ON THE UNDERGROUND WATERS OF LINCOLNSHIRE.

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The County of Lincoln occupies an area of no less than 1,775,000 acres, or rather more than a million and three-quarters, and, with the exception of Yorkshire, is the largest county in England. It is drained entirely by streams flowing into the German Ocean, of which the Welland, the Witham, and the Ancholm are the most important; to the north-west a small tract drains into the Trent; and to the north-east small streams flow off the Wolds direct into the sea, or the north of the Humber.

The surface geological structure is largely modified by thick deposits of Glacial Boulder Clay, while below the strata range from the Keuper Marls, under the Trent on the west, to the Upper Cretaceous on the eastern margin, where they disappear below the overlying glacial drift, about 600,000 acres consist of porous rocks, but these are in part covered by impermeable Boulder Clay. The Witham drains no less than 176,000 acres of fen-land, the Welland 77,000 acres.

More than 80 per cent. of the land is cultivated; 35 per cent. of the whole area, or nearly half the cultivated area, grows corn crops, half the latter being wheat. Green crops occupy $12\frac{1}{2}$ per cent. of the total area, and fallow and grasses and clover under rotation nearly 9 per cent. Permanent pasture is nearly 26 per cent., and towns, woods, gardens, and waste 19 per cent.

All water, whether visible in streams and rivers, or concealed beneath the earth's surface, being derived from rainfall. In Appendix I. I have tabulated the rainfall at four local stations from the returns furnished to Mr. Symons, F.R.S., and published by him in his annual volumes of "British Rainfall." In 26 years, at Lincoln, the rainfall has been 20 inches or less, no less than 9 times, and on 2 of these

9 years it fell below 16 inches, viz., in 1884 and 1887. In 22 years at Navenby the rainfall has been 20 inches, or less, no fewer than 6 times, on 2 of which it was below 17 inches. At Sleaford in 15 years, the rainfall fell below 20 inches on three occasions, viz., 1884, 1887, and 1890. At Pode Hole, Spalding, the rainfall in 21 years, was 20 inches, or less, in six different years, viz., 1870, 1873, 1874, 1884, 1887, 1890. Of these four were below 17 inches, and one below 16 inches ; that of the Jubilee year, 1887, in which only 15·13 inches fell.

An inspection of an Ordnance one-inch map, on which no geological features are coloured at once discloses the permeable or impermeable nature of the rocks and soils of which the area may be composed, by the absence or presence of stream lines indicated on the map, on any particular area that may be selected for observation. For convenience it is found useful to have “one-inch squares traced on tracing-cloth, each of which when placed over the map, covers an area of one square mile. If the area so covered contains no stream lines engraved, it may be safely assumed that, after deducting the proportion of the annual rainfall evaporated, the whole of the balance left will find its way into the underground stores of water below. If the stream lines are above a mile in linear extent, about a third of the rainfall will be evaporated, a third run off in floods, and a third absorbed. If numerous stream lines traverse the square inch in all directions, two-thirds of the rainfall will be run off in floods, and be only available in catchment reservoirs of large extent, capable of storing the rainfall of several months. The porous rocks vary much in degree of porosity, and still more in the rate at which they discharge water absorbed. The minimum supply of underground water in the county of Lincoln is therefore 5 inches per annum, or 200,000 gallons of water per square mile per day.

One inch of rainfall per annum gives 62 gallons of water per day per acre, or a supply for three persons from each acre were it all available, assuming evaporation to take a third of this quantity. The balance left for human consumption of the 5 inches percolating depends on the amount sucked up by vegetation ; this is an exceedingly variable quantity. After a long drought the first rainfall never

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passes a yard underground ; it probably would average an inch and a quarter per acre, leaving a balance of three inches and three-quarters for drinking purposes, necessitating an area of one acre to give the quantity of water required by ten persons daily, so that looking to the acreage of the county of Lincoln it should be able to supply no less than six million persons from underground sources, whilst its population is under half a million. Its inhabitants therefore should be very amply supplied, but this is far from being the case through the underground stores being seldom utilized.

COLLINGHAM.

At South Scarle, nine miles S.W. of Lincoln, and half way between that city and Newark, on the Nottinghamshire side of the county boundary, an unsuccessful boring for coal gave very important results as regards the character of the strata and its water-bearing capacity.

A feeder of water was met with at a depth of 134 feet in the Keuper Sandstone, running 11 gallons per minute, and another occurred at 950 feet, running at 50 gallons per minute, in the same formation. The last is stated to have risen 52 feet above the surface. These artesian waters are separated from the water in the Bunter Sandstones beneath by intervening shales, but there is every reason to believe that the whole of the sandstones, from 958 feet to 1500 feet, are similarly charged with water, absorbed as rainfall, in the magnificent gathering ground between Retford and Worksop, an area capable of supplying millions of gallons of pure water daily, and at present practically untouched. The temperature taken in the Scarle bore-hole points to the free passage of water in the porous rocks beneath, rising from 69 deg. on the base of the Keuper marls to $69\frac{1}{2}$ deg. at the base of the Keuper sandstone, and to no less than 73 deg. in the water flowing off the top of the Permian upper marls. I have no information as to the diameter of this bore-hole at the surface, but at the termination it was only 0·9 of an inch. I presume it is not now available for waterworks purposes, and any future boring to reach the required depth, and give a proper supply, should not be less than 24 inches at the commencement.

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GAINSBOROUGH.

Boring made by Messrs. E. Timmins & Sons, Bridgewater Foundry, Runcorn, for the Local Board, at the recommendation of myself, the site is six miles from the outcrop of the New Red Sandstone.

	Feet.
725 Keuper marls, with much gypsum to 350 feet ...	725
1201 New Red Sandstone, with red and white pebbles, at 750 feet and 960 feet in depth ...	375

The well is 58 feet deep, the bore-hole is lined with cast iron tubes of 19 inches internal diameter to 140 feet, of 15 inches to 212 feet, of 12½ inches to 335 feet (of wrought iron), of 10½ inches diameter (wrought iron), to 737 feet, and 10 inches internal diameter (wrought iron) to 1201 feet.

The water contains 32·20 grains per gallon of solid residue, at 212 F, and contains of combined chlorine 1·40 grains per gallon. Its hardness on Clarke's scale is 25·76, of which 16·31 is permanent; the water in the boring is mixed in the well with some upper waters, to which its hardness is due. This mixture was not due to any defect in the work done by the contractors under their instructions, and there is every reason to believe that, if the whole of the water were derived from the New Red Sandstone it would be found much softer. The quantity pumped is about 15,000 gallons per hour. The character of the underground waters from the New Red Sandstone of this district, where no admixture has taken place, is well seen in the analysis accompanying the following particulars of a recent boring at Worksop.

WORKSOP.

