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MEMOIRS OF THE GEOLOGICAL SURVEY.

ENGLAND AND WALES.

THE WATER SUPPLY OF SURREY,

FROM UNDERGROUND SOURCES,

WITH RECORDS OF SINKINGS AND BORINGS.

BY

WILLIAM WHITAKER, B.A., F.R.S.,

WITH CONTRIBUTIONS ON THE RAINFALL BY

HUGH ROBERT MILL, D.Sc., LL.D.

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PREFACE.

This is the eleventh of the series of County Water Supply Memoirs, and the seventh of those which Mr. Whitaker has written, or to which he has largely contributed. Both as regards the length of the record of wells and the importance of the subject the Memoir is second only to that on Kent.

The copious literature on subjects connected with underground water in Surrey includes several descriptions of such well-known phenomena as the bourne-flows of the Wandle Valley. Especial mention should be made too of papers by Mr. Baldwin Latham and Mr. J. Lucas, whose observations, together with those of other authors, Mr. Whitaker has largely utilised, supplementing them from his own long experience of the County.

Though most of the well-records have been published before, new particulars have now been added to many of these, more especially from information obtained by Mr. G. Barrow and Mr. L. J. Wills during the preparation of a Memoir on London Wells, now in the press.

Much new information has been given by engineers and well-sinkers, and is duly acknowledged. Among Chemists, Dr. J. C. Thresh's assistance must be particularly mentioned. An account of the Rainfall has been contributed by Dr. H. R. Mill, and the author of the Memoir has been greatly helped by his son, Mr. H. L. Whitaker, in passing the work through the press.

J. J. H. TEALL,
Director.

Geological Survey Office,
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Yorkshire, East Riding, 1906. Price 3*s.*

A Memoir containing Records of London Wells is in the press.

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Rainfall Map of Surrey *at end of Vol.*

INTRODUCTORY.

General Remarks.

Surrey lies in two great geologic districts, the London Basin on the north, from the Chalk-escarpment of the North Downs, and the Weald on the south, from below that escarpment. The former is essentially a gentle trough in geologic arrangement, the latter a gentle arch; but in this county we are dealing only with the southern part of the trough, the northern part of the arch and a comparatively small part of each, especially of the Basin.

The county is one of diversified character, by reason of the varying composition of its geologic formations, the chief natural districts, from this point of view, being as follows:—

1. On the north-~~ea~~st is the more or less barren tract of the we/ Bagshot Series, the general sandy character of which leads to the formation of hills and of wide-spreading commons. The gravel-cappings add to the flatness of the hill-tops, and the whole is largely given to the growth of heather, gorse, bracken, and firs.

2. ~~We~~stward of this is the gently undulating ground formed Ea/ of the London Clay, largely under grass. It is on the London Clay only that the Drift Gravels materially affect a great part of the surface forming flats of considerable extent, at various levels, the dryness of which flats contrasts with the damper character of the clay-tracts.

3. Southward of the above districts, through the middle part of the county, from west to east, is the Chalk-tract, rising from the line of outcrop southward to the escarpment, sometimes to over 800 feet above sea-level, by the eastern border of the county, Botley Hill, near Oxted, being 875 feet above Ordnance Datum. In many places the height is more than 700 feet; but it decreases westward. Very narrow on the west, from Farnham to Guildford, on account of the high dip, the outcrop broadens eastward, with decrease of dip.

4. The sandy tract of the Lower Greensand follows soon to the south of the Chalk, also through the county, from west to east; but in this case the outcrop is broadest at the western end of the county, between Farnham, Godalming and Haslemere. Indeed this tract, with the adjoining part of Hampshire and to a less extent of Sussex, is the widest outcrop of the Lower Greensand in the kingdom. Throughout there is beautiful scenery, especially perhaps amongst the bold hills of the tract from Leith Hill westward, that hill being the highest ground in the south-east of England (965 feet above Ordnance Datum), Blackdown (in Sussex) is 918 feet, Hindhead 875, and some other places over 800 feet above the sea. Here, as with the Chalk, the general level rises southward, from the line of outcrop to the escarpment.

5. To this sandy tract succeeds the tamer ground of the Weald Clay, which forms the southern border of the county from Haslemere eastward for many miles, it being only on the far east that the Tunbridge Wells Sands rise up to the surface.

Surrey is almost wholly in the Basin of the Thames; but a small area, on the south-west (near Haslemere, Chiddingfold and Dunsfold) drains southward to the Arun, the only stream that, rising in the northern part of the Wealden area, crosses it and flows southward to the sea. The tributary-basins in which the county is placed are those of the Wey and of the Mole, both of which reach through it from north to south, of the Wandle and of the Ravensbourne, which start in the middle part of its eastern end, of the Darent (a very wee piece only, near Westerham), and of the Medway, one branch of which (the Eden) rises in the south-eastern corner of the county.

The north-eastern part of the county contains the greater part of southern London, which, with its border, is supplied, by the Metropolitan Water Board, with water chiefly taken from the Thames, but supplemented by the yield of a few wells, at Merton and Camberwell.

Outside the area of the metropolitan supply, which goes beyond the boundary of the London County Council, Surrey is almost wholly dependent on underground supply; but (according to the Waterworks Directory, 1911), the South West Suburban Company and the West Surrey Company take water from the Thames, for populations of respectively 65,300, of which only part is in Surrey, and of 32,000 partly not in Surrey. Wells, and to a small extent springs, supply the rest of the county.

According to the census of 1911, the administrative county of Surrey, that is excluding the London area and Croydon (? also Wimbledon), has a population of 845,544. This is an increase of 156,219 over the number for 1901, or a percentage of 29·4, the fourth highest rate of increase among the counties of England and Wales.

The six Surrey boroughs that are included in London, are as follows, with their populations at the census of 1911, and the changes since 1901:—

Wandsworth, 311,402, the highest of all the London boroughs and showing an increase of 34·3 per cent.; *Lambeth*, 298,126, a decrease of 1·2 per cent., the highest figure having been in 1901; *Camberwell*, 261,357, an increase of ·8 per cent.; *Southwark*, 191,951, a decrease of 6·9 per cent. the highest figure being in 1901; *Battersea*, 167,793, a decrease of ·7, the highest figure being in 1901; and *Bermondsey*, 125,960, a decrease of 3·7 per cent., the highest record having been in 1891.

Outside London Surrey contains but one very large town, and that joins on to London. *Croydon* has a census-record of 169,599, an increase over 1901 of 35,664, or at the rate of 26·6 per cent. The population is now estimated at considerably over 170,000. The northern part of the borough is dependent on the metropolitan supply, whilst the central and southern parts have an independent one, from wells.

The only other large town (that is, with a population not less than 50,000), is *Wimbledon*, with 54,876, an increase of 13,224, or at the rate of 31·7 per cent., though by taking Kingston and Surbiton together, as ought to be done, for they are continuous, we get the figure 55,690. All these are dependent on the metropolitan supply.

There are seven other boroughs or urban districts with a population of not less than 20,000:—*Kingston*, 37,977, an increase of 3,602, or at the rate of 10·5 per cent.; *Richmond*, 33,223, an increase of 1,551, or at the rate of 4·9 per cent.; *Barnes*, 30,379 an increase of 12,558, or at the rate of 70·5 per cent.; *Reigate*, 28,505, an increase of 2,512; *Woking*, 24,810, an increase of 6,461; *Guildford*, 23,823, an increase of 3,184, mostly due to extension of the borough; *Sutton*, 21,275, an increase of 4,052, or at the rate of 23·5 per cent.

