rock wells extend through the entire thickness of the drift and communicate with the system of joints and solution passages which ramify through the limestone, and which are charged with abundant excellent though hard water that is everywhere under pressure. Drilled rock wells are most common in the western part of the county and least numerous in the central part where the drift is deep.

The good features of rock wells can be summarized as follows: (1) They contain no sand to cause trouble; (2) their yield is usually large and permanent; (3) the water is under enough pressure to rise high above the bottom of the wells, thus requiring a comparatively small lift; and (4) if they are properly cased their water is pure. As at all points the limestone is within easy reach of the drill, it is advised that, where the yield from the drift is not abundant or the sand causes trouble if not screened, drilling should be continued until limestone is penetrated and free communication is established with its water-filled crevices. It is poor economy to stop with an unsatisfactory sand well when a little deeper drilling would result in a good limestone well.

HEAD.

The water in the limestone and deeper parts of the drift is invariably under a pressure which lifts it far up in the wells. The lowest head, relative to the surface, is found in some of the highest areas in the central part of the county, but even here the lowest head reported was only 75 feet below the surface.

Near the west margin of the county flows are obtained in the creek valleys and other low-lying areas. In the well at Forest City a light flow was struck in gravel at a depth of 80 feet and stronger flows were obtained at lower levels. Other flowing wells could probably be obtained in the valley of Lime creek. The following table shows the head of the water from the lower part of the drift or the subjacent limestone at several points:

Head of water in Winnebago County.

Locality	Altitude of surface above sea level	Height to which water rises	
		Above or below surface	Above sea level
	Feet	Feet	Feet
Lake Mills	1,265	—30	1,235
Forest City (in valley)	1,180	Above	1,180
Thompson	a1,275	—75	a1,200
Buffalo Center	1,183	—14	1,169
Rake	1,154	—10	1,144

a Approximate.

Wells which, like the Forest City well and the Lake Mills railway well, have been sunk to some depth into the limestone, yield so generously, have so good a head of water, furnish such a fair quality of water, and are in every respect so satisfactory that it does not seem advisable to drill deeper even where large supplies are required. From the deep-well data in this region it may be inferred that the water from the lower sandstones would not rise so high as that in the limestone underlying the drift.

DRAINAGE WELLS.

Where the water in rock wells stands at some depth below the surface, it is possible to drain ponds and swamps through them into the rock, though it is not certain that this method of drainage can be made profitable. Where the water rises nearly to the surface, as along the west margin, drainage through wells is not feasible. In other sections of the state wells discharging into sand have not proved as successful as those which discharge into creviced limestone, and the same condition would probably exist in Winnebago county.

CITY AND VILLAGE SUPPLIES.

Buffalo Center.—The village well at Buffalo Center (population, 456) is 168 feet deep, the last 44 feet of which are in limestone. The water stands 14 feet below the surface, or 1,169 feet above sea level. There is an elevated tank, and new mains are being laid to replace the old ones which have become corroded. The people depend almost entirely on private wells, many of which are sunk only a short distance into the drift.

Forest City.—The well which furnishes the public supply at Forest City (population, 1,691) is four inches in diameter and 300 feet deep, the last 180 feet of which are in limestone. It is located in the valley, and the water rises a few feet above the surface, or to about 1,180 feet above sea level. It yields several hundred gallons per minute by natural flow at the surface and discharges into the bottom of an underground reservoir at a rate of about 800 gallons a minute when the water level in the latter is lowered to seven feet below the surface. Approximately two-thirds of the inhabitants of Forest City are reported to use the public supply. The water is pumped into a standpipe and delivered through 3½ miles of mains to 33 fire hydrants and about 140 taps. It is estimated that an average of 90,000 gallons of water are consumed daily.

According to a forecast of artesian possibilities made by Norton, the Saint Peter sandstone is estimated to lie only 700 or 800 feet below the surface, or between 400 and 500 feet above sea level. Water may be found in considerable quantity above the Saint Peter, in the Galena limestone, and in the Platteville limestone above its basal shales. These basal green shales of the Platteville, which rest on the Saint Peter, may be expected to be heavy and to need casing. The Saint Peter sandstone should exceed 50 feet in thickness, and may be more than double that. The limestones and sandstones underlying the Saint Peter would add largely to the supply, and sinking for less than 500 feet below the base of the latter would test their possibilities. The quality of the water should be excellent, its chief mineral ingredients being calcium and magnesium carbonates.

