Water supply reports and well records. 1931-1943

Thwaites, F. T. (Fredrik Turville), 1883-1961
[s.l.]: [s.n.], 1931-1943

Underground waters at Highlands, Indiana

On April 22, 1930 the undersigned made a brief examination of underground water conditions at Highland, Indiana at request of Mr. F. M. Gray, Jr., well contractor, Milwaukbe, Wis.

Highlands is situated on the second or Calumet beach of ancient Lake Michigan (Lake Chicago) and lies approximately 40 feet above the present Lake level. The surface material in the ridge which gives the town its name is a medium grained yellow sand which contains a few pebbles, most of them of shale. No gravel deposits were observed or reported. Material underlying this sand was not seen. The surface sand extends south under a large swamp. To the north the land slopes toward Lake Michigan and appears to be a clay soil.

Existing water supply is derived from three wells. No 1. groump is situated south of the main street and east of the bank corner. Several wells were put down here. The deepest well (6" in rock, 8" pipe) which is west of the others is 600 feet total depth. The drift is reported to consist largely of clay but there is considerable sand next to the rock for several 80 foot Cooke screen wells were also used for some time. Drift is said to be about 100 feet thick. The yield is reported to be about 50 g.p.m. Static head is about 5 feet below surface but amount of draw down has not been measured. No. 2 pumping station is south of the main part of the town. The single 6" well has a total depth of 340 feet of which about 140 feet is drift. Material on dump seems to indicate blue clay and fine silty sand. Water is said to stand about 3 feet from surface and a 4¼ inch cylinder at 140 feet is supposed to get about 50 g.p.m. Drawdown cannot be measured on account of fact that the cylinder is set in the casing. No. 3 station is east of No. 1 and was not visited. The single well is reparted to be about the same as at No. 2 but a shot was exploded in the casing and it only gives about 8 g.p.m.

An oil test being drilled by C. W. Houk at the east end of the town was visited. This was reported by Mr. Houk as follows

0-125 10" pipe through clay.

125-129

129-137 10" hole in limestone

137-160 10" hole in broken limestone-water

160-350 10" hole in limestone

350-545 some water in limestone 10" hole 8" pipe landed here

350-1133 Limestone, shale, limestone, small amount of sulphur water in last 8" hole

1133 St. Peter sandstone with much water which stood 150 feet from surface 8" hole

1200 Landed 6" pipe to shut off cave belwo St. Peter

1448 Landed 5" pipe here to shut off water which stood 100 feet from top.

2200 Present depth with 4 7/8" hole. Drilling in gray shale of Eau Claire formation. Did not admit salt water although said some was found before this. Water now stands 100 feet from surface. No water below 1880. Probably no effective shut off of upper waters from Dresbach, etc.

In the opinion of the writer this hole will be a salt water well. There is no chance whatever of finding oil although a little gas might possibly be found. The driller was using so tight a bialer that the hole may be lost at any time since it is too small for effective fishing. If this well is abandoned it must be plugged at 1200 feet to insure against contamination of higher formations by highly mineralized ~~and~~ salty waters from the deeper levels. Unless this is done ~~contamination may spread for a long distance~~.

It was recommended to drill a 8" test hole adjacent to the pumping station of No. 1 group. This well to have a Cater screen 5 feet long on bottom of the drive pipe so as to ~~save~~ the water in the broken top of the limestone. This hole will show (a) possibility of constructing a gravel-wall well in the sand and (b) may itself be a fair well drawing water from the broken surface of the rock. A test hole might also be drilled at Plant no. 2 provided that an outhouse at the rear of an adjacent residence is removed to a distance sufficient to comply with Indiana State rules. Here it does not appear that the chances for making a gravel wall well are as good as farther north. It is possible that the sand at the No. 1 group is an older buried beach ridge similar 5o the present one. If so it would extend in about the same direction but its underground extension is unknown. It is not found either east or south so far as could be discovered.

The writer can ~~at present~~ offer little encouragement for expecting a wide extent of water-bearing sand. The water conditions in the underlying limestone are variable and a poor well might easily adjoin a very good one for the water is wholly in crevices which are very ~~undertain~~ in occurence. It seems probable that the most water will be found in the broken surface of the bed rock. Failing a sufficient supply from either gravel-wall wells in the sand or combination screen and rock wells in the limestone two courses remain: (a) purchase of the oil test~~xxxThisxcouldxbexmadexintoxaxwater~~ and (b) drilling of a well through the St. Peter probably at ~~group~~ No. 1. The oil test could be made into a water wellby pulling the 6" and 5" casings and putting in a ~~cent~~ cement plug at 1200 feet. a 6" liner would have to be placed through the first shale ~~since~~ that would cave and give muddy water if it ~~did not close the hole entirely~~. Pumping costs would be greater ~~in eitherxdeepx~~ than with present wells if water is taken from the sandstone. Such water will probably be much more highly mineralized than the water now in use. All things consiered every effort should be made to develop the present shallow supply before resorting to deep wells although the latter would be entirely satisfactory in ~~point of~~ safety and quanity.

RACINE WATER DEPARTMENT

The orignal Water Works was built in 1886 and 87 using Lake Michiga as a source. There was a 24" intake constructed about one and one-quart miles northwasterly terminating in an submerged crib under 30 feet of wat This was a privately operated utility which ahanged hands several times and in 1919 following a period of litigation was purchased by the City for $1,225,000.

The original plant has been expanded and improved, particularly since the purchase by the City. The first considerable amount of extensions under the City administration were constructed in 1920 and 1921 as the system was somewhat underbuilt at that time. In 1925 one of the Blake pumps was taken out and an Allis Chalmers Centrifugal pump was installed to pump to the coagulation basin which had just been built. Thi basin was constructed as the first unit of the purification plant and wa located on property east of Michigan Boulevard and just north of Hubbard Street. These lots had been purchased in 1923 to provide a site for an new pumping station and treatment plant. For two years thereafter the water furnished to the City was allowed to settle in this basin before being pumped to the consumers. In February 1927 a nine million gallon filtration plant of the rapid sand type was put into operation and has been continuously in service since that time. A year after the initial construction three million gallons more capacity was added. In this plant the water is pumped from the lake and has a small amount of anhydrous ammonia added to it and them about one-half grain per gallon of aluminum sulphate and about three pounds per million gallons of liquid chlorine. The water then passes thru the coagulation basin down thru the filters which consist of 27" of sand, supported by 30" of gravel. Below the gravel a series of collecting pipes take the water to the clear water basins, upon leaving which a small amount of liquid chlorine is added for further safety. The treatment is carefully controlled by chemical tests for chlorine content every two hours and a complete set of bacteriological and chemical analyses made daily by a qualified chemi This liquid chlorine treatment above mentioned superceded the use of hyprchlorite of lime in 1922.