Of places with a population between 10,000 and 20,000 there are eleven. *Epsom*, 19,156, an increase of 8,241; *Surbiton*, 17,713, an increase of 2,696; *Chertsey*, 13,819, an increase of 1,057; *Frimley*, 13,673, an increase of 5,264; *Merton*, 12,938, an increase of 8,428, owing chiefly to extension of boundary; *Walton-on-Thames*, 12,858, an increase of 2,529; *Egham*, 12,551, an increase of 656; *Esher and the Dittons*, 12,518, an increase of 3,029; *The Maldens and Combe*, 12,140, an increase of 5,907; *Carshalton*, 11,635, an increase of 4,889; *Caterham*, 10,841, an increase of 1,057.

It is notable that of all these 26 boroughs and urban districts with a population of over 10,000 there is a decrease of population only in four, and these are all London boroughs, for the most part surrounded by other highly populous tracts, places in fact which ought to decrease in inhabitants. This increase of population, still going on, means of course an increase in the amount of water needed for public supply, and in some cases to a considerable extent.

In the matter of water-supply, outside the metropolitan area, Surrey has four undertakings of considerable size: the Croydon Works; the East Surrey Company, estimated to supply a population of 89,000 in 1910, 11; the Sutton Company, the estimated population supplied in 1910 being 70,000; and the Woking and District Company, supplying 35,000 people (1909). The last three, with the smaller Leatherhead and District Company, give the only widely extending supplies from underground sources wholly in the county.

It is notable, however, that some undertakings are not restricted by that often inconvenient thing a county-boundary. The Wey Valley Company is concerned with Hampshire and Sussex, as well as with Surrey; the Frimley and Farnborough Company reaches into Hampshire and Berkshire; whilst the Limpsfield and Oxted Company extends its supply into Kent. The Aldershot Company, which is concerned with Hampshire, supplies the hamlet of Tongham, in the parish of Seale in Surrey.

We have records of very old waterworks in the county. A probable one of Prehistoric age, at St. George's Hill, is noted on p. 49; one of early in the Middle Ages, at Waverley Abbey, on pp. 39, 40; one of Tudor age, with buildings well-preserved, near Kingston, on p. 50.

Geological Formations.

Surrey is based on two great groups of the stratified rocks, the Eocene Tertiaries (of which the topmost part is wanting) on the north, and the Cretaceous Series (of which the bottom part does not come to the surface in the county) on the south. Both of these groups are well represented and the latter is of great thickness, one division, the Weald Clay, reaching its greatest thickness in Western Surrey (*see* p. 154).

Besides the above there are also various surface-deposits, or Drifts, which rest irregularly on the older formations of the two great groups. There is indeed a great gap between the oldest of these deposits and the newest of the Eocene beds. Though these surface-deposits occur over a large extent of country and often have considerable effect on the surface, in parts where there are large sheets of them, they are never of any great thickness in Surrey, there being none of the great masses of Glacial Drift, so common in some of the more northerly counties.

No less than 26 stratigraphic divisions are marked on the geologic maps, by distinctive colours and index-marks. These and their classification are shown by the following table:—

		Divisions coloured on the map.
Recent ...	... ...	... Alluvium.
Pleistocene	... River Drift ...	... Valley Brickearth.
		Valley Gravel.
Of doubtful age...	On the Chalk ...	... Plateau Brickearth.
		Clay with Flints.
	... ...	... Plateau or Hill Gravel and Sand.
Eocene	Bagshot Series ...	... Upper Bagshot Sand.
		Bracklesham Beds.
		Lower Bagshot Beds.
	... ...	... London Clay.
	Lower London Tertiaries	Blackheath Beds.
		Woolwich and Reading Beds.
		Thanet Sand.
Upper Cretaceous	... ...	... Chalk (not divided).
	Selbornian ...	... Upper Greensand.
		Gault.
Lower Cretaceous	Lower Greensand	... Folkestone Beds.
		Sandgate Beds.
		Hythe Beds.
		Atherfield Clay.
	... ...	... Weald Clay.
	Hastings Beds ...	... Upper Tunbridge Wells Sand.
		Grinstead Clay.
		Lower Tunbridge Wells Sand.
		Wadhurst Clay.
		Ashdown Sand.

Of the last four divisions there is but a mere trace, at the extreme south-eastern corner of the county.

We have no boring that proves any of the beds that usually occur beneath the Hastings Series, nor have we any evidence of Upper Jurassic. The two deep borings at Richmond and Streatham add the following to the list:—Great Oolite and

New Red or Old Red Sandstone (or both): possibly Carboniferous, if the red sandstone in the former should turn out to be a stained rock of that age.

Water-bearing Beds.

We will now consider those of the geologic formations which more readily absorb water and from which water may be got as a rule. Of course all formations absorb the rain to some extent and all furnish a certain amount of water somewhere: for instance there are sometimes sandy beds in the London Clay which may give a small supply, and this is notably the case with its basement-bed; the same too is the case with the Weald Clay. In neither of these and other like cases however could we reasonably class such great clay-formations as water-bearing: it is to our sands and sandstones and to our limestones that we look for large supplies of water, and Surrey is not wanting in representatives of both classes, the Chalk being simply a soft and sometimes earthy limestone.

On the other hand we must remember that beds which, as a general rule are markedly water-bearing, sometimes fail to yield a supply, or give but a small one.

We will begin at the top of the series in the table on p. 4.

The Drift. Gravel and Sand.

The various gravels and sands may all be taken together here, without regard to classification. They are the source of many supplies for houses &c., but they are not used alone for any public supply, though they may contribute to some supplies. The beds are amongst the most permeable that we have, and there may sometimes be a considerable amount of water in them, thin though they be, where they form a large surface, as is often the case. But they are especially subject to surface-pollution, being unguarded, except where covered by loam or brickearth, which may form a protective cap, though not always an efficient one. The getting of water from these beds therefore needs careful consideration, in order to avoid the risk of evil.

The Bagshot Beds.

The much thicker mass of the Bagshot Sands is of service in local supplies; but no large supply is got from them. The clayey middle part (the Bracklesham Beds) though not of very great thickness and not wholly impermeable divides the sands into two separate masses, each with its own supply of water.

There seems to be a sort of fascination in these and other sands to folk wanting water, and of old schemes for the supply, or partial supply, of London from this source were brought forward, sometimes in considerable detail, but it is almost needless to say without success; luckily they never got beyond proposal. It is one thing to infer the existence of a large amount of water in a formation of more or less uncompacted sand and another thing to get a large amount of water out of such sand.

In 1850 the General Board of Health treated of water-supply from the Bagshot Sand fully, and its Report with Appendices will now be dealt with. The subject is generally alluded to (together with that of water from the Lower Greensand) in the Report;[1] but it is to the Appendices that we must go for details.

In Appendix iii. Dr. R. A. Smith notices the softness of the water and some of its other characters, as also does Prof. Way (pp. 101, &c.). The geology and fitness of the Bagshot district are described by R. W. [R. A. C. Godwin] Austen and [Sir] A. C. Ramsay (pp. 198-203 and plate). The latter of these says that the sands "are easily percolated by water, so that a large proportion of the rain that falls on the district must, necessarily in the first instance, be absorbed. This circumstance is rendered apparent by the fact that the smaller valleys branching out on either side of Chobham Ridges were, when visited by me, destitute of brooks. The water so absorbed is, however, checked in its downward course by the Bagshot marls (=Bracklesham Beds), and when the disposition of the strata is favourable, it is thrown out to the surface at the junction of those marls with the Upper Sands, forming a series of springs round the retentive marly outcrop."