Lake Mills.—The well which furnishes the public supply at Lake Mills (population, 1,214) is 233 feet deep and enters limestone at 105 feet. The water rises to 30 feet below the surface, or about 1,235 feet above sea level, and has been pumped at 35 gallons a minute. The well of the Chicago & North Western Railway Company at the same place is 334 feet deep, and enters limestone at 120 feet, with the water rising within 21 feet of the surface, or about 1,235 feet above sea level. In this well pumping at the rate of 125 gallons a minute for 10 hours did not perceptibly lower the water.

The public supply is pumped to an elevated tank, which connects with more than a mile of mains and 11 fire hydrants. Most of the people use water from private wells, but a few are supplied from the public waterworks. Approximately 17,000 gallons of water are used daily.

No deep wells have been drilled within a considerable distance of Lake Mills, but the dip of the strata, as estimated from the sections at Easton, Minnesota, and Mason City, indicates, according to Norton, that the Saint Peter sandstone lies 500 to 600 feet above sea level or about 700 to 800 feet below the surface. If any deep well is drilled it should be sunk to the bottom of this formation, which may be 100 feet in thickness.

Thompson.—The public supply at Thompson (population, 500) is derived from a drilled well six inches in diameter that ends in limestone at the depth of 300 feet, the water rising to a level 75 feet below the surface. The waterworks consist of an elevated tank with less than a quarter of a mile of mains and four fire hydrants. The people rely chiefly on private shallow drift wells, using only 2,500 gallons daily of the public supply.

WORTH COUNTY

BY O. E. MEINZER.

TOPOGRAPHY AND GEOLOGY.

The outer margin of the terminal moraine of the Wisconsin drift sheet crosses Worth county diagonally from northeast to southwest. West of this margin the topography is irregular and morainic and the drainage is poor; east of it an older drift lies at the surface, which, although only slightly dissected, has a well-developed drainage system.

The total thickness of the glacial drift is greatest in the northwestern morainic townships, where over extensive areas it measures between 100 and 200 feet, and in the extreme northeast, where in many places it exceeds 100 feet. Throughout the rest of the county its average thickness is probably 50 feet or less. The drift is for the most part underlain by Devonian limestone, which is exposed in many places along Shell Rock river and other streams.

UNDERGROUND WATER.

SOURCES.

The water supply of Worth county is obtained from alluvial and outwash deposits, glacial drift, and limestone of Devonian age or possibly older.

There are many drilled wells in all parts of the county, although shallow dug, bored, and driven wells are numerous in the morainic area and in the areas where alluvial and outwash sands and gravels lie at the surface. The drilled wells end in the lower parts of the drift or in the subjacent limestone, the average depth, as well as the proportion that end in drift, being greatest where the drift is thickest. In general the wells ending in limestone are the most satisfactory, and, as in nearly all parts of the county this rock is within easy reach of the drill, it is usually unwise to depend on the drift for either farm or village supplies.

One of the deepest wells in the county is that of the Chicago & North Western Railway, at Hanlonton, which enters limestone at a depth of 23 feet and extends to a total depth of 260 feet. The water in this well is reported to rise within 23 feet of the surface and to have been pumped at the rate of 100 gallons a minute.

CITY AND VILLAGE SUPPLIES.

Northwood.—The city well at Northwood (population, 1,264) is 10 inches in diameter and 92 feet deep, the last 50 feet being in limestone. The water rises within 18 feet of the surface, or to about 1,204 feet above the sea, and has been pumped continuously for 15 hours at 100 gallons a minute without noticeable effect. It is lifted from the well into an elevated tank and is thence distributed by gravity through about one and three-fifths miles of mains to 20 fire hydrants and approximately 70 taps. It is estimated that 400 people are supplied and that about 18,000 gallons of water are consumed daily. Nearly all the private wells are less than 100 feet deep.