In 1927 and '28 a number of major improvements were made. A 36" intake closely parallel to the old 24" was constructed; a new low lift pump erected to operate from this intake; a ten million gallon De Laval Turbine driven Centrifugal pump for high service was installed at the old pumping station. This latter unit gave the City a capacity of twenty-two million gallons per day in the pumping Department, which however, is inadequate for fire demands.

The Water Department is now constructing a new pumping station to cost about $450,000, adjacent to the filtration plant. This new statio will be equipped with nine electrical driven centrifugal pumps of varyin sizes (two of which can also be driven by gasoline motors) and two high lift pumps for emergency service driven by gasoline motors. This new station will have pumping capacity of sixty-two million gallons per day, which it is expected will be adequate until about 1945.

Another improvement constructed in 1930 and which was put in operationg in August of this year is a ~~capacity~~ standpipe west of the City on 15th Street. This standpipe has a capacity of two and three quarter million gallons and is used to provide storage and to prevent excessive drops of pressure on the west side of the City. The construction cost the Department about $75,000 in addition to the cost of the 24" main connecting it with the City system.

Since the purchase of the plantin 1919 the population of the City has increased about 20% and the number of consumers and miles of mains and services have each increased about 60%. The City has far increased fire protection by an increase of 139% in the number of fire hydrants. During the same period the annual income has increased almost 80%. The plant valuation has increased about 138%, which is due to the construct of the purification plant. The present total mileage of mains is 147 miles ranging in size from 6" to 24".

The present personnel of the Department's regular employees are 7 in the office, 6 in the meter Department, 10 in the pumping station, 4 in the construction Department and 4 in the filtration plant. The Department now operates ten cars and trucks.

All of the water now furnished is measured, the number of meters for public schools, parks, public buildings, etc. being 109; industrial 285, commercial 14,396; fire protection 71 and public utility 13, the number of meters indicating individual consumers.

LOW TEMPERATURE GROUND WATER AT RACINE, WISCONSIN

On April 18 and 19, 1930 thw undersigned made an examination of ground water supplies at Racine, Wisconsin in response to a request by F. T. Thwaites. The following wells were examined.

1. B. D. Eisendrath Tanning Co., West Sixth St.

Total depth 1608 8" hole to 628 feet, 6" hole below. When drilled flow was 285 g.p.m. with head 4 feet above surface. 30 years ago a 1500 foot well would give 500 g.p.m. natural flow. Temperature of water reported as 56 F. but actual measurment gave 63.5 F.

2. Ajax Rubber Co., Taylor Ave.

Total depth 1700. 12" through the Niagara; lined with 8" pipe to 1410. Byron-Jaclspm turbine pump gives 1170 to 1185 g.p.m. with drawdown of 27 feet. Specific capacity = 40+ which seems too high Temperature reported at 62 F.

3. Racine Woollen Mills

Total depth 1609 Original head 45 feet above surface but does not now flow. No other data

4. Wisconsin Gas and Electric Co.

Total depth 1720 feet. 70' of 20" pipe to rock. 12" hole at bottom, apparently largest deep well incity. Natural flow 400 g.p. m. Pump delivers 1200 g.p.m. with draw down of 120 feet or specific capicity of 10 Two weels steady pumping has caused all wells within a radius of nearly a mile to cease flowing. Temperature reported at 60 F.

5. Modine Mfg. Co., 17th St.

Total depth 1800. Has stopped flowing so could get no temperature

6. Nash Auto works

Total depth 2500. Only pumped once a week. No temperature could be taken

7. Ajax Auto Parts Co., Fifteenth St. and tracks

Total depth 1700 feet. Orignally had 40 lbs pressure (seems too much). No flow now and could get no temperature.

8. Racine Pure Milk Co.

Total depth 200 ft. 80 feet to rock 6" well. A single acting pump with 17" stroke, 4 " cylinder at 30 strokes per min. pumps water down from30 to 128 feet in less than an hour. Temperature about 52 F.

9. Freeman Mfg. Co.

Total depth 313.5 feet. Cased to rock at about 40 feet. Pu mp gives 40 g.p.m. steadily. Water at 4 feet, pump at 28'. Temperature 54 deg. F.

<u>Conclusion</u>. The sources of cold ground waters at Racine are (a) the glacial drift, (b) the Niagara limestone, and (c) sandstones not too far from the surface. The temperature of waters increases below a depth of about 50 feet above which they vary with the season. No indications of gravel or sand in the glacial drift which might furnish water were found. A test hole at the locality in question might show some but if of local distrubution only the amount of water would certainly be small. The two wells in the Niagara limestone show comparatively little water and the temperature of the water from the larger well is near to the limiting figure of 55 degrees F. It is apparent from the considerable depth of the wells of large capacity that little water has been found above the Mt. Simon sandstone. Well records show that both the St. Peter and Dresbach sandstones are thin at Racine. None of the deep wells gives water which is less than 60 F. and it is notable that all the observed temperatures are higher than the reported temperatures. Results of this survey do not encourage the hope that over 1000 g.p.m. of water with temperature not over 55 F. can possibly be secured at Racine.

Respectfully submitted,

REPORT ON PLYMOUTH WATER SUPPLY

by

F. T. Thwaites

On April 19, 1927 I made an examination of sources of water supply at Plymouth, Wisconsin. The present supply is from three well, the depths of which are variously stated. In Bulletin 35 of the Geological Survey published in 1916 it is said that 300 g.p.m. was obtained by a natural flow from a well 374 feet deep whose diameter was 10.8 inches near the surface and 6 inches below. The original head of the wells is said to have been over 16 feet above the ground.

The information received at Plymouth was to the effect that the deep well is 477 feet deep and 8 inches in diameter near the surface and 6 inches below. The total yield at present with air lift is reported at 478 g.p.m., this lowering the water approximately 45 feet.

According to Frank Robb the deep well is 474 feet, 13 feet to rock, and 20 to 30 feet at the bottom into what was called a blue flint rock. This is probably part of the Richmond shale. Samples of cavings which were shown to me after having been picked up at depth of 245 were identified as belonging to the very dense so-called lithographic stone layer which lies approximately 200 feet above the base of the limestone formation. This confirms Mr. Robb's statement. The shale is to be expected at a depth of approximately 450 feet.