Appendix v. is a Report on the Soft-Water Springs of the Surrey Sands, by the Hon. W. Napier, who gives gaugings of springs and rivulets "taken at the end of a drought of nearly five weeks and at the close of an average dry summer," and these certainly do not look particularly hopeful (*see* pp. 48, 49 for details). From local information he says "A curious circumstance was in several instances related, that the close of autumn, generally in October, when there has been no rain in this district (including Lower Greensand as well as Bagshot Beds), the springs commence rising just after a high wind." Many of the springs are secluded and not very apparent. He devotes more than eight pages to the question of the advantages of soft water.

Two years later the subject was again taken up in a "Return To an Order of the House of Lords,"[2] with Gaugings or Reports on the Soft-water Springs on the Surrey Sands; but these refer chiefly to the Lower Greensand.

In 1867 Mr. T. Macneill proposed to use the Bagshot Beds as a huge natural filter, by pumping water from the Thames on to them and taking "the effluent for the supply of London."[3]

In 1886 Mr. W. Eassie gave a general account of water from the Bagshot Beds,[4] and said "It has been admitted . . . that the supply of water derived from the Bagshot sands would have been insufficient to satisfy the population of London, even in 1850; and considering the increase of population . . . it was a wise thing not to have spent the money upon the scheme (above

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[1] Report of the General Board of Health on the Supply of Water to the Metropolis, pp. 96, &c.

[2] 8° Lond., 1852.

[3] Royal Commission on Water Supply, Minutes of Evidence, pp. 320–326. Fol. Lond. 1869.

[4] *Trans. Soc. Med. Officers Health* and *Sanitary Record*, June 15.

noted)." He adds "The result of my own researches into the quality of the waters derived from the Bagshot series goes to prove" contamination with vegetable matter.

The Lower London Tertiaries.

The sandy beds and the pebble-gravel of this series yield water in small quantity, at all events in the eastern part of the county, elsewhere the beds being chiefly clays; it is indeed only at the far east that we have a broad outcrop of permeable material, the pebble-beds and sand of the Blackheath Beds. The whole is of no great thickness and the outcrop is mostly very narrow.

Sometimes however a fairly large amount of water seems to come from the Thanet Sand, where it is reached at considerable depth: so large indeed as not to be accounted for by the small extent of gathering ground provided by the narrow outcrop. The explanation of this is that the water from the underlying Chalk must have forced a passage upward, the somewhat clayey bed at the base of the sand not being strong enough to withstand the upward pressure.

The Chalk.

We now come to what is far and away the chief water-bearing formation of the South East of England, and which is indeed the chief contributor to the largest water-supply in the world. London, using that name in a broad sense, unlimited by any legal boundary, gets a large amount of water from wells in the Chalk, chiefly in Kent, Hertfordshire, and Middlesex, but also in Essex and Surrey. Moreover the water of the Thames and of its tributary the Lea, from which the metropolitan supply is chiefly taken, very largely comes from Chalk streams and springs. To this perhaps, together with the care that is taken in filtering the water, is owing the excellence of the supply, the only large one in the kingdom that is mainly taken direct from lowland rivers.

In Surrey no really large supply is got from wells in any other geologic formation, whilst the Chalk-wells of Croydon, of the Sutton Company and of the East Surrey Company afford a notable supply in the eastern part of the county, and all three sets of works have been greatly extended since their start. These are followed by other supplies of considerable extent, the Woking and District Company, Richmond, Guildford, and the Leatherhead and District Company supplying populations ranging from about 35,000 to 15,000.

Many years ago Prof. E. J. Chapman made some experiments on the absorption of water by Chalk, and one of his specimens came from the neighbourhood of Blechingley. It had a specific gravity of 2·49 and the water absorbed by 100 parts was 15·6.[1]

Chalk in itself is by no means a type of a permeable formation; sometimes indeed the lowest part more nearly approaches the impermeable. It is chiefly to the planes of jointing (more or less vertical cracks or fissures) that the Chalk is indebted for the

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[1] *Phil. Mag*, 1853, ser. 4, vol. vi, p. 118.

passage of water: to some extent also the planes of bedding help; but comparatively little water can find its way through the mass of the rock itself. The way then to get a large supply from the Chalk is to cut as many of the water-bearing fissures as possible, and this is done by work extending laterally, below the plane of saturation, that is by means of horizontal galleries, adits or headings, as they are indifferently called. Works of this sort are really *mines*, just as much as those worked for coal or for metallic ores. There are cases of course where, by good luck, a large supply is got with very little of this horizontal work; sometimes with none; but such success is not to be counted on, only to be accepted with thankfulness.

In Surrey, as in Kent,[1] the Chalk is divided into two distinct water-areas, the narrow southward sharp slope of the great escarpment, and the northerly more gentle dip-slope, usually much broader, though along the Hog's Back (as the ridge between Farnham and Guildford is called) the two are about equal in area and also in angle of slope. Where the dip-slope is fairly broad, that is in the central and still more in the eastern part of the county it is divided into a set of valley-systems, namely those of the Wey, the Mole, and the Wandle, each of which again is more or less sub-divided by various dry valleys.

The underground water-level as a rule roughly follows the level of the surface, but is less uneven, being at a considerable depth on the high grounds and at no great depth in low parts. This of course can be tested wherever there are wells.

It is in Surrey that some of the most notable work has been done in measuring the varying underground water-levels in the Chalk, and in regard to this the county should be proud of one of its residents, MR. BALDWIN LATHAM, who, having spent great part of his life in Croydon, has devoted much time and gone to great expense in recording the water-levels in a large number of wells. Through his work in recording the water-levels in the Basin of the Wandle, work spread over many years, the underground proceedings of water in that district are fully known. Extracts from his papers are made further on (pp. 68, 71-75, 77).

There is one peculiarity in the water of the Chalk that is shown in Surrey, as in neighbouring counties where that water is often got by means of wells or borings through a considerable thickness of Tertiary beds. Under such circumstances the water is of a different character to that got where the Chalk is at or near the surface. In the latter case the water is hard, from the amount of lime-carbonate that it contains, whilst in the former case alkaline salts largely take the place of the lime-salt, as may be seen from the analyses of the various waters. The explanation is that by the constant flow of water from the Chalk of the higher grounds the alkaline salts of that Chalk have been gradually dissolved out, carried away in solution and concentrated in the deeper underground Chalk, whence there is no outflow, until wells or borings are made. These waters moreover contain little carbonic acid, and so cannot dissolve lime-carbonate. For details of

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[1] *See* Memoir on the Water Supply of Kent, 1908, p. 13.

this explanation the reader is referred to a paper by R. Warington, based on researches made on the northern side of the London Basin.[1] In treating of the waters of Essex, in which large county the Chalk is mostly covered by a thick mass of Tertiary beds, Dr. J. C. Thresh has called these deep seated waters " Soda water " :[2] certainly they have more right to that name than has the beverage to which it is commonly given.

The Chalk itself is of course a never-ending supply of lime-carbonate, being almost wholly made up of that compound. The waters from Chalk-springs and from wells in the more open Chalk will maintain their native hardness as long as they exist. This hardness can of course be remedied by the process of softening, and this has been done for many years with the supply of the East Surrey Company, an example which the Sutton Company has lately followed.

But the town in which I live has declined, by the vote of its rate-payers (well-advised though they were by competent experts), to take any such action. Some of the people of Croydon object to what they are pleased to call adulteration; but some day perhaps so ridiculous an argument against softening may go the way of other absurdities. I have no recollection of having heard it elsewhere, and am inclined to think that it may have been more or less of a mask for an objection to any outlay.