Hodsock Priory. Bored March, 1891. Surface 55 feet above Ordnance Datum. Depth of six-inch boring 94 feet. Permanent water level before pumping, three feet from surface; after pumping 150,000 gallons in 24 hours it fell to 18 feet below the surface, but recovered in a few minutes on stopping the pumps.

The boring commenced in six feet of surface soil, and was then carried through the Lower Mottled Sandstone, with numerous thin layers of marls. Water occurred throughout the boring.

Analysis given in grains per gallon :—

Total solid residue	...	...	...	18·48
Oxidizable Organic matter	...	...	...	·02
Chlorine	...	...	...	·90
Equal to Chloride of Sodium	...	...	...	1·48
Nitric Acid as Nitrates	...	...	...	3·85
Free Ammonia	...	...	...	·0005
Albumenized Ammonia	...	...	...	·001
Hardness—Clarke's scale	...	...	...	14

“ Water was bright, clear, and free from colour and deposit . . .
 . . . It is a beautifully pure supply for drinking purposes ; it not
 being excessively hard makes it also serviceable for general domestic
 purposes.”

The excellent character of the water derived from the New Red Sandstone, and its power of naturally filtering and purifying waters passing through its pores, was acknowledged by the Rivers Pollution Commission, and from this formation are derived at Liverpool six-and-a-half million gallons a day, and the whole of the supplies of Birmingham, Birkenhead, Southport, Wallasey, Crewe, Staffordshire Potteries, South Staffordshire Waterworks, Nottingham, Coventry, and Leamington, as well as a large number of smaller towns. The outcrop of these rocks lies sixteen miles westward of Lincoln, where they occupy a very large area between Worksop and East Retford, of dry sandy ground, absorbing a large proportion of the annual rainfall, which water is practically untouched. The eastward dip of the New Red Sandstone carries down that formation, and with it the underground stores of water contained in it below the Lias and Oolites of the Grantham, Lincoln, and Gainsborough districts, through which they have been touched at several points, and in some cases penetrated.

The Keuper Marls contain sandy beds, which at several localities have given local supplies, but they cannot be depended on for large public water supplies.

The Marlstone Rock Bed, lying between the Lower and Upper Lias Clays, is often of great value as a source of springs, but in the Lincoln district this is not the case.

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In the two shafts and borings made at Kirkstead and Woodhall, near Horncastle, in 1819, in a futile search for coal, no water appears to have been met with, except the saline spring known as Woodhall Spa, which was met with at a depth of 530 feet, and is believed by Mr. Jukes Brown, of the Geological Survey, to have issued from the Inferior Oolite, but it is more probable that it came from the Lias. He thinks it probable that the beds passed through were as follows:—

Ft.	In.		Ft.	In.
10	0	Gravels and Boulder Clay ...	10	0
360	0	Kimeridge and Oxford Clays ...	350	0
		Kellaway Rock, Clays, Cornbrash ...		
500	0	Great Oolite, Upper Estuarine ...	140	0
640	0	Limestone Oolite and Northampton Beds ...	140	0
1020	0	Lias, Upper, Middle, and Top of Lower ...	380	0

The temperature of the water in 1883 was 59·6 Fah. In 1865 it contained:—

	Grains per Gal.
Chloride of Sodium	1215·17
„ Potassium	2 15
„ Magnesium	86·84
„ Calcium	105·00
Bromide of Sodium	5·14
Iodide of Sodium	2·73
Sulphate of Soda	30·62
Bicarbonate of Soda	45·76
Carbonate of Lime	9·38
„ Iron	0·27
Silica	0·33
Organic matter	Trace.

At Stamford, the Marquis of Exeter had a futile boring for coal put down, which commenced in the Kimeridge Clay, was discontinued at 500 feet, still in the Lias, as might have been expected.

The gorge of the River Witham, at Lincoln, has cut through the following rocks in descending order:—

g^5	{	The Lincolnshire Limestone.
$g^{5'}$	{	The Lower Estuarine series.
g^3	{	Upper Lias Clay.
g^3	{	Lias Marlstone.
$g^{2'}$	{	Middle Lias Clay.
g^1	{	Lias Clay and Limestone.

Except some small springs thrown out by an ironstone rock in the Middle Lias, at Bracebridge, at 45 feet above the sea level, no underground water is yielded by the Lias, and it may be regarded as an impermeable floor on which water absorbed on the porous rocks lying above it are supported, and carried by their dip beneath the sea level, from whence they are prevented from rising by the overlying impermeable Oolitic Clays.

Above the Lias Clays occur the inferior Oolitic Basement Beds, consisting of the Northampton sand, and the overlying clays, shales, and sands of the Lower Estuarine series, varying much in character in different parts of the district. From Navenby to Burton four to eighteen feet of massive ironstone beds occur ; between Burton and Ingham clay and sands without ironstone replace the ironstone ; but northwards, the Northampton sands are represented by the compact hard ironstone called " the Dogger ;" the sands above at Ingham are also cemented into " pan," and associated with grey clay.

These ironstone beds occur at about 200 feet above the mean sea level below the Cathedral, and dip eastwards, and descend beneath the sea level at a point on the Witham, half-a-mile on the Lincoln side of Washingborough Station, or 200 feet in two miles, which is equal to an inclination of rather more than two degrees in that direction. Strong springs rise in a small combe about 200 yards south of the Wragby Road, and a little more than a mile E.N.E. of the Cathedral, which are due to the faulting of ironstone beds against the Lias. The structure of the ironstone varies from very compact to cellular, the latter being called " fire-stone " by the well-sinkers, who imagine the rock has been exposed to fire.

Northwards from the gorge of the Witham at Lincoln, these various beds, capped by the Lincolnshire Oolite, form a fine escarp-

ment, often locally known as the "Cliff," ranging nearly north and south, while the beds dip gently eastward. Small springs are thrown out at various points along the outcrop, as at the Burton Mill spring, issuing from six feet of ironstone.

From the variable character, small outcrop, and the widespread presence of iron, I consider the Inferior Oolite Basement Beds to be of no value for water supply purposes. But the upper part of the Inferior Oolite or Lincolnshire Oolite is an important water-bearing stratum ; it has a wide area of absorption, and is exceedingly porous, or, more correctly, it is much traversed by fissures, which afford a ready passage to rain water flowing over them from high levels, and readily discharging the same as springs at low levels.

The Lincolnshire Limestone, south of Lincoln, is remarkable for having, from its water-bearing properties given rise to two lines of villages, the one at its base or the foot of the escarpment, where the water is supported by the underlying impermeable Lias clay, the other on the east, where the porous limestone dipping under impermeable clays, leaves no escape for the contained waters, the rock being water-logged up to the top of the overlying clay, the overflowing being the water absorbed over the whole porous area.

The Lincolnshire Limestones of this area generally consist of :—

1. White Limestones.
2. Whitish or Buff Limestones, with Oolitic grains.
3. Hard Grey Limestones (hydraulic).

Seams and partings of calcareous marls crowded with fossils occur at various horizons, and have the effect of dividing up the water contained into several distinct sheets, but none of these shale beds are absolutely continuous, so that the various sheets of water intermingle at certain points. The upper beds are well seen at Blankney and Metherrington, between which issue very powerful springs.