The supply at the pumping station is supplemented by a shallow dug well and a 148 foot drilled well at the corner of Western Avenue and Schwartz Street.

The northwestern part of the city near to the Schwartz Street well is underlain by gravel, but the depth to rock is so slight, varying from 20 to 30 feet, that no large supply of water can be obtained. Explorations for gravel on the west side of the river slightly south of the station also are reported to have found rock at shallow depths. I have decided that the bulk of the hill west of the river is not gravel. Information from wells in the eastern part of the town indicates the general absence of gravel formations.

The possible means of adding to the water supply may be divided into three general heads:

A. Development of gravel wells northwest of the city.

B. Additional wells in Niagara limestone within the city.

C. Deep drilling to the St. Peter sandstone and underlying formations.

A. As stated above, the thinness of the gravel formation in the city appears to preclude any large development. It would be necessary to prospect to the northwest to find out anything about the gravel. The proposition is therefore not recommended on account of the high cost.

B. The water resources of the Niagara limestone depend upon the amount of crevicing. The crevices extend both horizontally and vertically and may be found at almost any level clear down to the underlying shale. The best places to develop the Niagara are where the drift is not unduly thick so that the maximum thickness of limestone is obtained. Such appears to be the case in the northern part of the city and I recommend the drilling of a larger well at the Schwartz Street plant, one at at least 12 inches in diameter carried to a depth of approximately 500 feet or until the shale is struck. Other possibilities are east of the factories in the southwestern part of the city. This site would show a heavier drift, possibly considerably over 100 feet, which would very materially reduce the thickness of the limestone compared with the Schwartz Street location. It would also be possible to drill in the northern part of the city along the river. Here the thickness of the drift is possibly less although not accurately known.

C. A well was drilled at the Crystal Lake Crushed Stone gravel pit by F. M. Gray, Jr. about the time of the war. The log is reported in brief as follows:

Sand and gravel	0 - 110
Sand mixed with clay	110 - 117
Sand and gravel	117 - 150
Limestone	150 - 605
This formation was very much creviced between 345 and 455 and yields the bulk of the water obtained by this well.	
Shale	605 - 866
Limestone	806 -1092
Sandy shale	1092 -1125

The well was abandoned at 1125 because of the loss of the tools which was due to water running down the hole causing the cuttings to settle around them. As the hole was very small, only 5 inches in diameter, it was impossible to recover them. The lost tools must nearly fill the hole up to the limestone so that no test has ever been made of the water possiblities of the St. Peter.

At New Holstein a recent village well found the St. Peter practically dry. It is doubtful whether any large quantity of water is taken from the St. Peter at Chilton.

At Sheboygan Falls and Sheboygan the St. Peter carries salty water. It is my opinion that salty water would not be found at Plymouth as the probable depth of the St. Peter is much less than at Sheboygan. I forecast the top of the St. Peter at 940 feet which figures out 120 feet below sea level. The sandstone is found in Sheboygan at 1208 feet from the surface or approximately 588 feet below sea level. It therefore seems imporbable that salt water extends as far west as Plymouth. On the other hand the water from the St. Peter probably stands much farther below the surface than the water in the Niagara and the cost of pumping would be considerably higher. I therefore do not recommend a well to the St. Peter if wells in the Niagara are successful. If, however, it should be desired to keep all the pumping equipment at the same location, a well to the St. Peter should be considered in spite of the discouraging results elsewhere.

There are other sandstones below the St. Peter whose water bearing possibilities are very good judging from experience elsewhere in the state.

YOUR WELL SAMPLES AND HOW KEPT

The writer has been collecting samples of cuttings from deep wells for the Wisconsin State Geological Survey ever since 1912. The purpose of samples is to permit more accurate and detailed determination of rocks than is possible at the well. Drillers' logs are valuable but can never supply all the facts needed by modern science. The value of accurate well records is known to every driller and engineer. Such records furnish the basis for forecasts of conditions which will be found in new wells and are invaluable when it is necessary to repair an old well. When a well is contaminated or it is desired to change the casing to eliminate poor water and improve the chemical quality of the product, then accurate geological information is essential. When a point for landing casing must be fixed a study of samples is often a great aid. The Survey is naturally also interested in purely scientific results such as the study of the glacial drift, tracing the changes in the different rock formations and determining their elevation in different parts of the state, but the primary purpose of this work is to help engineers and well drillers in practical problems concerned with the development of underground waters.

Much of the value of well samples depends on how the driller collects them. Samples should be taken direct from the bailer by dumping its contents into a clean pail. They should never be taken from the ground or the slush-pit for both of these result in mixing with foreign material. If possible, the sample should be taken from the second or third bailer rather than from the first, as the cuttings nearest the bottom of the hole are least mixed with cavings from above. Samples should never be taken from material which sticks to the bit, for that may have been scraped off the walls of the hole above the point where drilling is going on. It is sometimes impossible to get any sample either because the material will not settle or because the cuttings are carried away into crevices of the rock. In such cases the cause should be noted on the label of an empty bag. Samples should not be washed any more than is necessary, for this may remove the softer parts of the sample. For instance, in shale with limestone "shells" the sample when washed would mislead anyone into thinking that only limestone was passed through. It is urged that samples be taken at intervals of 5 feet unless longer runs are made. In the case of shorter runs a sample should be taken from each. When there is a marked change in character of the rock it is well to depart from the regular interval to indicate that fact. Large chunks of rock which fall into the hole are interesting if the depth at which they were picked up is indicated, but they should never be used as regular samples.

If possible, samples should be dried by laying out on a board preferably on or close to the boiler or stove. In deep well drilling there is plenty of time to put them in sacks during each run. After many years of experiment with different kinds of bags it was finally decided that those with separate cardboard labels are best. Bags should be kept in a dry place so as to keep the labels as clean as possible. When samples which have been wet or frozen and have mildewed come into the laboratory it sometimes takes days trying to decipher the labels many of which can never be read or have been lost.

On completion of a job the samples should be packed in a box (not a bag), and either mailed or shipped express collect to the Wisconsin Geological Survey, Science Hall, Madison, Wisconsin. Samples bags can be obtained free by writing the same address. When keeping samples for the Survey is not called for in the contract, drillers are compensated for the extra trouble at the rate of five cents a sample with a minimum of $2.50 for each record.