The chief trouble in softening-works is to get rid of the lime-carbonate that is deposited, a white powder the grains of which are in the form of very minute crystals and therefore useless for the manufacture of whitening, as they decline to adhere to anything except in a temporary way. At the Kenley Works of the East Surrey Company the precipitate has been dumped on the low-lying ground below the works, bringing it up by a few feet in level. At the Purley Works, lower down the valley, it has been run into an old gravel-pit, bringing the level to that of the original ground. Very soon however there must come an end to these things, and even the large old chalk-pit, which is used as a dumping ground by the Sutton Company, will not last for ever.

Any one who can find a use for finely divided crystalline lime-carbonate will deserve a fortune: as yet the only place where I have seen it dried for use is at the South Hants Works, at Timsbury. Mr. W. Matthews tells me (August, 1910) that the deposit is also dried at Canterbury, at the East Surrey Works and at Henley. He does not know however what the dried material is used for " as it is for the most part exported, a good deal to Japan. So far as one can tell it is probably used in the manufacture of high explosives and tooth-powder, and as weighting for cotton goods." One might prefer better uses than the last of these.

Although the Chalk is the chief water-bearing formation of the county we must be careful not to over-estimate its capacity in that

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[1] A Contribution to the Study of Well Waters, *Journ. Chem. Soc.*, 1887, vol. li, p. 500.

[2] Report on the Water Supply of the County of Essex, 1901, map opp. p. 34.

respect, a mistake that has often been made, though less in Surrey than in some other counties, where the chance for this error has been greater.

The chief source of error with which geologists have to do is the over-estimation of the area of Chalk that may serve as a gathering ground, an area that involves measurement on a geologic map. It is clearly important however not merely to measure the area of outcrop, but also to examine the character of that area, so as to see if there be anything in it to hinder the passage of rain into the Chalk, and this is a matter that could not be gone into in detail until fairly late in the last century.

All the older geologic maps, including those of the Geological Survey, are characterised by the omission of any notice, save by words, of those surface-beds of gravel, loam, clay, &c. grouped under the name Drift. They are of somewhat various ages (though all of late geologic age), of very irregular occurrence and rest more or less irregularly on the beds below.

These beds, even where they are of no great thickness, often have a very considerable effect in restricting the area of Chalk open to receive rain, sometimes indeed, cutting off large tracts, shown on old maps simply as Chalk, over which a practically impermeable mantle of clayey beds has been laid. In Surrey however we have not to deal with these impermeable beds, but only with those that hinder, without actually stopping, the passage of water from the surface into the Chalk, and this rarely to a very great extent.

Seeing the importance of this matter, in the course of an investigation of some questions on water-supply, made for the Metropolitan Board of Works, a good many years ago, I started a set of maps, two descriptions of which were published in 1884,[1] for the purpose of showing the areas over which the Chalk was open, partly open, or closed to infiltration of water from the surface. The subject was returned to in 1892,[2] and the next year it was taken up by Mr. Topley in a somewhat different way, by giving measurements of the areas of the various geologic formations, including the Superficial Beds over the Chalk.[3] Lastly in 1897 Mr. H. B. Woodward gave a map of the subsoils of the country around London in which the beds were grouped, not geologically, but according to permeability, that is as clayey, gravelly and sandy, a map that was repeated in 1906.[4]

The construction of my Chalk Area Maps, as I have called them, depends on the existence of Drift Editions of the Geological Survey Maps, though with the sole exception of the tracts of bare Chalk it does not follow strictly on geologic lines. In other words it is not a question of what the beds at the surface are; but simply one of their relation to the underlying Chalk,

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[1] *Proc. Norwich Geol. Soc.*, vol. i, pt. viii, pp. 285–294. Reprinted in *Geol. Mag.*, dec. iii, vol. i, pp. 23–29, with small exceptions. *International Health Exhibition* (Conference), 10 pages. Also in *Journ. Soc. Arts*, vol. xxxii, no. 1,653, pp. 847–851.

[2] *Trans. San. Inst.*, vol. xiii.

[3] *R. Comm. Metrop. Water Supply, Appendices*, p. 414 and folding table.

[4] Memoirs of the Geological Survey. Soils and Subsoils.

as regards the likelihood of water getting through them to the Chalk. Thus although in the midst of a Chalk-tract there may be a mass of sand, or other permeable material, over a large space, it does not follow that the water falling thereon may readily pass down into the Chalk. There may be a layer of clay between the two, almost completely cutting off the passage of water downward, or there may be some such layer in parts only, thereby hindering though not completely cutting off the passage.

It was found that the various tracts where the Chalk was at or comparatively near the surface were divisible into four, as follows:—1. *Where the Chalk is bare*, except for the ordinary soil, as shown on the Drift Edition of Geological Survey Maps. 2. *Where the Chalk is covered only by Permeable Beds*, and in this the word "only" is important, as the efficacy of a thick mass of permeable beds may be greatly lessened by an underlie of a comparatively thin impermeable bed, or even of one but partially permeable. 3. *Where the Chalk is covered or protected by Beds of a Mixed or Varying Character*, such as loams, which may be somewhat permeable, or irregular alternating layers of sand and clay, which must greatly delay the downward passage of water. Of course this class includes not only parts where such beds lie directly on the Chalk, but also those, above alluded to, where permeable beds are underlain by beds of this kind. 4. *Where the Chalk is covered or protected by Impermeable Beds*, whether these lie direct on the Chalk (which does not occur in Surrey) or come between permeable beds and the Chalk, which also may be left out of account here.

Naturally there is often a difficulty in classing various formations as permeable or the reverse: thus in Surrey the Thanet Sand has been put with the permeable beds; but really the slightly clayey bottom part may often stop or hinder water from passing directly downward into the Chalk. The outcrop however is here so small as to be practically of no account. There are too formations of a varying character that decline to be classed as permeable or impermeable, being sometimes one, sometimes the other and sometimes betwixt and between: for instance the Woolwich and Reading Beds here consist chiefly of clay, there chiefly of sand, and elsewhere of a mixture or alternation of the two.

It is convenient therefore to have a Mixed division (3 above) for the reception of the more doubtful characters amongst the geologic formations, and this division is important in Surrey, where the higher parts of the Chalk-tract are often marked by the presence of a capping of loam and clay-with-flints ever varying in thickness. That these irregular deposits, which materially affect the surface of the ground and the scenery, hinder direct passage of water downward can hardly be denied; but on the other hand it cannot be said that they are an absolute bar, for their position implies that they have often been let down irregularly into the Chalk beneath, the junction of the two being singularly irregular, and explainable only on the principle that the superficial masses have been gradually and irregularly let down by the dissolving away of the Chalk by infiltrating water, into the irregular and sometimes deep pipes, with highly inclined sides, in which they almost universally occur. Moreover, clayey though these deposits are, they do not support surface-streams; the water that falls on them must to some extent soak in.

The greater part of the Chalk-tract of Surrey is shown on Sheet 8 of the Geological Survey Map, and on this the following areas have been measured:—Bare Chalk about 73 square miles. Chalk covered only by permeable beds, about 7 square miles. Chalk protected by beds of mixed character, about 34½ square miles. Of these however about 4 square miles of the first and about a square mile of the last are in Hampshire. In Sheet 6 Surrey takes up about 25 square miles, divided roughly in the proportions of 12, 1 and 12 of the above divisions. Sheet 1, S.W. adds about 1½ square miles to the last division.

Putting together these figures we get the following for the county, approximately of course, though without serious error.