At Great Spring Head the line of permanent saturation occurs more than a mile west of the overhanging lip of impermeable rocks. The water issues from fissures in a pink limestone with fine sandy grains. These springs are derived from the rain falling over the area lying between Harmston and Coleby, Dunstan Pillar, and the

Green Man. Its breaking out at a higher level than most of the other springs appears to be due to the obstruction to the passage of water down the dip of the strata, caused by the N.W. and S.E. fault ranging between Dunston and Nocton.

At the Green Man, 154 feet above the mean sea-level, there is a well 25 feet deep with bore-hole, the water at time of visit (July, 1891) did not rise to bottom of well. A slimy pond by the roadside was used 40 years ago, and has a puddled bottom ; no spring occurs.

At Warren House there is a double bucket well ; the water flows strongly to the south-east. The water is lifted by horse-power. A quarter of a mile to the north is a deep dug combe, pointing to a seasonal variation in the level of the plane of saturation. This is also apparent in the park approaching Blankley Hall, where a combe has evidently been recently occupied by a stream, now (July) reduced to a single clear, rather shallow, pond.

Shallow wells, with ordinary pumps, supply the village of Blankney.

Traversing the same district along the strike of the Lincolnshire Limestone, from Lincoln southwards along Ermine Street, at the cottage $4\frac{1}{2}$ miles south of the city, water stands at 35 feet from the surface, and yields a copious (cottage) supply. This is also the case at the cottage at the corner of bye-road just north of the monument ; the water level is just 30 feet from the surface and varies about five feet. The Pillar is 198 feet above the mean sea level, so that the water level is 161 feet above the same. At the first cottage south of the monument a single bucket-pump reaches water, and a very small stream was flowing down the combe between. With the exception of the above well the whole of the facts observed south of Lincoln, in the Lincolnshire Limestone, point to less local irregularities of water level, and a more uniform eastern trend than is observable north of the city, where the limestone is broken up by hard bands, probably of ironstone. The aggregate thickness of the limestone, as measured by the Geological Survey at Washingborough, amounts to 65 feet, in which occur the following impermeable beds :—

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						Ft. In.
Marly, Rubbly Limestone	...	...	...	...	...	5 9
Hard Clay and Stony Marl	...	...	...	...	...	4 10
Ditto	„	...	...	...	...	0 11
Marl	...	...	...	...	...	0 3
Clay	...	...	...	...	..	0 6
Marl	...	...	..	...	...	0 7
						12 10

Or about 13 feet in all, leaving 52 feet of porous material, of which half may be considered as permanently saturated with water, or 26 feet. Taking the width of outcrop between Coleby and Dunston at five miles, a pumping station placed beside the railway south of Dunston Station, draining the rock half-a-mile north and south respectively, might be expected to produce, in dry years, the daily quantity of 700,000 gallons of water.

The best site for a boring to obtain the waters in the Lincolnshire Limestone north of the city is Scothern, and after that Dunholme. In either case the boring should commence in the Oxford Clay, so as to have the cover of an impermeable material. Such borings would be of an artesian character. This has been proved on the west side of the village of Dunholme by a boring 106 feet deep, the water rising five feet above the surface, in a pipe $1\frac{1}{2}$ inches in diameter, with a discharge of 20,000 gallons in 24 hours. This boring must penetrate the

Cornbrash	...	...	...	...	...	5 ?
Great Oolite Clay	...	...	...	...	...	25 ?
Great Oolite Limestone	...	...	...	...	...	15 ?
Estuarine Beds	...	...	...	...	...	35 ?
Lincolnshire Limestone	...	...	...	...	...	26 ?

The occasional presence of "swallow-holes" in the Lincolnshire Limestone, into which the streams are precipitated, the cracks and fissures that seem to accompany the outburst of springs, all tend to show that this rock is capable of holding a very large quantity

of water. The chief motion of underground water takes place along cracks and fissures in underground defined channels, rather than through the pores of the rock. Two very adverse conditions arise from this: First, that when water passes through fissures, and not through pores of the rock, the natural process of filtration is not exerted. Second, that in works of this class (as will be seen in the chalk) there is an unsatisfactory element of chance as to whether any particular boring may intercept a fissure along which water is travelling or capable of travelling. In the case of the Lincolnshire Oolites, as they are carried by the dip under overlying Oolite and Cretaceous rock under the German Ocean, there is no probability of the beds appearing at the margin under the sea, and consequently the water is passing under the overlying strata, though fully charged with water previously absorbed, and an artesian pressure which varies in amount according to whether the head of water rises after rain or sinks after drought, as is seen in Dunholme Boring, which increases in flow after rain, the rain in question having been absorbed several miles to the west. This ready response to rainfall is a most unsatisfactory element in the Lincolnshire Oolite, and is well evidenced by the great variability in the springs gauged by Mr. Teagne, C.E., at Welton, running in—

August, 1878	...	...	...	105,000 gallons
June, 1887	...	...	...	168,000 „
June 15, 1891, after heavy rainfall	...	...	...	2,800,000 „
July 29, 1891	...	...	...	759,600 „
Sep. 16, 1891	...	...	...	493,560 „

The whole of the rainfall absorbed by the Lincolnshire Oolite is thrown out as springs, which act in direct response to the rainfall, and any wells or artesian boreholes to obtain a large supply will have to pump at a greater rate than the water can naturally flow out at the springs at the high level, and it is doubtful whether the pumps could do this, unless they should be fortunate enough to be placed in a line of natural fissure. Regarding the springs as interest and the water stored under the clay area as capital, it follows that no water can be permanently pumped beyond the capacity of the springs, and then only at their expense.

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The Upper Estuarine Series is 35 feet in thickness at Lincoln, and thins northward to 15 feet at Ancholme Head. They consist of clays, sandy clays, and sands, that are generally impermeable, forming an impervious barrier between the waters of the Lincolnshire (Oolite) Limestone and the Great Oolite Limestone. A hard sand at the base of this series yields water at a depth of 49 feet below the platform at Potter Handworth Station, blue and red clays, with jet and bands of pyritous sandstone occurring above. The latter are a great feature of this series, and the decomposed pyrites produces an acidity of soil as deleterious to vegetation as to purposes of water supply. Strong clays of this age occur at Nettleham, Dunholme Lodge, and Gorse Cover, between Welton and Hackthorn, and support a sheet of water in the Great Oolite.

The Great Oolite Limestone is a compact shelly ragstone, its average thickness is 15 feet, though water-bearing, its small area and thickness render it of little importance for a public supply. The water rising to the surface near Dunholme Church in the Kellaway Rock, lying at the base of the Oxford Clay, may be derived from Great Oolite or Lincolnshire Limestone ; both are penetrated by a boring 106 feet deep on the west of the village.