This is paid only for samples from wells in Wisconsin when sent in by the driller not the owner or engineer. The Survey will, however, be glad to examine and report on samples from wells outside the state but such work is often delayed because Wisconsin records take precedence. It should also be understood that payment is made only when the record is desired by the Survey and only for reasonably complete sets which appear to have been carefully collected. It is also a good thing to send a copy of the drillers log including a casing record.

When samples are received at Madison they are sorted and bottled. Two ounce square tablet bottles are marked in ink on a spot which has been treated with a glass etching compound. Examination is made mostly with a hand lens, sometimes with a binocular microscope. This work can be done effectively only on sunny days. Some samples have to be washed and others are treated with acid to remove the limestone. In the latter case the residue is washed, dried, and examined microscopically. The number of samples now in storage is nearly 22,000. It must be realized that recognition of geological formations depends largely upon the succession of materials in the record. It is commonly impossible to place a single isolated sample. One of the most important things in well drilling is to recognize the pre-Cambrian rocks below the sandstones for drilling in them in such places is fruitless. Many drillers have been misled by slow-drilling sandstones and have, therefore, not fully developed the resources of the water-bearing rocks by quitting before the pre-Cambrian was encountered. Others have ~~awarded~~ wasted their effort by drilling into fairly soft pre-Cambrian.

After the samples have been examined a blue print log of the well is made on the scale of one inch to 100 feet. This log shows not only geology but also the size of hole, casing, and water level whenever such information has been furnished. Ordinarily copies of this log are sent only to the owner of the well and to the driller. Records of wells which belong to the state, counties, or cities are held to be public property and are available in advance of publication to everyone who applies but records of private wells are not given out except as stated above unless special permission has been obtained. If it is requested that a record by kept confidential it will never be published and no one outside of the Survey staff will be allowed to see it. Other records will probably be published some day but it may be many years before Bulletin 35, on water supplies, is brought up to date. At present little effort is being made to collect records of or samples from shallow wells.

Some drillers fear that if records of their wells are sent to the Survey their competitors will benefit. The attitude of the Survey is that exchange of information will greatly help the well drilling industry by promoting more scientific development of underground water resources. As the number of accurate well logs increases the resulting dividends to drillers will be far in excess of the trouble of sending in samples, and the benefits will vastly offset any possible temporary losses.

F. T. Thwaites,

Geologist in Charge of Well Records

WISCONSIN GEOLOGICAL SURVEY

JOHN MOHR AND SONS CO. WELL, SOUTH CHICAGO, ILL.
Gray Well Drilling Co., Contractors
J. G. Mayer, Driller, Dec. 1, 1926-May 19, 1927
Samples examined by F. T. Thwaites

Formation	Thickness	Depth	Feet	Description	Casing
DRIFT		0 -10	10	Drift or fill, no sample	21'of 10" pipe
		10 -38	28	Sand, no sample	73' of 8" pipe
	73	38 - 73	35	Clay, bluish gray, no sample	
NIAGARA		73 -120	47	Dolomite, light slaty gray	
		120-410	290	Dolomite, light gray to white	680' of 8" hole; 680' of 6" pipe
		410-450	40	Dolomite, light gray to white; chert, white	
		450-460	10	Dolomite, light gray	
		460-480	20	Dolomite, slaty gray	
		480-490	10	Dolomite, blue and light gray	
		490-510	20	Dolomite, white, pyritic	
	457	510-520	10	Dolomite, gray	
		520-530	10	Dolomite, bluish gray, light gray spots	
RICHMOND		530-650	120	Shale, blue, dolomitic	
	128	650-658	8	Shale, hard, gray, slaty, dolomitic	
		658-880	222	Dolomite, gray	680'

Formation	Thickness	Depth	Thickness	Description	Remarks
GALENA-BLACK RIVER		880-890	10	Dolomite, gray and blue	
	324	890-982	92	Dolomite, gray	921' of 6" hole
ST. PETER		982-990	8	Sandstone, fine, gray, dolomitic	
		990-1000	10	Sandstone, medium, white	
		1000-1005	5	Sandstone, very fine, gray, dolomitic	
		1005-1140	135	Sandstone, medium to fine, white	
		1140-1148	8	Sandstone, like above; shale, gray	
	188	1148-1170	22	Chert, white	
LOWER MAGNESIAN		1170-1415	235	Dolomite, gray	
MAZOMANIE		1415-1455	40	Sandstone, fine, gray, some pink, dolomitic, slightly glauconitic	
		1455-1475	20	Sandstone, like above with gray shale, part dol.	
		1475-1540	65	Sandstone, very fine, gray, very dolomitic, glauconitic	
	135	1540-1550	10	Sandstone, coarse to fine, gray, dolomitic	
DRES		1550-1590	40	Sandstone, medium, white, dolomitic	
	51	1590-1601	11	Sandstone, medium-coarse, white	

UNDERGROUND WATER NEAR MOSINEE, WISCONSIN

F. T. Thwaites, Geologist in charge of well records,
Wisconsin Geological Survey

Introduction. On August 24, 1931 the writer inspected the geology near Mosinee, Wisconsin at the request of Mr. S. R. Fisher to see if there is probably a sufficient supply of underground water to meet the needs of the Mosinee Paper Mills. The geology of this district has been investigated by Irving (Volume 4, Geology of Wisconsin, 1882), Weidman (Bulletin 16, Wisconsin Geological and Natural History Survey, 1907), and Aldrich (unpublished notes in files of Wisconsin Geological Survey). The general results of the three surveys as regards this problem are in essential agreement.

Geology. The bed rock near Mosinee consists of several types of hard rock, most of which are igneous. After the formation of these rocks the region was upraised into mountains. Then it was worn down by streams and weather to a surface not unlike the present one. Prior to the glacier which invaded eastern Marathon County and the district of the upper Wisconsin River the Wisconsin valley at Mosinee was at least 100 feet deeper than it is today. The river then followed a course west of the site of the present village. Waters derived from the melting ice sheet swept down the valley and filled it with alternating layers of sand and gravel up to the level of the highest bottom land flats of today which are known to geologists as outwash terraces. The tributary valleys although they did not carry glacial waters found their outlets blocked and so the debris which they carried was deposited and the side valleys also filled. The glacial Wisconsin River wandered around on its wide floodplain and when the floods subsided and it cut down its bed to the present level it happened to cross spurs of rock which projected into the old valley. Thus originated the falls at Mosinee whose waterpower led to the location of the mills.