Bare Chalk	81	square miles.
Chalk covered only by Permeable Beds	8	"
Chalk protected by Beds of Mixed or Varying Character	47	"

The area where the Chalk is protected by impermeable beds is left out, as insignificant; but it must be remembered that even such areas sometimes contribute to the water in the Chalk, where streams passing over them flow to the Chalk, and, in the case of streamlets, sometimes sink bodily into the Chalk. This condition of things however rarely holds in Surrey, the streams of the Tertiary beds flowing away from the Chalk, except on the far west, over a small tract at Farnham, where some water flows over the Tertiary beds to the Chalk and then sinks into swallow-holes (*see* pp. 58-60) and on the far east, at and beyond Croydon, where the water from springs in the Lower London Tertiaries flows to the Chalk and sinks in.

Another outside contribution to the water in the Chalk occurs where streams from tracts of the beds below flow across the Chalk and may lose some of their water therein. Surrey owns the most notable case of this, in the River Mole, some of the water of which passes down into the Chalk, by means of the well-known swallow-holes (*see* pp. 62-67).

The subject of water in the Chalk in Surrey has a considerable literature. Some of the papers referring to this have already been noticed; others can be more fittingly taken under the heading Bournes (p. 61) and elsewhere; but some will now be noticed, and chiefly those by MR. B. LATHAM and MR. J. LUCAS.

In a general work, published in 1874, the latter of these authors referred largely to Surrey,[1] and it should be noticed here, though later he withdrew the chief suggestion, which was that a supply for London might be got by driving very great lengths of galleries, so as to intercept the underground water in the Chalk and in the Lower Greensand of Surrey.

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[1] Horizontal Wells, 4° *London.*

He gives much information as to Chalk-water and recognises that "in the chalk after the coming on of the Tertiary Beds, a great diminution in the number of fissures takes place, and a consequent damming back of the waters percolating the body of the chalk" (p. 32), and "that no general rule can be laid down . . . as to the part of the chalk which is most fertile in water" (p. 33).

He notices springs and bournes and estimates the Chalk-areas of the various river-basins (pp. 33-36). On p. 41 (and Errata) the Croydon branch of the Wandle Basin is credited with 43¼ square miles and the Carshalton branch with 8.

There are tables (xiii.-xvii.) showing the rise in the water-level from Sutton and Croydon to Banstead, from Carshalton to Oaks Park and Little Woodcote and from Beddington to Russell Hill, all in April, 1873, and in a set of wells at Epsom, followed by others (xviii-xxii)) at various places "when the water was nearly at its lowest in December, 1873" (p. 50).

A map shows the contours of the water-surface in the Chalk, from Epsom to Croydon, early in 1873, at intervals of 10 feet, from 100 up to 230, and also at the end of 1873. Two plates of sections mark the sites of wells and show the water-levels, as referred to in the Tables.

MR. LUCAS' paper read to the Society of Arts in 1877[1] though having a title that covers an enormous area, is really confined to the north-eastern part of our county, with the adjoining margin of the north-western part of Kent, dealing only with the following river-basins:—The Mole (in part) on the west, the Abrook or the Rythe (from Claremont &c. the names are not on the Ordnance Map), the Hog's Mill, the Beverley, the Wandle, and the Ravensbourne, on the east. Although the paper deals with Tertiary sands and also refers to the Lower Greensand it is mainly concerned with the Chalk and so may be noticed here.

He says "In this area the artesian principle of overflow is developed to a remarkable degree . . . The Thames itself, and its tributaries on the tract in question, all lie below the artesian plane, consequently all the basins above-named contain natural areas of overflow."

Of the Wandle Basin he says that it "presents a probably unique feature in the number of overflowing wells it contains. The oldest of them, the public well near Tooting Church, was bored in 1822" and its success led to others being made, so that in 1876 there were "at least one hundred and ten on the area in question. Those that still overflow are contained within an area of about four square miles" in the parishes of Wandsworth, Streatham, Tooting, Mitcham, Morden, Merton and Wimbledon. "Owing partly to the multiplication of vents, the discharge from the older borings has materially diminished, though some very strong ones remain . . . The height to which the water will now rise is less than formerly, and as an effect of this, the area over which the water will overflow is also diminished."

[1] The Artesian System of the Thames Basin, *Journ. Soc. Arts*, No. 1,277, p. 597.

From inspection of all and a knowledge of the discharge of some of the strongest wells he is " inclined to average them at 10 gallons a minute, which, for 110 springs would give rather more than a million and a-half gallons daily." He dealt also with the wells outside the area of overflow and with variations in their water-levels.

" The Beverley basin contains at least five overflowing wells. The area of overflow is continuous with that of the Wandle basin."

The overflowing wells at Kingston, which are classed as belonging to the Basin of the Hog's Mill River seem to me to belong rather to the main valley of the Thames.

A map is given showing the natural area of outflow and the modern area of outflow (from wells), and two hydrogeological sections, from Esher to the Middlesex side of the Thames (Whitbread's Brewery), and from Woldingham to Southwark. There are also some 9 pages of Tables of Artesian Wells, in various Surrey parishes.

In the discussion Mr. B. Latham said " There was a large area between the Wandle and Ravensbourne, which appeared to be almost devoid of water, and wells sunk within it yielding hardly any."

Mr. J. Lucas' paper on " The Chalk Water System "[1] is based on a survey of the Chalk-tract between the Wey and the Darent, that is to say through nearly the whole of Surrey into the western part of Kent. This survey extended over four years, and during this time many hundreds of wells were measured.

Of the 10 miles of Chalk-escarpment between the Wey and the Mole 2 rise above 700 feet, 6 above 600, 7½ above 500, and 9 above 400. Of the 22 miles between the Mole and the Darent 2½ rise above 800 feet, 13 above 700, 18 above 600, and 21 above 500.

The greatest depth of dry chalk pierced, to reach water, was 327 feet.

" The water in the Chalk nowhere exists as a voluminous mass; each little stream is under the control of the fissure that contains it."

" The upper surface of the water in the Chalk . . . is a long inclined plane, terminating against another inclined plane, that of the Chalk Marl, which slopes in the same direction, but at a greater angle . . . The inclined plane of the Chalk Marl continues to rise for a long distance after, and to a great height above this line of abutment."

" There is therefore a considerable strip of chalk in which there is no water." But this I think may be questioned, as it presupposes that there is no water in the Chalk Marl. He continues by saying that the line of abutment of the two planes " never rises so high or approaches so near the escarpment as to pour springs over the Chalk Marl into the Weald, except in the case of two permanent springs. In the 36 miles of chalk escarpment between the Darent and the Wey, the only springs . . .

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[1] *Proc. Inst. C. E.*, 1877, vol. xlvii, pt. 1.

flowing out of the Chalk over the Chalk Marl are those at the Sherbourn Ponds and the Brockham Lime Works." But there are springs at or near the base of the Chalk Marl I believe.

He discusses at some length the variation of water-level in the Chalk and the origin of bournes, giving Tables of seasonal variations; of differences in heights, and gradients between four Epsom wells, from March, 1873, to November, 1874; and (in 12 pages) of Chalk Wells in Surrey, with heights, depths, and depths to water at various dates, all but one of the 12 pages being from his own observations, from 1873 to 1876.

In a Hydrogeological Map (pl. 3), on the scale of an inch to a mile, sites of wells are shown, as well as underground water-contours at 150, 200, 250 and 300 feet, at a minimum, and the line of abutment of the minimum water-level with the Chalk Marl, the outcrop of which division is also marked.