At Honeyholes Farm a pond receives the water from the roof of a large barn. It is situated on a soft sandy clay, doubtless belonging to the Boulder Clay Drift. The vegetation changes, and ditches are seen in the area overlaid by the Boulder Clay, and on the outcrop of Upper Estuarine series. Deep-set ponds occur south of Honeyholes, but they only contain surface water.

The Great Oolite Clay is an impermeable dark bluish deposit about 25 feet in thickness, and occasionally used for the manufacture of bricks, as at Metherringham Station.

The Cornbrash is a thin-bedded shelly limestone, of a rusty colour above and of a deep blue below, it is compact and crystalline and only five feet in thickness ; for water supply purposes it is of no importance.

The Kellaway Beds consist of a few feet of black shales at the base, overlaid by the Kellaway sands, the junction being well seen in

Scothern Mill. In the sands occur the "Kellaway Rock." The shales support a small sheet of water of no sanitary importance.

Above occur the impermeable Oxford and Kimmeridge Clays, which are practically impermeable, and prevent the water in the porous strata beneath from rising to the surface, and therefore constitute an area of artesian pressure, both North and South of Lincoln.

The Geological sequence at Sleaford is similar to that of the Lincoln area, and for boring purposes, to obtain a water supply, the conditions are hardly as favourable as nearer Lincoln.

CRETACEOUS ROCKS.—The Lower Cretaceous, or Neocomian Rocks, consist of the following strata in the Tealby district :—

	Ft.
Red Chalk	6
Upper Sands or Carstone	25
Tealby Clays, Limestones, and White Ironstones of Claxby	65
Spilsby Sandstone and Lower Sands	42

The Spilsby Sandstone is an extremely hard calcareous grey grit, passing horizontally into soft sandstone with mud from oxide of iron. Narrow outcrops, and shallow thickness alike, prevent the above being useful for purposes of public water supply, and were the conditions otherwise the presence of iron would seriously affect their quality.

The Carstone is a coarse grit, mixed with ferruginous clay, but never passes, like the softer portions of the Spilsby Sandstone, into a "running sand."

The Red Chalk is shaly and impermeable, and throws off springs at the base of the Lower Chalk, and a spring half-a-mile south of Stanton-le-hole is thrown out by the Carstone.

UPPER CRETACEOUS.

Lower Chalk : This formation in Lincolnshire is marly, and cannot be relied on for a good supply of water.

Middle Chalk : For borings see end of Appendix II.

Upper Chalk : For borings see end of Appendix II.

APPENDIX I.
RAINFALL, FROM "SYMONDS' ANNUAL."

	LINCOLN. M.S. & L. Ry. Co. 25 feet above O.D.	NAVENBY. Rev. J. Hays.	SLEAFORD. BLOXHOJME. Mr. D. Lumsden 20 feet O.D.	SPALDING. PODE HOLE, Mr. H. Harrison 20 feet O.D.
1863	16·64	...	...	...
1864	...	...	...	...
1865	...	...	...	...
1866	22·62	..	...	...
1867	23·46	...	...	..
1868	19·64	...	...	...
1869	24·10	28·77	...	...
1870	16·29	18·82	...	16·88
1871	19·12	24·88	...	25·50
1872	32·15	36·14	...	32·50
1873	18·31	19·95	...	19·63
1874	16·58	18·38	...	16·22
1875	25·74	25·57	...	32·25
1876	29·79	30·83	32·92	31·00
1877	25·95	25·70	29·43	24·25
1878	28·04	28·40	30·18	25·63
1879	24·98	29·59	31·64	24·35
1880	30·68	22·93	32·59	37·13
1881	23·83	26·55	25·36	26·13
1882	32·96	33·08	33·71	30·50
1883	31·49	35·85	31·62	30·88
1884	15·43	16·25	16·92	16·75
1885	25·07	26·06	23·75	23·88
1886	24·57	27·21	27·34	30·25
1887	15·53	16·68	17·04	15·13
1888	20·34	23·62	22·39	21·46
1889	26·01	25·63	23·15	26·50
1890	18·20	17·31	18·29	20·12

APPENDIX II.

LINCOLNSHIRE STRATA.				Feet.
Cretaceous.	Chalk	Middle Chalk	...	164
		Lower Chalk	...	72
		Red Chalk 11ft., and Carstone 36ft.	...	47
	Tealby Beds.	Tealby Limestone	...	15
		Tealby Clay	...	50
		Claxby Ironstone	...	10
		Spilsby Sandstone	...	30

				Feet.
Oolitic.	Upper	Upper Kimeridge Clay	...	800
		Oxford Clay	...	
	Middle	Kellaway Rock	...	10 ?
		Basement Clay	...	18 ?
	Great Oolite Series	Cornbrash	...	5
		Great Oolitic Clay	...	25
		Great Oolitic Limestone	...	15
		Upper Estuarine Beds	...	35
	Inferior	Lincolnshire Limestone	...	60
	Oolite	Basement Beds (Northampton Beds)	...	30
Liasic.	Lias.	Upper Lias	...	100
		Marlstone Rock-bed (represented by clay)	...	20
		Middle Lias Clay	...	15 ?
		Lower Lias	...	814
		Rhætic	...	22
Triassic.	Trias	Keuper Marls	...	725
		Keuper Sandstone	...	249
		Upper Soft Sandstone...	...	206
		Pebble Beds	...	113
		Lower Soft Sandstone	...	223
Permian.	Permian	Upper Marls	...	118
		Upper Magnesian Limestone	...	44
		Middle Marls	...	140
		Lower Magnesian Limestone	...	26
		Marl Slates	...	193
Carboniferous		Upper Coal Measures...	...	10

An examination of the table of the sequence of the rocks discloses that though there are no less than 15 water-bearing horizons, half of them are only 30 feet in thickness, or less, and though valuable for supplies to private dwellings are of no use for a public water supply. This can alone be afforded by the following:—(1.) The Middle Chalk, 164 feet; (2.) The Lincolnshire Oolite and Nottinghamshire Sands, together about 90 feet; (3.) The New Red Sandstone, in four horizons, together 791 feet.

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LINCOLNSHIRE WELLS AND BORINGS.

COLLINGHAM, OR SCARLE.