Underground water. The bed rocks of the Mosinee region are virtually impervious to water except where they are broken. Crevices which contain water extend in abundance to a depth of not much over 200 feet. The amount of water which they contain even in wet years is nowhere nearly enough for industrial purposes and search for water in the bed rock is not recommended. On the other hand the sand and gravel filling of the Wisconsin valley and the lower part of the Bull Creek valley, which may have been a part of the Wisconsin valley at one time, is extremely pervious. The percentage of soak-in from rainfall is undoubtedly high and during dry times the streams must replenish the ground water. These surficial deposits are probably not less than 100 feet thick and of this probably 4/5ths is filled with water even on the high terrace. Many of the coarser layers should furnish a large amount of water with very moderate drawdown of the well.

Sites for exploration. Since the Mills are located on hard rock there is no use exploring for water at them or for at least a mile and a half below on the same side of the river. Deep sand and gravel deposits in which water should be found exist in three nearby localities: (a) downstream from the Mills in Sec. 6, T. 26 N., R. 7 E., (b) west of Wisconsin River in Secs. 29, 30, 31, and 32, T. 27 N., R. 7 E., and (c) north of Mosinee on the east side of the river in Secs. 21 and 28, T. 27 N., R. 7 E. The first location was not considered by the writer since the lands are not controlled by the company and a two mile main would have to be laid along the railroad right of way at many points of which rock is undoubtedly present. The location west of Mosinee across the river from the plant is nearer but the expense of bringing a water main across the river on a new bridge appears to exclude the project from serious consideration. Attention was, therefore, concentrated on the third locality. Although rock is near the surface most of the distance from the Mills north on U. S. Highway 51 to the crossing of Bull Creek there is a terrace of sand and gravel between the road and the river. In the SW¼NW¼ Sec. 28, which is leased by the company, the terrace is wider than elsewhere. In section 21 water conditions appear to be better than below. The distance from rock outcrops is considerable and the area is crossed by Bull Creek so that underground water not derived from Wisconsin River must be present. The company owns or has leased all of the SW¼ except a small portion southeast of Bull Creek, all of the NW¼ except the southeastern 40, and the NW¼NE¼. Throughout this district percolation from the River which carries waters poluted by sewage, industrial wastes, and swamp drainage high in iron is at a minimum. The construction of a water main was not examined in detail as this is a purely engineering project but it seems as though it could be laid alongside or on the right of way of the C. M., St. P. and P. R. R. where excavation would be nearly all in loose material. It is probable that enough water could be obtained within 1.6 miles of the Mills to supply all demands and that present needs might be met at less distance.

Development program. It is suggested that the first test well be located in the wider part of the terrace near the bridge over Bull Creek on the old location of Highway 10 Tests should be more than 150 feet from the river and if possible so located that local ground water coming from creeks or side valleys has a chance to reach the well. Rock will be found at varying depths along this narrow terrace in Section 28 so that several tests might be needed. Some will certainly strike buried rock spurs so that the best location for deep sand and gravel is opposite tributary valleys in the bluffs east of Highway 51. Tests in Section 21 where the valley is wider should find deeper surface material. Location may be fixed by land ownership and advisable route for the water main. A location for the latter should be sought which will permit extension to the north as more water is needed.

Wells. The well driller should so far as possible test the water from test holes for iron and manganese. Permanent wells should be of the screen type rather than a solid open end pipe as is reported in the Mosinee village wells. No deep wells appear to have been made in the location under consideration since water is cheaply obtained by shallow driven wells. Such wells tell nothing as to quantity of water and no attempt was made to get information about them Large screen wells are of two general types: (a) screen consisting of large openings in an iron or steel pipe surrounded by screened gravel, and (b) brass or bronze scree with rather small openings. The second type require development by pumping at an excessive rate until the sand is largely removed around the screen and the coarser material thus concentrated. Choice of type is a matter to be decided not only by first cost but by the experience with other wells in the same region. Solid casing should be extended down below the level of water when pumping since the surface waters undoubtedly contain more iron than do those lower down.

Conclusion. A large supply of underground water is indicated in the sand and gravel formation where thick. The best waters will be found where a minimum amount of water comes from Wisconsin River. The most favorable locality both from the standpoint of local source of ground water and cost of building a main is north of the Mills in Secs. 21 and 28. It seems highly probable that enough water can be obtained for the entire needs of the Mills and that this water will be much superior in chemical quality to the present river supply.

August 26, 1931

GEOLOGICAL ASPECTS OF WATER SUPPLIES FROM ROCK FORMATIONS

Abstract of extemporaneous talk before Wisconsin section of American Water Works Association, Racine, Wisconsin, October 27, 1931

F. T. Thwaites, Geologist in charge of well records, Wisconsin Geological and Natural History Survey, Madison, Wisconsin

Introduction. The attention of the writer was first attracted to the study of underground water problems in the rock formations of Wisconsin and adjacent states when a set of cuttings from the deep artesian well of the Horlick Malted Milk Company at Racine was presented to the Wisconsin Geological Survey in 1909. At first attention was directed only to the strictly geological problems of the character and succession of the different rock formations. A gradual growth in scope has enlarged the writer's study to include quality of underground waters, temperature of waters, yield of wells, mechanical construction of wells, and methods of recovering water. An effort has been made to avoid entrenching on the legitimate field of consulting engineers and, therefore, little attention has been paid to costs. The number of samples of cuttings now exceeds 23,000.

Rock formations. Wisconsin is underlain by both hard impervious rocks like granite of pre-Cambrian age and by relatively soft in part very pervious rocks like sandstone, and limestone of Paleozoic age. The old hard rocks form the central core of the state. They are found not only as the surface rock but have been discovered in many deep wells which have encountered them after passing through the younger or soft rocks. The different soft rocks lie in slightly inclined layers which slope away from the central mass of hard rocks. Passing outward from the high north-central part of the state we cross the beveled edges of the different soft rock formations. The full succession of young rocks occurs only along the Lake Michigan coast. The writer has published a contour map of the top of the old hard rocks. This level is important, for drilling into these rocks to find large supplies of water is futile. Above the pre-Cambrian lies the Mt. Simon sandstone, which is the best producer of water particularly where layers of very coarse soft sandstone are encountered. On top of the Mt. Simon is two to three hundred feet of shaly sandstone and shale, the Eau Claire formation. This contains little water. Above the Eau Claire is a good water producer, the soft pure white Dresbach sandstone. A contour map of its top in Illinois has been published. The Dresbach and Mt. Simon are the backbone of water production in deep wells throughout Wisconsin and northern Illinois. The overlying formations in general produce little water except where they form the surface rock. The St. Peter sandstone, which in some places directly overlies and in other places is separated from the Dresbach by a maximum of nearly 1000 feet of firm sandstone and limestone, is not a good producer at depth. Overlying the St. Peter is limestone and shale.