Plate 4 consists of six Hydrogeological Sections, five of which are in Surrey: from Albury to Clandon, from Shere to Effingham, from Effingham Hill to Leatherhead, from Merstham to Ewell, from Godstone to Beddington. The water in the Chalk at the minimum is shown in light-blue, and the lines of all these sections are marked on the map.

In the discussion this paper was criticized by Mr. Baldwin Latham, who differed as to the well-levelling and gave two sections (plate 4, a) along the Brighton Road Valley and the Caterham Valley (southward of Croydon). These show four water-lines in 1876, from May to July, July to August, in September and in November, plotted from a number of wells; the first is from the Bourne Culvert, Croydon, to the Feathers Inn, Merstham, and the second from Ebenezer Cottage, in the parish of Coulsdon (Purley of the present day) to Tyler's Green, Godstone. He treats also of the subject of Bournes.

In 1877 Mr. Baldwin Latham read a paper to the British Association, based on observations in the neighbourhood of Croydon[1], from which the following extracts are made. Though much of this matter may now be classed as common knowledge I prefer to give it in Mr. Latham's words:—" An examination of a district having a number of contributing valleys shows very clearly that the subterranean water moves down the subsidiary valleys into the main valley; and the confluence of the streams produces identically the same effect in the underground channels as is observed by the junction of two streams (but see further on, for exception) . . . The increase of the volume of water brought into a main subterranean channel from a subsidiary valley elevates the surface of the water at the point of junction . . . if a line is drawn from the surface of the water at a point above where a junction is known to take place with the surface of the water at another point below where the junction is effected, the result shows that at every period of the year, and whether the water is rising or falling, there is a considerable convexity in the longitudinal section of the water [surface] at the point at which water is received. A number of examples of this character

[1] Rep. Brit. Assoc. for 1877, pp. 207-216 (1878).

are shown in making careful sections of the chalk valley south of Croydon, particularly in a valley about eight miles long, extending from Caterham to the river Wandle at Croydon. Not unfrequently we find one valley runs across another, and such continuity of the surface may be observed which might lead to the supposition that the flow of subterranean water is continuous down the valleys. This, however, is not always the case, as is clearly shown by a section made . . . in the neighbourhood of Smitham Bottom . . . It might be supposed that the water flows from Merstham to Croydon; but this is not so, for the cross valley at Smitham Bottom intercepts the water and conveys it away in another direction. This abstraction of the water is clearly indicated by the depression in the water-line at the point where the water leaves. A line drawn from a point in the water-line above the point of abstraction to a point in the water-line below this point shows, during all periods, a concavity in the water-surface at the point of abstraction. Where such a depression is observed it is evidence of the abstraction of water . . ." It is "feasible to determine, by careful measurement, the exact direction in which subterranean water is flowing in such a district, . . . and also to pretty accurately determine both the extent of the contributing area and the probable quantity of water such an area will yield."

In "a long valley, as . . . the Caterham valley . . . the water begins to rise in the wells located at the top of the valley before it rises in the wells situated in the lower part; . . . in fact the water in the upper wells began to rise while the water in some of the lower wells was still falling." The reason suggested is that the rainfall is greater in the higher than in the lower parts; but in one case (Cambrian House, Caterham; Rose and Crown; and Croydon) "the water rose both in the upper and lower parts . . . before it rose at an intermediate point. The rise in the upper part . . . was probably due to rainfall, and the rise in the lower part . . . to the effect of the united contributions of a number of short valleys discharging into the main valley."

"Very careful observations on the Chalk formation south of Croydon show that . . . December is the month which appears principally to contribute to the supply of the springs, and that after a rainfall it takes some time for the springs to rise, depending mostly on the dryness or wetness of the season . . . a dry December interferes, to a most marked extent, with the contribution of water to the springs; for although . . . certain quantities of water percolate at all periods of the year, the measurement of wells and gauging the volume of springs show that a large part of the rain falling never influences the quantity of water in the ground."

"In the year 1876, between the beginning of May and the end of November, although over twelve inches of rain had fallen at Croydon, the rainfall did not affect the quantity of water in the subsoil; but during the whole of this period both the volume of water flowing from the springs and the height of the water in the subsoil steadily diminished."

He discusses the question of temperature of the water, and the differences at certain places and in certain periods and gives tables of well-gaugings, in the valley from Caterham to Croydon (5 pages) and in the valley from Merstham to Caterham Junction (=Purley, 2 pages). On the plate are two sections showing a number of well-sites and giving the water-plane in December, 1876, and in July, 1877: on the same lines as those noted above, p. 15.

In 1879 MR. J. LUCAS gave the following figures of the Chalk Areas of River Basins in Surrey, showing two cases in which the underground drainage is less than would be inferred from the ground-slopes, and one case in which it is more;[1] but I fear that the last will not now hold good, the Oxted railway-tunnel having done damage to the Wandle. Probably too other observers may hold somewhat different views.

The apparent Chalk Area of the Ravensbourne Basin is given as 21 square miles, but this is partly in Kent. The area proved to drain elsewhere is 1¾ square miles on the western side and 3½? on the eastern side, which must be chiefly in Kent, the real Chalk Area being therefore reduced to 15¾ square miles.

The Basin of the Wandle has a Chalk Area of 52½ square miles and the extraneous area proved to contribute is 1¾ miles, on the eastern side.

The Basin of the Hog's Mill River &c. has an unaffected area of 13 square miles.

The Basin of the Mole has 14 square miles of Chalk Area on the western side and 9 on the eastern; in each an area of 2¾ is proved to drain elsewhere, the total loss reducing the area to 17½ square miles and causing a mean daily loss of 1,309,000 gallons of water, on the supposition that 6 inches of rain are absorbed in a year, probably much too low an estimate.

The Surrey part of the Wey Basin has an area of 7½ square miles on the western side and of 11 on the eastern all unaffected, though the Hampshire part of the same Basin is greatly affected, to the extent of 28½ miles out of 39½.

In 1896 MR. A. SMEE published a letter to the Earl of Onslow on the subject of Surrey water,[2] in which he took the percolation of rain over the Chalk and Greensand tracts at six inches a year, on an average, an estimate that I believe is too low.

He alludes to the amount of water got from wells through the Tertiary beds to the Chalk, and says:—" The effect of this constant pumping and the increasing number of artesian wells in London has been to decrease the volume of water in the Wandle. There has been a very appreciable diminution in the last 30 years of the quantity of water flowing down this river in the low water period, demonstrating conclusively that the reserve of the water held up in the chalk of the Surrey hills has been materially lessened by this constant abstraction of water by wells outside the

[1] *Journ. Soc. Arts*, vol. xvii. Reprinted in "Annual Conference on National Water Supply," p. 93.

[2] Privately printed, pp. 3, Folio.

administrative county." But our bournes still run, after wet seasons, and this implies that the Chalk has been filled with water to overflowing, that it cannot hold more.

He goes on to predict "that in the early part of next century the inhabitants of the towns and villages in rural Surrey . . . will be in serious difficulty as to their water supply," not only as to quantity, but also as to quality (*see* p. 84).

In 1906 Dr. E. C. Seaton[1] alluded at some length to the public water-supplies of the county, giving tables of the supplies from the Thames (3), from sands (7), from sands and Chalk (2), and from Chalk (8); but these are in the administrative county only, and so do not include those for London and Croydon.

In 1909, in treating of percolation, through gauges,[2] Mr. B. Latham described two gauges, each consisting of a cubic yard of material. One was made of earth from Riddlesdown "and consisted exactly of the material which formed the first yard in depth of this down, including the natural growth of grass," and it was therefore "chalk with a small amount of chalky soil on the surface." The other was "a section cut out of the valley in the Old Town of Croydon, with its natural soil and vegetation, consisting principally of gravel." This gravel overlies chalk.