This section was first described by Dr. Hull, F.R.S., late Director of the Geological Survey of Ireland; and subsequently by Mr. Dalton, F.G.S., late of the Geological Survey; and Mr. Wilson, F.G.S., of the Bristol Museum. It appears to have been as follows:—

Depth in feet.		Thickness, feet.	
21	Drift Deposits, river gravel ...	21	753
	Lower Lias Clay Limestone ...	29	
	Rhætic Shales and Limestone ...	15	
753	Keuper Marls (Gypsum)...	688	205½
958½	Keuper Sandstone, fine-grained and grey shales		
1164	Upper Soft Sandstone ...	205½	113
	Blue Shales ...	1	
	Reddish-Brown Coarse Sandstone {Pebble Beds}	73	
1277	Quartzite Conglomerate ...	39	223
1500	Lower Soft Sandstone, Marls in first 79 feet...		
1618½	Permian Marls ...	118½	519
	Light Yellow Magnesian Limestone ...	43½	
	Red and Blue Marls and Gypsum ...	138	
	Lower Magnesian Limestone ...	26	
	Dolomitic Limestone, Marl Slates...	58	
	Lost Cores ...	16	
	Thin-bedded Dolomites, Grey Shales, and Sandstone ..	118	
2019	Permian Basement Beds..	1	10
2031	Deep Red Indurated Marls, with hæmatite nodules, Carboniferous ...		

NEWARK.

Trent Brewery Well, No. 3, surface level 49 feet. Sunk by Messrs. Mather and Platt, Manchester, 1870.

Ft.	In.		Ft.	In.
325	6	Red and Blue Marls ...	160	0
		Gypsum and Hard Sandy Marl ...	30	0
		Red and Blue Marl, hard bands at 231 feet ...	125	6

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Ft.	In.		Ft.	In.
576	0	{ Blue Flints (? hard rock)	4	0
		{ Pea Stone, hard bright red, soft sandstone ...	60	6
		{ Blue Clay	1	0
		{ Red „	4	0
		{ Red Stone (very hard)	14	6
		{ Brown Rock	7	0
		{ Brown Sandstone	18	0
		{ Stone Bind (hard sandy marl)	73	6
		{ Brown Rock (very hard sandstone)	2	0
		{ Stone Bind (hard sandy marl)	6	0
585	6	{ Brown “Granite” Rock (coarse sandstone) ...	75	0
		{ Stone Bind (very hard sandstone)	13	6
		{ Brown Rock	37	6
		{ Redstone	4	6
		{ Red Clay	9	0

Abstract of above :—

	Ft.	In.
Keuper Marls, with sandstones	325	6
Keuper Waterstones	190	0
Keuper Sandstone	69	6

Messrs. Warwick and Sons' Brewery, surface level 36 feet.

	Ft.	In.
Keuper Marls, with Gypsum	400	3

The water yielded contains six grains to the gallon of carbonate of lime, 84·93 grains of sulphate of lime, and 23·91 grains of sulphate of magnesia. The two latter are doubtless from the lower beds of the Keuper Marls, as the boring was only tubed down to 300 feet, those ingredients being suitable for brewing.

OWTHORPE.

Boring for Coal, 1876-80. [Qr. Sheet, 71 S.E.] Information from Mr. Harrison.

Ft.	In.		Ft.	In.
12	0	Lower Lias	12	0
46	6	Rhœtic Beds	34	6
679	6	Keuper Marls (Gypsum)	633	0

DE RANCE : UNDERGROUND WATERS IN LINCOLNSHIRE.

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Ft.	In.		Ft.	In.	
		Red Sandy Marl and Sandstones ...	15	0	
772	6	Red Sandy Marl ...	44	0	93 0
		Reddish and White Gritty Sandstones, with pebbles ...	34	0	
804	6	Fine White Micaceous Sandstone ...	22	0	32 0
		White-pink Gritty Sandstone...	10	0	
941	6	Coarse-grained Gritty Sandstone, pass- ing into coarse and fine conglomerate, of which the larger pebbles were quartzite ...	137	0	
		Red Marl and White Marl ...	2	0	264 0
		Sandstone and Conglomerate ...	56	0	
		Fine White Micaceous, sometimes gritty	36	0	
		Dark Red Coarse-grained Sandstone ...	16	0	
1068	6	Red and Grey Sandstone, conglomerate } predominating ...	17	0	
1097	6	Red Marl, Banded Red and Grey Marl, Soft White Clay ...	14	0	29 0
		Red, Grey, and White Fine-grained Micaceous Sandstone ...	15	0	
1342	0	Coal Measures, with coal seams ..	244	6	

In abstract I classify the above section as follows :—

Ft.	In.		Ft.	In.
46	6	Lias and Rhoetic ...	46	6
679	6	Keuper Marls ...	633	0
772	6	Keuper Sandstones ...	93	0
804	6	Upper Soft Sandstones ...	32	0
1068	6	Pebble Beds ...	264	0
1097	6	Upper Coal Measures? ...	29	0
1342	0	Coal Measures ...	244	6

Boring east of East Retford, made by the Retford Coal Company in a futile search for coal. A plentiful supply of water was met with, but somewhat impregnated with iron. Communicated by the late Mr. Charles Tomlinson, C.E., of Rotherham, to C. E. De Rance, F.G.S.

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	Ft.	In.		Ft.	In.
Keuper	29	6	Soft Red Marl and Sandstone	...	29 6
	60	0	Red and Grey Marlstone and Gypsum	30	6
Upper Mottled Sandstone	183	0	Red Sandstone ...	...	123 0
	186	0	Grey and Red Marl	...	3 0
	278	6	Red Sandstone ...	...	92 6
Bunter Pebble-beds	289	0	Red Sandstone and Gravel	...	1 6
	510	0	Red Sandstone ...	...	230 0
	511	6	Red Marl and Gravel	...	1 6
	654	0	Red Sandstone ...	...	142 6
	662	0	Pebbly Conglomerate	...	8 0
Lower Sandstone	733	0	Red Sandstone	...	70 0
	736	0	Red Marl	...	3 0
	805	0	Red Sandstone ...	...	69 0
Permian	904	6	Red and Grey Marl and Red and White Sandstone	...	99 0
	911	0	Red Marl and Limestone	...	7 0

Following the sub-divisions I have proposed above the abstract would be :—

Ft.	In.		Ft.	In.
60	0	Keuper	...	60 0
278	6	Upper Sandstones	...	218 0
662	0	Pebble Beds	...	383 6
805	0	Lower Sandstones	...	143 0
911	0	Permian	...	106 0

From Mr. John Bennett, Goole, per H. Franklin Parsons, M.D., F.G.S. Section of Trial Boring at Reedness, five miles east of Goole, made by the late Mr. Egremont in 1835 :—

From surface			Thickness.
Ft.	In.		Ft. In.
1	6	1. Dark Soil	1 6
1	9	2. Yellow Sandy Warp	0 3
9	3	3. Dark Blue Warp	7 6
15	3	4. Fine Blue Clay ...	6 0
21	3	5. Blue Sandy Warp	6 0
30	3	6. Light Grey Sand, with water	9 0
42	0	7. Black Moor Earth, with some rotten wood	11 9