Quality of waters. Although the available data is still unsatisfactory, much progress has been made in the study of the chemical quality of underground waters. As the soft rocks were deposited under the sea, they must originally have contained nothing but salt water. Rain water which has fallen on the outcropping edges of the rocks for long ages has washed away the salt waters down to a depth of about 2000 feet. At the suggestion of the writer the practice has been adopted by some engineers of testing samples taken from the bottom of deep wells for chlorine. Drilling is stopped when this substance rises in amount. Thus expensive plugging back jobs are eliminated. Some successful experiments have also been made, in part under the direction of the writer, in casing wells so as to diminish the amount of encrusting solids.

Water temperatures. Down to about 60 feet depth the temperature of underground waters varies with the season, the lag from air temperatures increasing with depth. At 60 feet the temperature is unchanging and is slightly above the mean annual air temperature of the locality. From there on down the temperature rises at a different rate in different places. Many observations have been made by the writer on flowing wells and springs and in a few places thermometers have been lowered in new wells. From the practical standpoint temperature observations are important. They offer an inexpensive means of telling where most of the water pumped or flowing from a well is derived. Thus they detect bridged holes, leaks in casing, etc. Many more accurate observations are needed.

Yield of wells. The older geological studies paid scant attention, if any, to the yield of wells which is commonly given in gallons per minute per foot of drawdown. Much data has been collected but more is urgently needed before any general conclusions are possible. Long since the writer has outgrown the idea that every sandstone formation is a water producer, for he has found, in some cases to his sorrow, that such is not the case.

Construction of wells. The writer has given much attention to the mechanical construction of wells, for in many places this should be governed by the geology. For instance, it does little good to case a well unless the pipe ends in an impervious layer. Moreover, simply dropping a string of pipe into a hole does not insure what oil well drillers call a "shut-off." The importance of good pipe and the desirability of following oil well practice in cementing or mudding of shut-offs has been stressed very much in recent years, but no discussion of methods is here possible. A good scheme which was recently tried is to locate a suitable seat for the casing by drilling a small hole ahead of the big one. The exploratory hole is centered so that it can later be reamed without trouble.

Recovery of water. The choice, design, and installation of pumping equipment is the task of the engineer and not the geologist. Nevertheless, where geological conditions affect the question it is only just for the geologist to warn those concerned that a certain type of equipment is preferable. For instance, where it is known that inclined layers of rock or slanting fissures make straight holes almost impossible air lifts are favored instead of pumps. Forecasts of the probable static level in different formations are also very important. In some localities the maximum ecomonical depth of wells is thus determined.

Summary. Thus it is that a study which was when started merely "pure science" has grown into one of immense economic importance. Booms and depressions may come and go but underground waters are always in demand. As their amount is limited their best utilization is only to be obtained when geologists, engineers, well drillers, and owners cooperate in collecting vital data. It is urged that records be filed with the State Geological and Natural History Survey at Madison. Consultation there costs nothing and may save much. It is to be hoped that our knowledge of underground waters will constantly increase in the future as it has up to now.

References. Thwaites, F. T., The Paleozoic rocks found in deep wells in

~~deep wells in~~ Wisconsin and northern Illinois: Jour. Geology, vol. 31, pp. 529-555, 1923

Thwaites, F. T., Stratigraphy and geologic structure of northern Illinois with special reference to underground water supplies: Illinois State Geological Survey, Report Investigations No. 13, 1927

Thwaites, F. T., Buried pre-Cambrian of Wisconsin; Geol. Soc. America, Bull., vol. 42, pp. 719-750, 1931

March 19, 1932

TABLE 1

Well records showing nature of concealed pre-Cambrian rocks in Wisconsin; samples have been examined by geologists. For sources of data see original publication.

Well number-city	Owner or location	Surface elevation	Depth to pre-C	Elevation pre-C	Rock; remarks
1. Baraboo	City test	856	424	432	Quartzite
2. Barron	City	1120	420	700	Quartzite or conglomerate
3. Black Creek	Borden Co.	785	512	273	Granite under drift
4. Bloomer	Armour Co.	1006	170	836	Granite
5. Gasco Junction	G.B. and W. R. R.	728	1675	-947	Granite
6. Clintonville	City test	825	140	685	Granite under drift
7. Delavan	Bradley Knitting Co	938	1660?	-720?	Quartzite? (doubtful)
8. Eleva	Jackson Farm	870	300	570	Basalt
9. Fond du Lac	City test	750	740	10	Quartzite, slate, etc.
	Galloway West Co No.1	760	440	320	Quartzite
	No. 9 city	755	835	-80	Slate
10. Friendship	Oil test NE¼ NW¼ sec. 30, T. 18 N., R. 6 E.	960?	265	655?	Gneiss, granite
11. Gillett	Gillett Canning Co.	801	412	389	Hornblende schist under drift
12. Green Bay	Waterworks	590	855	-265	Granite
	Ninth St.	610	855	-245	Granite
	Cass St.	585	912	-327	Granite
	Gray St	615	800	-185	Granite
	Preble	601	960	-359	Schist
13. Hartford	Power House	980	500?	480 ?	Quartzite
	City Hall	981	490	491	Quartzite
	Johnson St.	1013	532	481	Quartzite
	Sixth St.	1015	550	465	Quartzite
	East Sumner St.	982	560	417	Quartzite
14. Hubbleton	Diamond drill holes T. 9 N., R. 14 E. NE¼SW¼ sec. 31	790	614	176	Slate, quartzite (a)