The result of long continued observations is "that in the 30 years (1879-1908) the total average amount of percolation through the chalk gauge has been 10·84 ins., and through the gravel gauge 10·34 ins." The yearly figures vary of course with the rainfall, from under 5 inches in 1884, 1887 to over 26 in 1903. Monthly figures are given in tables.

The Upper Greensand.

This division being thin and with a very narrow outcrop throughout the county, from west to east, yields but little water, serving only for small local wants, though its beds are mostly permeable.

Mr. Baldwin Latham made a long series of observations on the level of the water in the Godstone Quarries, or rather Mines, as the fire-stone was there worked underground, along galleries driven down into the hill northward, with the dip. These levels were marked on the sides of the galleries, where I have seen them, by a man who had worked there many years and the following results are taken from a published table.[3]

The maximum water-levels in the years 1843 to 1857 (in 1858 the water-level was so low that the quarries were probably dry), 1859 to 1867, and 1873 to 1876, range from 436·81 feet above Ordnance Datum on May 4, 1874, and April 12, 1875, to 467·45 feet on January 31, 1853, when there was a copious flow of the Croydon Bourne. Another copious flow of the Bourne is recorded when the level was 462·31 feet (March 17, 1866), and other flows at various times.

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[1] Surrey County Council. Ann. Rep., 1905 (M.O.H.).

[2] *Quart. Journ. R. Met. Soc.*, vol. xxxv, pages referred to 189, 191–193.

[3] *Proc. Inst. C.E.*, 1877, vol. xlvii, pt. i, Discussion on paper by J. Lucas.

In the same year Mr. J. Lucas treated of the hydrogeology of the Upper Greensand of Surrey, in a general paper,[1] in which, from a survey between the Hampshire boundary and the Darent he concludes that the water-system of the Upper Greensand is distinct from that of the Chalk. He gives a table of springs from the Upper Greensand (pp. 175, 176), of which 40 are in Surrey, in most cases with the approximate height above Ordnance Datum; and another table (p. 177) of Upper Greensand Wells in Surrey, 23 in number, with the height, depth and depth to water.

In the discussion Mr. C. Homersham held that the water of this formation was not distinct from that of the Chalk Marl.

Mr. C. J. Mason tells me that in a hole 27 feet deep, from Ejector 4, in the main road about 570 yards south of Guildford Castle, 50,000 gallons of water an hour were pumped from Upper Greensand.

The Lower Greensand.

This set of beds comes next in importance to the Chalk as a water-bearing formation in Surrey. Westward of Reigate it may be treated as a whole as regards water, in the absence or extreme thinness of the loamy or clayey Sandgate Beds. Eastward of Reigate however that middle division occurs to a mappable extent, except at the far east, and then the two great sandy divisions, the Folkestone Beds above and the Hythe Beds below, have separate water-systems.

Whether the clayey beds in the middle of the formation here should be classed as Sandgate Beds has been a matter of controversy, with which however we are not now concerned: whatever they may be called they are clayey and serve to stop, or to greatly hinder, water-communication between the other and thicker divisions. The thin Atherfield Clay, at the base, goes of course with the thick underlying Weald Clay in the matter of water.

The Lower Greensand used to be a great subject of speculation as to affording large water-supplies, even for London: indeed it has been thought that all there was to do was to make a set of deep wells or borings and so to get the water that was waiting to be tapped. We have known however for many years that in its underground course northward from the outcrop this formation gradually decreases in thickness from 300 feet or more to nothing, or to nearly nothing, both in Eastern Surrey and in Western Kent; so that it is only by works on or reasonably near the outcrop that a supply of note can be got. Thus at Richmond, if present, the Lower Greensand is very thin, whilst at Streatham it has gone altogether. On the west we know less as to the underground range; but the sand has been reached at great depth (1,234 feet) at Winkfield, in Berkshire and at Slough, in Buckinghamshire, at the depth of 1,024 feet;[2] so that it looks as if thereabouts it may be continuous right under the London Basin, to the northern outcrop. This conclusion was strengthened by the deep boring at Ottershaw Park, Chertsey (*see* p. 134) having been

[1] *Trans. Inst. Surveyors*, vol. ix, pts. vii–ix. (with discussion).

[2] Memoirs of the Geological Survey . . The Water Supply of Berkshire, 1902, pp. 95, 96.

carried down apparently to Lower Greensand after the above had been written. Probably however the formation is of no great thickness beneath the Tertiary beds.

It seems that this great mass of sand must follow the less widespread Bagshot Sands in being relegated to the group of permeable formations from which no very large supply can be got. Of course the compacted and jointed sandstone of the New Red shares with the Chalk the position of yielding vast quantities of water from wells which serve many large public supplies; but this differs greatly from the sands with which we have to deal; and we may add to the latter the sands of the Hastings Beds. The New Red sandstone is thicker, has a larger outcrop, and freely allows the passage of water.

Of the Lower Greensand generally one may say that it has been, and to some extent still is, a much over-rated formation as regards water-supply. I have had occasion lately to study this matter, and have been unable to find a single case of a large town wholly supplied from this source. By far the largest supply is that of the Mid Kent Company, which supplies a population of more than 65,000 scattered over a great number of country-parishes, and an irregular area of some 200 square miles, from two distant pumping stations.

There are but few cases in which a large amount of water has been got from the Lower Greensand. In Surrey the Dorking Company leads, the population supplied being about 14,400. Godalming comes next, being credited with an area of control of 19,500 people, of which about 14,000 are supplied. There are no others dealing with a population of as much as 10,000, the Wey Valley Works coming next, with a population of about 8,900, of which however only part belong to Surrey, and then the Farnham Company with about 8,100 people supplied.

The literature of this formation, as regards water-supply in Surrey, seems to start with the Report of the General Board of Health in 1850 (already referred to, p. 6), wherein a scheme for the supply of London from the Surrey Sands is gone into, the Lower Greensand being noticed on pp. 103-109 (extracts from evidence given). The conclusions are "that from a tract of upwards of 150 square miles of gathering ground (including the Bagshot tract) there is derivable a supply nearly double the present actual domestic consumption," that the water is of the best quality, and that it could be got at reasonable cost (pp. 320, 321).

One may safely say that no engineer would now venture to suggest that some 70 millions of gallons of water a day could be got out of the Surrey sands. The figure of 39,574,081 gallons a day is given for the private house-supply of London on p. 6, the total supply being only 44,383,332.

In Appendix iii, the hardness of some of the sand-waters is given (pp. 101, 102) and also the amount of peaty matter (p. 107).

Appendix v (1851) is devoted to the Soft Water Springs of the Surrey Sands.[1] Mr. Napier gives the result of his examination

[1] This was also printed separately, under the title "Soft Spring Water from The Surrey Sands," pp. x, 113, 8° *Lond.* Arranged somewhat differently, with a Preface and an Appendix, being a Report on the Gaugings, etc. by T. W. Rymmell.

of the gathering grounds, and gaugings of the springs and rivulets (*see* p. 40). The figures for the Lower Greensand sources are certainly ahead of those for the Bagshot Beds; but the total comes only to 39,407,324 gallons a day. Probably this figure may now be thought too high, although the gaugings were taken in a dry season.

Mr. Napier and other observers seem to have thought that pretty nearly all the water in the various sands could be got out of them and collected together, a somewhat sanguine view to take. He alludes to the injuries to property that would be entailed by this process, specially referring to the loss of water to mills, &c., and comes to a conclusion that is certainly not justified by what has happened in any scheme for water-supply, for he says "I am convinced that the millers will, if left to themselves, readily come to terms, and be glad to be rid of their unprofitable calling and unsaleable stock."