Northwood is 1,222 feet above sea level. According to a forecast of the artesian conditions of the locality made by Norton, the drill, after penetrating the cover of drift clays and sands, will pass through Devonian limestones and shales with possibly some Silurian limestones, the whole, however, being less than 175 or 200 feet thick. The Maquoketa shale, here rather thin, will then be penetrated, and below it several hundred feet of magnesian limestones may be expected. As these last are underlain by a heavy shale belonging to the Platteville limestone, considerable water will probably be found in their crevices and porous beds. A dependable supply will be found in the Saint Peter sandstone immediately below the heavy shale mentioned, which may be expected at about 600 feet above sea level, or about 625 feet below the surface, although it may lie 100 feet deeper. About 100 feet should be allowed to penetrate this shale.

WRIGHT COUNTY

BY O. E. MEINZER.

TOPOGRAPHY AND GEOLOGY.

All of Wright county is covered with glacial drift. Extending across it, somewhat east of the center, with a general north-south trend, is a high morainic belt which contains several lakes and other undrained depressions and forms the divide between the basin of Iowa river, which flows through the eastern part of the county, and the basin of Boone river, which flows through the western part. In this belt is found the deepest drift, the average depth probably being not less than 200 feet; at one point, two miles south and two miles east of Clarion, a depth of 367 feet is reported. In much of the eastern part of the county, on the other hand, the depth of the drift is only about 100 feet, and in the Iowa valley it is generally less. Throughout all or nearly all of the county the drift rests upon a surface of indurated Paleozoic limestone.

UNDERGROUND WATER.

SOURCES.

The water supply is derived from the glacial drift and the underlying limestone. The upper layer of drift, owing to its loosely consolidated and somewhat gravelly condition, is to a certain extent porous, and because of the poor drainage, it is normally saturated nearly to the surface with water which it yields slowly to shallow dug or bored wells; but in time of protracted drought this surficial water largely disappears and leaves the wells without adequate supply. In certain small districts, where beds of sand or gravel lie at the surface, as in parts of the Iowa valley, inexpensive wells with large yields are obtained by driving points only a short distance into these porous water-filled deposits. Deeper in the drift beds of sand and gravel are interbedded with dense blue bowlder clay, and these beds are almost invariably saturated with water under pressure. Numerous drilled wells are supplied from this source.

The limestone below the drift is hard and impervious, but more or less broken and cavernous, and it is this condition, probably produced by preglacial weathering, that renders it an excellent aquifer. The openings in the rock are charged with water under considerable head, and when they are encountered by the drill the water surges into the well and rises rapidly to a level determined by the head. That large supplies can be obtained by drilling some distance into the limestone is shown by the village wells at Forest City, Britt, Latimer and Clarion, each of which will furnish several hundred gallons a minute without any great lowering of the water level. Moreover, wells ending in rock do not give trouble as do so many of the sand wells, and the yield does not deteriorate with time as is frequently the case in wells ending in fine-grained unconsolidated material. Though it is not always necessary to drill to rock, yet there is much ill-advised economy in finishing wells in unsatisfactory sand beds when a little deeper drilling would reach rock and result in a much better and more permanent well. Another mistake frequently made, especially where large supplies are desired, is in stopping the drill before the limestone has been penetrated a sufficient depth. The farther the drill hole enters the rock the more water-filled crevices it taps and the more chances there are that a large fissure or cavern will be encounterd. The village wells mentioned above penetrate rock to depths ranging from 20 to 180 feet.

HEAD.

The following table shows the head of the water from the limestone and lower parts of the drift at several points in or near Wright county:

Head of water in and near Wright County.