Well number-city	Owner or location	Surface elevation	Depth to pre-C	Elevation pre-C	Rock; remarks
	SE¼SE¼ sec. 31	785	457	328	Slate, quartzite
	SW¼NE¼ sec. 15	800	753	47	Dolomite, slate, schist, quartzite
15. Hudson	City	670	393	277	Basalt
16. Jefferson	Carnation Milk Co.	790	825	-135	Quartzite
17. Jefferson Jct.	Ladish-Stoppenback Co. No. 1	820	879	-59	Granite
	No. 2	820	880	-60	Granite
18. Juneau	Libby, McNeil and Libby	910	730	180	Quartzite
	Fire station	949 ±	664	285 ±	Quartzite
	City waterworks	910			Quartzite
19. Kaukauna	City No. 3	650	778	-128	Granite
20. Kewaskum	Rosenheimer Malt and Grain Co.	950	1045	-95	Quartzite
21. Wisconsin Dells artesian test		928	450	478	Basalt, etc.
22. La Crosse	City	640	537	103	Granite (b)
23. Madison	Station well	858	733	125	Basalt
	East station	851	720	131	Basalt (c)
	No. 11	850	733	177	Basalt
	Unit No. 1	856	835	21	Granite
	Unit No. 2	851	730	121	Basalt
	Unit No. 3	850	730	120	Schistose rhyolite
	Unit No. 4	854	(715)	139	Rhyolite
	Unit No. 5 (9 Spring)	892	825	67	Basalt
	Unit No. 6	875	740	135	Rhyolite
	Unit No. 7	890	725	165	Granite
	Capitol	929	800	129	Basalt (d)
	Kennedy Dairy Co.	863	740	123	Basalt
	C. M. St.P and P.	863	790?	73?	Basalt (e)

Well number-city	Owner or location	Surface elevation	Depth to pre-C	Elevation pre-C	Rock; remarks
24. Marinette	City test	590	712	-122	Quartzite (f)
	Southern Kraft Paper Mill	590	687	97	Granite
	Gas works, Menominee, Mich	588	658	-70	Granite
25. Mather	Appleton Cranberry Co. sec.21, T. 20, R. 1 E.	1000	175	825	Basalt
26. Mayville	Youngstown Sheet and Tube Co. No. 2	920	1160	-240	Jasper
27. Mount Calvary	College	1060	1176?	-116?	Quartzite or granite (g)
28. Necedah	C. and N. W. Ry.	905	310	595	Granite
	No. 1 test hole	905	229	676	Diorite (h)
	No. 2 " "	~~282~~ 905	202	703	Granite, diorite (h)
	No. 3 " "	905	192	713	Diorite (h)
	No. 4 " "	905	203	702	Quartzite, granite (h)
29. Oconomowoc	Montgomery Ward	896	950	-54	Quartzite (i)
30. Oil City	Wildcat test	890	490	400	Granite (j)
31. Oshkosh	Algoma Street	755	680	75	Granite (k)
	Diamond Match Co.	750	675	75	Granite (l)
	State Hospital	765	714	51	Granite
32. Pewaukee	Edgewood Farm	860	1190	-330	Granite
33. Portage	Court House	819	530	289	Rhyolite (m)
34 Prairie du Sac	Phillip Farm	859	560	299	Granite
35 ~~34~~. Pray	Adbar Exploration secs. 1,2, T. 21, R. 2 W.	950	85-98	860	Iron formation and schist
36. Reeseville	Etscheid Farm	850±	93	860 ±	Quartzite under drift
37. Sauk City	City	757	523	234	Granite

Well number-city	Owner or location	Surface elevation	Depth to pre-C	Elevation pre-C	Rock; remarks
38. Stillwater, Minn	Oil test	~~850~~ 762	706	~~145~~ 56	Sandstone(n)
39. Tomah	Park	980	452	528	Gneiss
	City, north well	955	310	645	Granite
40. Two Rivers	Test No. 2	587	1610	-1023	Quartzite
41. Watertown	City No. ~~X~~ 1	809	750	59	Slate
	City No. 3	809	715	94	Iron formation
42. West Bend	City	920	930??	-10??	Chert?? (doubtful)
43. Waupun	City	883	750	133	Pegmatite
	Insane Hospital	880	509	371	Quartzite
44. Whitehall	City	815	265	550	Gabbro

New wells since publication in 1931

Well number-city	Owner or location	Surface elevation	Depth to pre-C	Elevation pre-C	Rock; remarks
89 Adams	City	956	278	678	Quartzite
90. Augusta	Village	968	88	880	Granite
91. Black Creek	Oil test, sec. 28, T. 24, R. 17 E.	780	500+-	280+-	Granite
92. Brandon	village	997	855	142	Quartzite
93. Brothertown	Hanson Farm	850	350+-	500+-	Quartzite
94. Cambria	Oil test No. 1, Slinger	870+-	650+-	220+-	Granite
	No1, Roberts	915+-	665+-	250+-	no sample
95. Chetek	No. 2 village	1084	256	828	Granite
96. Crivitz	C.M.St.P and P. R. R. Co.	682	196	486	Greenstone under drift
97. DeForest	Oil test	940	745	195	Granite
98. Eau Claire	Test No. 8	820	110	710	Gneiss
	Dells Paper & Pulp Co	837	100	737	no sample
99. Fort Atkinson	No. 3 city	782	1060	-278	Granite
100. Hustisford	Cannery	860	268	592	Quartzite

Well number-city	Owner or location	Surface elevation	Depth to pre-C	Elevation pre-C	Rock; remarks
101. Menomonee Falls	City	880	1360	-480	Quartzite, granite
102. Oregon	Industrial School	936	850	86	Rhyolite
103. Rosendale	Cannery	905	440	456	Quartzite
104. St. Croix Falls	City	920	249	671	Basalt
105. Powers, Mich.	C. and N. W. Ry.	867	403	464	Marble
106. Stephenson, Mich	Whitehouse Milk Co.	683	385	298	Granite
107 Shell Lake	City	1225	520	705	~~Granite~~? (no sample)
108 Kimberly	City	745	800	-55	Granite
109 Wilson Firetower SWNE 28-27-5W			124		? (weathered)
110 Roaspur SWNW 8-29-8W	Power Plant	946	65	881	? (weathered)
=59 ~~111~~ Granton	Test	1140 ~~1124~~	60	1080 ~~1052~~	Granite
— Irene, Ill	Oil test	820	2925	-2105	Granite
83 — Wells, Mich	C&NW Ry Co	608	760	-152	Schist

New well logs

47. Boscobel	City	690	965	-275
	C.M. St.P. and P. R. R.	675	1000	-325
56. Durand		720	460	260
65. Meridean		746	352	394
68. Depere	City	595	811	-221