DE RANCE : UNDERGROUND WATERS IN LINCOLNSHIRE. 41

From surface.			Thickness.		
Ft.	In.		Ft.	In.	
45	3	8. Strong Blue Clay ...	3	3	
46	0	9. Grey Sand, with water ...	0	9	
56	3	10. Black Gravel and Quicksand ...	10	3	
57	8	11. Red Sand ...	1	5	
63	0	12. Grey Sand and Gravel ...	5	4	
66	4	13. Red Sand ...	3	4	
69	8	14. Gravel and Sharp Sand ...	3	4	
72	10	15. Red Marl, metal with grey specks ...	3	2	
80	11	16. Red Sandstone, with gypsum and thin lists	8	1	
90	1	17. Strong Blue Stone, with thin white beds	9	2	
108	4	18. Dark Red Bind, with thin beds of gypsum	18	3	
110	0	19. Strong Blue Stone ...	1	8	
120	3	20. Red Bind, with beds of blue stone ...	10	3	
125	1	21. Blue Stone ...	4	10	
133	7	22. Red Bind, with thin white beds, and hard lists of blue stone ..	8	6	
135	7	23. Blue Bind ...	2	0	
143	2	24. Red Bind, with thin hard lists of blue stone and gypsum ...	7	7	
151	10	25. Red Stone ...	8	8	
168	8	26. Red Bind, with hard lists of stone and gypsum	16	10	
173	0	27. Blue Stone ...	4	4	
190	11	28. Red Bind, with thin beds of gypsum ...	17	11	
192	8	29. Blue Bind ...	1	9	
199	4	30. Red Bind, with thin beds of gypsum ..	6	8	
199	6	31. Blue Stone and white parting ...	0	2	
219	2	32. Red Stone, with blue lists ...	19	8	
241	8	33. Blue Bind, with thin beds of gypsum ..	22	6	
241	2	34. Blue Stone ...	5	6	
251	2	35. Blue Stone ...	4	0	
257	8	36. Red Bind, with hard list and white partings	6	6	
263	2	37. Red Sandstone, with thin white partings...	5	6	
269	8	38. Blue Stone, thin beds, and blue bind partings	6	6	
286	2	39. Blue Bind, with thin beds of blue stone ..	16	6	
297	2	40. Red Bind, with thin bands of gypsum ...	11	0	

42 DE RANCE : UNDERGROUND WATERS IN LINCOLNSHIRE.

From surface.			Thickness.		
Ft.	In.		Ft.	In.	
305	5	41. Blue Bind, with soft beds of gypsum ...	8	3	
337	10	42. Dark Soft Red Bind ...	32	5	
341	10	43. Blue Stone ...	4	0	
511	4	44. Red Sandstone ...	169	6	
513	4	45. Red Bind ...	2	0	
529	10	46. Red Sandstone ...	16	6	
533	4	47. Red Bind, with lists of blue stone ...	3	6	
766	10	48. Red Sandstone ...	233	6	
770	0	49. Red Bind, with bright shining specks ...	3	2	
772	10	50. Dark Red Bind ...	2	10	
784	4	51. Red Sandstone ...	11	6	
785	4	52. Dark Red Bind ..	1	0	
804	10	53. Red Sandstone ...	19	6	
807	1	54. Red Bind ...	2	3	
881	4	55. Red Stone ...	74	3	
882	4	56. Red Bind ...	1	0	
906	10	57. Red Stone ...	24	6	
910	8	58. Soft Red Bind ...	3	10	
930	10	59. Red Sandstone ...	20	2	
931	10	60. Dark Red Bind ...	1	0	
955	10	61. Red Sandstone ...	21	0	
957	1	62. Dark Red Bind ...	1	3	
995	4	63. Red Sandstone ...	38	3	
998	4	64. Light Red Sandstone ...	3	0	
1029	0	65. Red Sandstone ...	30	8	
			1029	0	

In abstract, the section will stand as follows :—

		Ft.	In.
Beds 1 to 14.	Drift	69	8
Bnds 15 to 43.	Keuper Marls, with hard bands and gypsum	272	2
Bed 44.	Red Sandstone ..	272	2
Beds 45 to 47.	Red Sandstone, with 5½ feet of red binds	22	0
Bed 48.	Red Sandstone ...	233	6
Beds 49 to 62.	Red Sandstone, with 16 feet 4 inches of red binds	190	3
Beds 63 to 65.	Red Sandstone ...	71	11
		1029	0

Out of 687 feet 2 inches of beds beneath the Keuper Marls, only 21 feet 10 inches consists of red binds, the rest being 665 feet 4 inches of red sandstone of similar physical character from top to bottom. They have been referred by Dr. Parsons to the Bunter.

In considering their age and character, it may be useful to compare this section with the borings for salt in the Middlesborough district, especially that of Saltholm Farm, on the Durham side of the Tees ("Sixth Report Underground Water"). I there suggest that "the limestones, thick salt beds, and gypsum are probably referable to the Permian; the intervening beds of red sandstone, 832 feet, are probably referable to the Waterstones and Lower Mottled Bunter, the Upper Mottled and Pebble Beds having thinned out." From more extended investigation, I think it more probable that the pebbly character of the middle portion of the Bunter has died away northwards, and that the Middlesborough section represents Waterstones and pebbleless Middle Bunter.

In the Lincolnshire area the valuable sections collected by Dr. Parsons throw light on this inquiry. He describes the beds below the Keuper Marls, in the surface sections, as "a loose red sand or friable semi-coherent red sandstone, often micaceous, with more coherent clayey bands, and with occasional partings or pockets of red, green, or yellow ochrey marl."*

Trial Boring for Water, Booth Ferry Road, Goole, made by Goole and Hook Parochial Sanitary Committee in 1876. From Mr. Tudor, Surveyor, Goole, per Dr. Parsons.

From surface.			Thickness		
Ft.	In.		Ft.	In.	
17	0	Warp, Peat, and Clay	17	0	
25	0	Rough Gravel	8	0	
28	0	Warp Clay, with a large pebble ..	3	0	
34	0	Red Sand	6	0	
58	0	Hard, Coarse, Light Red Sand ...	24	0	
68	0	Red Marl	10	0	
79	0	Hard Sand	11	0	

* Proc. Geol. and Polyt. Soc. of West Riding of Yorkshire, 1877, p. 216. From which several sections have been here reproduced for convenience of reference. C. E. R.

44 DE RANCE : UNDERGROUND WATERS IN LINCOLNSHIRE.

From surface.			Thickness.		
Ft.	In.		Ft.	In.	
82	0	Red Marl	...	3	0
108	0	Hard Sand	...	26	0
109	0	Red Marl	...	1	0
170	0	Hard Sand	...	61	0
173	0	Red Marl	...	3	0
176	0	Hard Coarse Sandstone, with small pebbles	...	3	0
260	0	Red Sandstone and Marl mixed	...	84	0
282	0	Red Sand	...	22	0
284	2	Stiff Red Marl	...	2	2
306	3	Marl and Red Sand	...	22	1
366	0	Red Sandy Marl	...	59	9
			366	0	

In abstract, this section gives drift probably 28 feet, red sand 338 feet, of which 19 feet were marl, if the red sandy marl last penetrated be omitted, which added gives an entire thickness of marl of just 80 feet. The occurrence of the small pebbles at 176 feet and the thick marl are worthy of note in this section, and differ from those adjacent ; they are probably referable to the Waterstones.