Locality	Altitude of surface above sea level	Height to which the water rises	
		Above or below surface	Above sea level
	Feet	Feet	Feet
Belmond	1,180	0	1,180
Galt	1,200	—50	1,150
Dows	1,140	0	1,140
3 miles east of Clarion	a1,240	—97	a1,143
Clarion	1,170	—28	1,142
Florence	1,130	0	1,130
Goldfield	1,108	Above	1,120
Eagle Grove	1,109	Above	1,120
Corwith (Hancock county)	1,178	—20	1,158
Luverne (Kossuth county)	1,169	—40	1,129
Renwick (Humboldt county)	a1,130	—30	a1,100

In the high central belt the water in the drilled wells remains far below the surface, lifts of 50 to 100 feet being general. On the lower ground east of this belt the water usually rises near the tops of the wells, and in the lowest parts of the valley of Iowa river at Belmond, Dows and elsewhere, flows are obtained. West of this belt over an extensive area the water rises above the surface or remains only a few feet below, flows being obtained all along the immediate valley of Boone river and far up the valleys of Otter, Eagle and White Fox creeks and their tributaries. James Rowe, an experienced driller in Eagle Grove, estimates that a flow can be obtained at some low point on approximately half of the farms in the western half of the county.

The above table shows that the head of the water is relatively independent of the surface configuration, the water rising to nearly the same level above the sea in the high central area, where it remains far below the surface, as in the valleys, where flows are obtained, the wells being as truly artesian in principle in one area as in the other. The table shows, however, that the head gradually lowers toward the south and west, a condition due to leakage at rock outcrops in the Des Moines valley to the west and in the Iowa valley and other localities to the south.

Information gained from deep wells drilled at several places near Wright county indicates that the water from the sandstone

[a]Approximately.

formations below the limestone will rise to approximately 1,100 feet above the sea. The supply from the rock immediately beneath the drift is so satisfactory in quantity, quality, head, and other respects that probably nothing would be gained by drilling to the more deeply buried sandstones.

DRAINAGE WELLS.

In the high central area, where the water in rock wells remains a considerable distance below the surface, it is possible to drain swampy tracts by conducting the surface water into drainage wells, but in the lower parts of the county, where the water from the limestone rises nearly or quite to the surface, this method can not be employed. Where it is possible to drain into stream channels or large cooperative ditches, drainage into wells will probably not be profitable, but it is possible that, where conditions are favorable, small isolated swamps, remote from any ditch or stream channel, can be profitably reclaimed by wells. The two favorable conditions in the central part of this county are (1) the low head of the well water and (2) the creviced character of the limestone, both of which increase the capacity of a well for receiving water; the one unfavorable condition lies in the thickness of the drift, which, of course, increases the cost of the wells proportionately. Thus far drainage wells have not proved very successful even where the physical conditions are the best, the chief difficulty being the rapid deterioration in the capacity of the wells, which is believed to be due to the clogging of the pores and crevices in the rock by sediment carried in with the water. This deterioration takes place more rapidly in sand and gravel deposits, whose pores readily become sealed, than in the limestone which has larger openings that are not so easily clogged. If drainage into wells—even into limestone wells—is to be made successful, it will be necessary to devise methods for lengthening the life of the wells used for this purpose, and this can probably be accomplished only by preventing sediment from entering with the water. An experiment that might be worth trying is to excavate a reservoir of considerable size in which the water could stand for some time, thus allowing the suspended matter to settle before the water is taken into the well. Such a reservoir would also greatly augment the potential capacity of the well in that it would receive the water from a heavy rain and supply it to the well gradually, thus draining the land before the crops were damaged and yet allowing the well to be functional during a large part of the time. Where the drainage is effected by an underground system of tiles, the difficulty with suspended matter is much less than where the water is led to the wells in ditches.

CITY AND VILLAGE SUPPLIES.

Belmond.—The public supply at Belmond (population, 1,224) was until recently taken from a dug well 14 feet in diameter and 25 feet deep and from eight driven wells 27 feet deep, the water coming from a surface layer of sand. There are an elevated tank, 1½ miles of mains, 16 fire hydrants, and 56 taps. It is estimated that about 225 people, or one-fifth of the population, are supplied and that about 18,000 gallons are consumed daily.

The city well recently completed has a depth of 500 feet and a diameter of 10, 8, and 6 inches; casing 10 inches to rock at 130 feet, 8 inches to about 250 feet. The curb is 1,180 feet above sea level and the head 16 feet below the curb. The depth to the principal supply is 500 feet; another water bed is at 25 feet. Date of completion, 1911; driller, W. L. Thorn, of Sparta, Wisconsin.