Negative Tests	Depth	Elev. Bottom
Monroe	1688	-883
Ripon	490	+435
Campbellsport	1317	-272
Columbus	565	+275
New Richmond	802	+183
Waukesha	1907	-1099
Brodhead	995	-205
Kewaunee	1700	-1110
Burlington	1917	-1140

Reid ~~Reed~~ Farm T 25 N R2E sec 6 NW 1/4 NE 1/4

115314 – 115341

115314 0'-3' Loess with some admixed sand and gravel
315
316 3'-11' Grey Brown Glacial Till
317-324 11'-17' Same, but very calcareous. About 20% $CaCO_3$ Equivalent.
325-330 17'-22' Same, but only faintly calcareous to non-calcareous.
331-335 22'-22'-6" Brown layer. Little organic matter. No pollen grains.
336,37 22'6"- 27' Grey clayey material, non-calcareous.
338-341

36 22-6 to 22-8
37 22-22-6 + 22-8 – 23-0

115342-115375

Hole at Experiment Station. T25N R3E sec.22
NW1/4,SW1/4,NW1/4

115342 4"-12" Silty loess with some sand and gravel admixed.

43 1ft.-2' Same

44 2'-3' Same

45 3'-4' Reddish brown,gritty,sandy glacial till

46 4'-5' Same

47 5'-6' Grey-brown till

48 6'-7' Same

49 7'-8' Yellowish or buff grey-brown till, Very calcareous (About 20% $CaCO_3$ Eq.)

50-60 8'-19' Same. Water table was at 11'6" on Sept.3, 1941

61 19'-20' Light grey silty material.

62 = 20 — 20-2" 63 = 20-2 — 20-4 64 20-4 — 20-6 65 = 20-6 — 20-10 66 - 20-10 — 21

(20'-21' Dark horizon. Organic matter content 15% at maximum. Pollen.

67 21'-22' Same as 19'-20'

68-75 22'-30' Same but 1.5% $CaCO_3$ equivalent contained.

~~75~~ 30'-34' Getting quite sandy with depth. Impossible to bring up a sample below 34' 30

76 = 0-6" Auburndale Hole T 25 N R5E sec line between 30 and 31,
77 = 6"-12" 78 = 1-1-6 79 - 1-6 - 3 0.1 mile E.

115376-9 1'-3'- Loess with some sand & gravel admixed

80 3'-4'- Silty glacial till, ~~calcareous~~ in lower 2 inches

81-86 4'-10'- Same but very calcareous.

water table at 10 FT on June 8, 1942

87 405 10'-29'- Grey clayey material, calcareous

406 7 29'-31'- calcareous Green clayey material with granite stones or fragments

115376-
115407

Copy

Department of Geology,
Science Hall,
University of Wisconsin,
Madison, Wisconsin,
January 8, 1943.

Dr. L. R. Wilson,
Department of Geology,
Coe College,
Cedar Rapids, Ia.

Dear Dr. Wilson:

I wrote you previously to the effect that I would turn over to Professor F. T. Thwaites remaining samples of buried "soils" which I have. I have now done so, and the list is as follows:

A. Black layer, from Locality #4 as described in my thesis, which is now in the University Library (Locality #4 is in the N.E. 1/4 N.W. 1/4 N.W. 1/4 of Sec. 34, T. 26 N., R. 1 W.), at a depth of 4.7' to 5'. The black layer has and organic matter content of about 5 %.

B. "Buried Soil" at the Marshfield Experiment Station, called Locality 8 in my thesis (N.W. 1/4 S.W. 1/4 N.W. 1/4 of Sec. 22, T. 25 N., R. 3 E), samples taken in the second hole, which I put down in June, 1942, encountering the "soil" at shallower depth than before:

Samples from the 18'-19' level:
"Ex3, Ex4, Ex5, Ex6, Ex7, Ex8, Ex9, Ex10"
(These are the field numbers, written on the bags, and were taken in the order numbered from the top down.

Samples from the 19'-20' level:
"Ex11, Ex12, Ex13, Ex14"

Sample from 20'-20'6":

"Ex15" ("Ex" stands for Experiment Station).

Since the samples were taken with a post hole auger, they were twisted and disturbed somewhat.

Very sincerely yours,

F. D. Hole

Francis D. Hole

116664 - 116681

HEMP MILL WELL - RIPON, WIS°
SE SW 33, T16N,R14E

Midwest Drilling Co. and Brown Hardware Co., Contractors, 1943

116664	0-22	Labled "Drift", glacial till, brown-gray, dolomitic.
65	22-55	Galena-Platteville, dolomite, light gray to light brown-gray.
66	55-140	Dolomite, light gray, some blue-gray. Total Galena-Platteville 118 feet.
67	140-145	Lower Magnesian. Dolomite, light gray.
68	145-153	Same.
69	153-160	Same.
70	160-165	Same.
71	165-175	Same. (Some green shale.)
72	175-180	Same.
73	180-195	Same. (Very fine cuttings.)
74	195-220	Same as above.
75	220-240	Same.
76	240-260	Dolomite, light gray.
77	260-270	Same.
78	270-275	Same.
79	275-285	Same. (A few grains of sand.)
80	285-300	Dolomite, like above; sandstone, fine to medium-grained, light gray. Total Lower Magnesian 160 feet.
81	300-330	Trempealeau (Jordan) sandstone, medium to fine-grained, light gray, dolomitic.

By F. T. Thwaites August 13, 1943

T. 25 N., R. 3 E.

City Park well, Marshfield, Wis.

McCarthy Well Co., 1945

	Thickness	Depth, feet
Clay	21	21
Sand	2	23
Clay	13	36
Sand and gravel	33	69

30" to 39 cased with 30" ½" steel pipe to 33; cememted to 39
20" below 39
20" 3/8" steel pipe from + 2 to 49 with 20" 3/16" everdur screen
below to 69

Tested 24 hours at 310 g.p.m. lowered water from 17 to 65 = 48' drawdown
specific capacity = 6.5 g.p.m.

T. 36 N., R. 13 W.

Stella Cheese Co. well, Barronette, Wis.

McCarthy Well Co., 1945

	Thickness	Depth feet
Hardpan and boulders	146	146
Sand, gravel, boulders	62	208
Red clay and stones	23	231
Fine sand	14	245
Soft sandstone	28	273
Hard sandstone	77	350

Cased with 45# steel pipe to 273 from + 1.5
16" to 50 filled with puddled clay
12" from 50 to 350

Tested 10 hours at 30 g.p.m.
Water at 150 not lowered by pumping