Helliwell's Brewery, Rawcliffe, from Dr. Helliwell, per Dr. Parsons. Well deepened in 1876.

From surface.			Thickness.		
Ft.	In.		Ft.	In.	
18	0	1. Old Well	...	18	0
45	0	2. Yellow Sand	...	27	0
47	0	3. Blue Clay	...	2	0
47	6	4. Peat	...	0	6
59	6	5. Clay, with gravel	...	12	0
200	0	6. Red Sand, with thin marl bed at 139 feet	...	140	6
			200	0	

Artesian Well at Rawcliffe Halls, 1877. Details from Mr. Tudor, Surveyor, Goole, per Dr. Parsons.

From surface.			Thickness.		
Ft.	In.		Ft.	In.	
16	0	1. Silty Stiff Red Warp	...	16	0
130	0	2. Red Sand and Marl	...	114	0
250	0	3. Coarse Loose Red Sandstone and Marl	...	120	0
			250	0	

Well near Rawcliffe Station. Per Dr. Parsons, 1876.

From surface.		Thickness.	
Ft.	In.	Ft.	In.
3	0	1.	Black Sand 3 0
8	0	2.	Brown Coarse Sand 5 0
16	0	3.	Mottled Brown Clay 8 0
		4.	Red Sand

These soft red sands and loose sandstones would appear to be referable to the Keuper Sandstone, and are the representatives of the Cheshire Frodsham Beds, which have been observed eastwards by Mr. Aveline, F.G.S., and myself as far as Ashbourne in Derbyshire.

Trial Boring for Water at New Bridge, near Snaith, in ancient course of the River Don, made in 1876 by the Goole Local Board, From Mr. Tudor, Surveyor, Goole.

From surface.			Thickness.		
Ft.	In.		Ft.	In.	
46	0	Brown Warp, Peat, and Loam	46	0	
51	0	Gravel, with magnesian limestone fragments	5	0	
56	0	Coarse Reddish-brown Sand (decomposed rock?)	5	0	
57	0	Light Green Marl	1	0	
80	0	Red Marly Sandstone	23	0	
87	0	Coarse Red Sandstone	7	0	
130	0	Bed Marly Sand	43	0	
133	0	Red Sand, with green marl	3	0	
170	0	Red Marly Sand	37	0	
173	0	Blue Marl	3	0	
175	0	Red Marl	2	0	
263	0	Red Marly Sand	88	0	
265	0	Variegated Marl	2	0	
309	0	Red Marly Sand	44	0	
329	0	Coarse Red Sand	20	0	
377	0	Red Marly Sand	48	0	
379	0	Variegated Marl	2	0	
403	0	Red Marly Sand	24	0	
404	0	Variegated Marl	1	0	
500	0	Red Marly Sand	96	0	
			<hr/>		
			500	0	

46 DE RANCE : UNDERGROUND WATERS IN LINCOLNSHIRE.

This section gives, in abstract, drifts probably 51 feet, and 449 feet of red sandstone, red sand, and coarse red sand, with 11 feet of intercalated marls, the whole of which may be regarded as one series, and compare well with the Goole section, and may be referred to the Keuper Sandstones, and might for their important thickness be called the Goole Beds.

It may be well to reproduce the section of the Selby Waterworks, obtained from Mr. Wetherill by Professor Green, F.R.S.

Surface level $20\frac{1}{2}$ feet above Ordnance datum ; the water out of a 6-inch bore-hole rises to 16 feet from Ordnance datum.

From surface.				Thickness.			
Ft.		In.		Ft.		In.	
5	0	1.	Alluvial Soil	...	5	0	
29	0	2.	Clay	...	24	0	
30	0	3.	Sand charged with water that one man could pump	...	1	0	
54	0	4.	Clay	...	24	0	
75	0	5.	Quicksand. Strong spring of water at base ...	21	0		
		6.	Red Sandstone	...	18	0	
93	0	7.	Marl, resembling fuller's earth ...	...	0	1	
		8.	Red Sandstone	...	10	3	
103	3	9.	Grey Sandstone	...	0	1	
		10.	Red Sandstone	...	64	9	
		11.	Red Hard Sandstone	...	118	6	
		12.	Very Hard Rock... ..	...	10	6	
		13.	Red Sandstone	...	6	9	
		14.	Very Hard Rock... ..	...	14	9	
330	8	15.	Hard Rock	...	22	0	
				<hr/>			
				330 8			

Here there was 75 feet of drift, all the remainder being more or less hard red sandstone, without the intercalated marl beds observable in the Goole section, which are presumably above those penetrated at Selby, which may be referred to the Pebble Beds.

Boring at Donington, on west side of River Bain. Communicated by Mr. Edward Bogg, the Geol. Soc., London, "Trans. Geol. Soc." 1816.

DE RANCE : UNDERGROUND WATERS IN LINCOLNSHIRE. 47

						Ft.	In.
1.	Clay Soil	...	...	...	...	3	0
2.	Dark Coloured Clay	...	...	...	...	9	0
3.	Soft Grey Shale, with fossils	...	...	...	...	1	0
4.	Dark Agillaceous Stone	...	...	...	...	0	5
5.	Dark Coloured Clay	...	...	...	...	3	1
6.	Soft Grey Shale	...	...	...	...	1	0
7.	Laminated Clay, slightly indented	...	...	...	...	23	2
8.	Soft Grey Shale, slightly inflammable	...	...	...	...	5	3
9.	Ditto, darker coloured	...	...	...	...	5	3
10.	Indurated Clay, with white fossils	...	...	...	...	37	6
11.	Ditto, but harder and blacker	...	...	...	...	7	3
12.	Dark Coloured Bituminous Inflammable Shale	...	...	...	...	6	0
13.	Dark-blue Ironstone	...	...	...	...	0	3
14.	Laminated Indurated Clay, with fossils	...	...	...	...	33	0
15.	Ditto, harder fossil impressions in pyrites	...	...	...	...	10	4
16.	Dark Blue Clay (iron) stone	...	...	...	...	0	4
17.	Hard Indurated Laminated Clay	...	...	...	...	18	4
18.	Laminated Bituminous Shale, with fossils	...	...	...	...	1	10
19.	Dark Blue Ironstone	...	...	...	...	0	2
20.	Laminated Bituminous Shale, like 18	...	...	...	...	11	0
21.	Dark Blue Ironstone	...	...	...	...	0	1½
22.	Laminated Bituminous Shale, like 18 and 20	...	...	...	...	18	10½
23.	Dark Indurated Clay, with fossils	...	...	...	...	3	6
24.	Laminated Bituminous Shale, like 18, 20, and 22...	...	...	...	...	9	0
25.	Dark Clay, like 23	...	...	...	...	5	0
26.	Laminated Bituminous Shale, like 24, &c.	...	...	...	...	4	6
27.	Dark Clay, indurated clay, like 25	...	...	...	...	30	3
28.	Grit	...	...	...	...	0	2
29.	Brown Laminated Clay	...	...	...	...	0	2
30.	Clay (iron) stone	...	...	...	...	4	10
31.	Hard Laminated Bituminous Shale	...	...	...	...	3	2
32.	Clay (iron) stone	...	...	...	...	2	0
33.	Hard Laminated Bituminous Inflammable Shale	...	...	...	...	2	4
34.	Inflammable Compact Shale	...	...	...	...	3	0
35.	Hard Laminated Shale, very inflammable	...	...	...	...	5	7½