Driller's log of city well at Belmond.

	Thickness	Depth.
	Feet	Feet
Gravel and clay (drift)	130	130
Lime rock (Mississippian)	100	230
Shale (Lime Creek, of Devonian)	40	270
Lime rock	?	?
Shale	20-30	?
Lime rock (to bottom)	?	500

The well penetrates deeply the Devonian and perhaps the Silurian limestones, but does not reach the Maquoketa shale, although that formation should be found within 100 feet of the bottom. The Saint Peter sandstone is estimated by Norton to be about 1,150 feet below the surface.

Clarion.—The village well at Clarion (population, 2,065) is 280 feet deep and ends in limestone from which the water rises to 28 feet below the surface, or 1,142 feet above sea level. It has been tested at 500 gallons a minute. An elevated tank has recently been erected and a system of mains laid.

Clarion is 1,170 feet above sea level. According to Norton, a deep well passing through the cover of glacial drift should find limestone with some shales extending to a depth of about 750 feet. In these limestones, which are of Mississippian, Devonian, and probably also of Silurian age, some water may be found and its quality will probably be so good that it will not require casing out. Below these limestones lies a bed of mud-rock shale. the Maquoketa (Ordovician), which effectually parts the waters above it from those below. The Maquoketa shale rests on 300 to 350 feet of dolomitic limestones (Galena), below which the drill will enter the heavy green Decorah shale and then the limestones and shales of the Platteville, which together may exceed 75 or even 100 feet in thickness. In the Galena and Platteville limestones the drill may be fortunate enough to strike one or more water beds in creviced or porous rock and may possibly find a supply sufficient for the town, but as the formation immediately underlying the Platteville limestone is the Saint Peter sandstone it is advised to carry the drilling into this white and smooth-grained sandstone. The top of the Saint Peter should be reached at about 1,270 feet from the surface, but the contract for a well should provide for going to a depth of 1,500 or 1,600 feet if necessary in order to insure against contingencies, although 1,400 feet should be amply sufficient to tap not only the Saint Peter but also the main water beds below it.

Dows.—The public supply at Dows (population, 892) is taken from an eight-inch well 85 feet deep, in which the water rises to 15 feet below the surface, or to 1,146 feet above the sea. There are an elevated tank, five-eighths of a mile of mains, nine fire hydrants, and 15 taps. The water is used by only a small part of the population and the average daily consumption is reported to be approximately 5,000 gallons.

Eagle Grove.—Only a few people in Eagle Grove (population, 3,387) use the public supply; the rest have private wells, most of which overflow. The public supply is taken from two wells, one of which is a 20-inch bored well that ends in gravel and is cased with tile, the other a six-inch drilled well with iron casing extending to a depth of 168 feet and penetrating limestone, from which the water rises above the surface. The two wells will together discharge 500 gallons a minute into an underground reservoir through an orifice 25 feet below the surface. There are a standpipe, 3 miles of mains, and about 35 fire hydrants. It is estimated that approximately 40,000 gallons are consumed daily.

Norton estimates that if the dip of the strata from Mason City to Fort Dodge is uniform the Saint Peter sandstone should occur at Eagle Grove at very nearly 1,300 feet below the surface, and that it and the formations immediately below it would yield a large quantity of wholesome water. In order to get the largest yield it is recommended to sink to 600 or 700 feet below sea level, or to 1,700 or 1,800 feet below the surface. As soon as the shales of the Saint Lawrence formation appear, at 1,700 feet or lower, the drilling should be stopped except under expert advice to the contrary.

No special difficulties in drilling need be apprehended. Shales may be expected to occur among the limestones of the upper 800 feet, and heavy shales will be found between 800 and 950 feet, and again between 1,200 and 1,300 feet. These should be cased to insure against caving.

Water beds will probably be struck in the limestones above the Saint Peter, but it is hardly probable that the quality of any of these waters will be such as to necessitate their being cased out.