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					Ft.	In.
36.	Dark Blue Compact Shale, with bituminous bands				13	9½
37.	Very Inflammable Shale	...	...	..	0	2
38.	Hard, Dark, Blue, Compact Shale	...	...	...	3	8
39.	Clay (iron) stone	...	...	...	1	0
40.	Ditto, but not so hard	...	...	...	1	0
41.	Hard, Dark, Compact Shale, like 38	...	...	...	22	10
					309	0

GRANTHAM.

Boring on Messrs. R. Hornsby & Sons, Iron Works, at Spittle-gate.

	Ft.	In.				Ft.	In.
832	0	Lower Lias	...	...	...	832	0
853	4	Rhætic	...	...	...	21	4
		Keuper Marl	...	...	...	(+)	

MELTON MOWBRAY.

Town Supply, boring 200 yards west of the North Station.
Surface level 260 feet above the sea.

	Ft.	In.				Ft.	In.
38	0	Drift Clays	...	...	...	38	0
268	8	Lower Lias Clays	...	...	...	230	8
285	0	Rhætic	...	...	...	16	4
476	8	Keuper Marls	...	...	...	191	1
533	0	Keuper Marls, with sandstones	...	...	...	56	4

Water was yielded by gypsum beds in the marls, and by the sandstones below them, and rose to 120 feet below the surface, or 140 feet above the sea level.

BOURN.

Spetchley's Brewery for the Spalding Waterworks.

	Ft.	In.				Ft.	In.
20	0	Fen Beds	...	...	...	20	0
28	0	Cornbrash	...	..	...	8	0
63	0	{ Great White Clay	..	...	.	35	0
75	0	{ Great Oolite	...	...	...	12	0
90	0	Green and Yellow Marl	...	..	...	15	0

BRACEBRIDGE, NEAR LINCOLN.

Trial bore-hole for Messrs. Bass & Co., by Messrs. Le Grand and Sutcliffe, London.

Ft.	In.					Ft.	In.
320	0	Lower Lias Clay	...	...	..	...	320 0
The water at that depth contained the following constituents —							
						Grains.	
Sodium Chloride	...	...	...	...	...	549·00	
„ Bromide	...	...	...	...	..	11·00	
„ Carbonate	...	...	...	...	...	15·00	
Calcium „	...	...	...	...	...	12·50	
Magnesium „	...	...	...	...	...	4·58	
Calcium Sulphate	..	...	...	...	...	1·13	
Silica	...	...	...	...	...	0·35	
Iron Oxide, Alumina, Phosphoric Acid	...	...	...	...	...	0·21	
Suspended Matter	...	...	...	...	...	0·04	
Total	...	...	...	...	...	593·81	

As this boring commenced in the Lower Lias, near the top of that deposit, which is at least 800 feet thick, the saline water must either be derived from the Lower Lias, or must have flowed up along the plane of some fault or joint from the Keuper Marls below.

SCOTHERN GRANGE WELL.

Boulder clay	...	...	...	...	...	7 feet
Gravel, with water	...	...	...	...	..	(+)

LANGWORTH.

Farm, 1¼ mile S.W. of Station.						
ft.						ft.
Boulder Clay	} sunk	...	...	...	...	30
30 Oxford Clay						
Ditto do	bored	...	...	...	...	60
90 Kellaways Sand		...	...	...	...	(+)

The water rises nearly to the surface.

SUDBROOK HOLME.

Boring by Messrs. Legrand & Sutcliffe, London. Water rises to level of top of house. Yielded 7000 gallons per day of 10 hours.

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Ft.	In.						Ft.	In.
2	0	Soil	...	...	..	...	2	0
7	0	Stone				...	5	0
20	0	Grey Sand	}	Kellaways Beds	...	...	13	0
27	0	Blue Clay				...	7	0
31	6	Stone	...	Cornbrash	...	..	4	6
43	0	Green Clay	}	Great Oolite Clay	...	...	11	6
57	0	Dark Clay				...	14	0
62	0	Stone 4 ft., Clay 1 ft.	}	Great Oolite	...	...	5	0
76	0	Shell Rock				...	14	6
80	2	Green Clay	}	Upper Estuarine	...	...	5	4
85	6	Stone				...	15	0
100	6	Clay	...	...	...	...	15	0
107	0	Stone	Lincolnshire Limestone			...	5	6

Grimsby Waterworks Co. Wells. Collected by C. E. De Rance from Messrs. Mather & Platt, Manchester. Boring west of Grimsby.

From surface.		Thickness.	
Ft.	In.	Ft.	In.
21	0	1. Very Soft Clay, full of vegetable matter	.. 21 0
24	6	2. Gravel and Sand	... 3 6
29	6	3. Clay	... 5 0
31	6	4. Rough Gravel and Small Flints	.. 2 0
33	6	5. Fine Soft Clay and Small Flints	... 2 0
45	0	6. Rough Gravel ..	... 11 6
60	0	7. Fine Gravel . .	... 15 0
75	0	8. Chalk, very hard. Water then rose to 4 feet above the surface in large volumes	... } 15 0
			<hr/> 75 0

Boring east of Grimsby, near Cleethorpes.

From surface.		Thickness.	
Ft.	In.	Ft.	In.
84	0	Stiff Bluish Clay, with flakes of chalk	.. 84 0
99	0	Sand and Gravel	... 15 0
224	0	Chalk, with flints in beds	... 125 0
			<hr/> 224 0

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In the Cleethorpes boring the top of the chalk was very rotten and had to be tubed out down to 120 feet from the surface, or 21 feet from the top of the chalk. The yield from this boring is only about 180,000 to 192,000 gallons per day, and it is evident that the water is not entirely tubed out from the upper part of the Chalk, from the fact that, when this quantity is pumped, the water-level being 24 feet from the surface, the neighbouring wells and boreholes all lose their supply of water, none of which do more than penetrate the top bed of the Chalk.

At Grimsby Docks there is a well in the Chalk 300 feet deep ; the water is clear and palatable. Analysed by the Rivers Pollution Commission, was found to have a hardness of 22·1, of which 7·6 was permanent ; chlorine was 5·00, in parts per 100,000.