In 1851 appeared an important work by Sir J. Prestwich,[1] which, though of a general character, should be noticed here, one of its objects being to show "that the sources, which there is every probability of finding in the *Upper and Lower Greensands* beneath London, would furnish a quantity of water sufficient, possibly, for the supply of the metropolis; or, at all events, so large as to constitute an important auxiliary supply" (pp. 6, 7). With the information then available Prestwich was justified in his endeavour and in the assumption that the Lower Greensand would be found to extend underground from the northern to the southern side of the London Basin, for, as he adds "no Artesian wells in London have as yet been carried through the chalk," though many had been carried into it.

Since that time various deep borings have been made, not only through Chalk, but also through underlying Cretaceous and Jurassic beds into much older rock. Prestwich himself took great part in recording and interpreting these borings, and in 1895 he added some Preliminary Remarks to his book, in which he says "The remarks, therefore, respecting the possibility of the Lower Greensand proving a source of an extensive water-supply no longer hold good." The book itself remains a valuable storehouse of facts and of fair inferences from those facts: it is in the above matter only that marked error comes in; but of course later work corrects some of the older work.

In 1852 the subject of the Surrey Sands was again taken up, by an Order of the House of Lords.[2] A summary of the gauging of springs in the Farnham and Hindhead districts is given. Besides those of Mr. Napier there are five others, details of which are given further on. They include Bagshot springs, &c., and they vary from over 35 million gallons a day to over 75.

Mr. T. W. Rammell reports upon Mr. Napier's Report (see above) and says (p. 5) "The testimony of old inhabitants . . .

[1] The Water-Bearing Strata around London. 8°. *Lond.*

[2] Return of any Gaugings or Reports . . . . in relation to the Sources of the Soft-water Springs . . . . &c. 8°. *Lond.*

went to prove that the springs are quite insensible even to the heaviest and long continued rains, or at least until after a considerable lapse of time. It appears that their flow, though somewhat greater in the spring, and less in the autumn, remains very constant throughout the year." It seems doubtful however whether the testimony alluded to is good enough as a basis for generalisation. Mr. J. F. Bateman criticizes the gaugings of Mr. Napier and of Mr. Rammell, but generally supports the scheme, and gives measurements of streams by T. B. Foster.

In 1874 Mr. J. Lucas[1] said "We have . . . in the lower greensands of Surrey, a combination of the circumstances most favourable for gathering and storing water. The height of the range attracts a high rainfall; the breadth of the absorbing surface causes much of this to be absorbed. The thickness of the porous beds . . . affords a large reservoir for water absorbed. The complete imperviousness of the retaining clays, Atherfield and Gault, prevents the escape of these waters, which are thus held in a subterraneous reservoir, whose lowest rim is at the deepest valley cutting through the Gault clays" (p. 22). Nevertheless I hold to what has been said above (and probably Mr. Lucas would now agree) that no very large amount of water can be got out of the Lower Greensand at any place, at all events without very widely extended and costly works, if even in that case.

He remarks (pp. 37, 38) on "the extraordinary development of the sandy beds . . . in the basin of the Wey" where "they occupy an area of 108½ square miles . . . The Hythe Beds occupy the high ground and form the principal catchwater, while the Folkestone Sands occupy the lower parts of the northern slopes. . . . In consequence of this arrangement the water that has been absorbed by the Hythe beds breaks out again lower down, and flows over and through the Folkestone Sands, and, breaking out all along its top line, floods the low land formed by the gault."

"The number of springs which break from the surface of each bed of sufficient size to form streams marked on the (old) Ordnance Map . . . is greatest in the case of the Hythe beds, caused by the valleys being cut down to the permanent line (plane) of saturation. The Folkestone Sands are too loose and incoherent to produce many decided springs, but the water oozes out at the low lines of escape . . ."

"The streams flowing on the lower ground determine the line (plane) of saturation, as is shown by their being fed by innumerable small springs as they go."

In Table ix he reproduces the gaugings of the Lower Greensand streams in the Basin of the Wey given in the pamphlet of 1852, above noticed (p. 21) and says that the streams spring mostly from the Hythe Beds; but some from the Folkestone Sands (p. 45).

[1] Horizontal Wells. 4°. *Lond.*

Table x shows the absorbent power of various specimens of Lower Greensand, as follows. These show the superiority of the Hythe Beds in the matter of permeability, as far as the specimens go.

Division, Locality and Lithologic character.	Water absorbed by a cubic foot.		Water permeating through equal portions in an hour.
	Cubic Inches.	Gallons.	Cubic Inches.
Upper Division (Folkestone Beds):			
Chelworth (? Chilworth). Fine bright ochreous (sand) ...	615	2·21	18
Limpsfield. Very fine white pure sand	518	1·87	9·6
Lower Division (Hythe Beds):			
Betchworth. Very coarse sand with small pebbles of quartz	605	2·18	8·4
Chilworth. Rather coarse light-greenish sand	605	2·18	7·5
Reigate. Fine yellow sand, slightly clayey	734	2·64	4·8

"The experiments were made with portions of sands measuring 40 cubic inches. The permeability . . . was determined by measuring the quantity of water that passed through 15 inches of the different sands, in a glass tube 1¼ inches in diameter and bent at right angles, under a pressure of 6 inches of water in the longer branch."

In 1875 appeared the Memoir on the Geology of the Weald, in which Mr. W. Topley devoted a chapter to springs and Water Supply, and from this the following remarks are taken (pp. 353-363).

"The Lower Greensand generally has springs at the foot of its escarpment; and, where the clayey beds of the middle division exist, there is often a line of springs at the bottom of the Folkestone Beds. The most powerful springs are in those valleys which are cut through the Hythe Beds to the Atherfield Clay below."

"The springs of the Hindhead district do not for the most part arise from this cause, save that at the Devil's Punch Bowl. They may be thrown out by clayey beds in the rock, or more probably by the valleys reaching the line (plane) of saturation" (p. 353).

He notices the schemes for supplying London with water from the Lower Greensand, noting that then there was a preference for an underground scheme, rather than for one of surface-collection and says "The success of this . . . depends evidently upon whether or not there be any great quantity of water in that formation . . . Whether or not the Lower Greensand on the south of London will furnish a sufficient supply is a difficult question. . ."

"Only so much water as falls as rain *on* the Lower Greensand can avail for underground water supply. The small quantity which may run off the Gault on to the Folkestone Beds . . . is scarcely worth consideration, but even this could be allowed for. It is certain, however, that no water falling on the Weald Clay passes away through the Lower Greensand, unless it be that the rivers are themselves in part absorbed in their passage over that formation. But this is not likely to be the case. Each river, in running through the lowest ground, determines the line (plane) of saturation, and upon this depends the height at which the springs break out in the neighbouring district."

"If then, we ascertain the total area of exposure of the Lower Greensand, and also the amount of rainfall over that area, we can calculate the greatest quantity of water that can possibly avail. Of this a very large quantity drains off the surface at once into brooks, and, passing into the rivers, is carried out of the district. Another portion evaporates, either directly from the surface or through vegetation. The rest sinks into the ground, but in part re-appears as springs, which afford a constant supply of water to the brooks. If we could ascertain the total amount of water thus withdrawn, we could estimate the maximum amount which passes under the Gault and away northward beneath the London Basin."

"It is certain that a very large quantity of the water absorbed by the Lower Greensand does re-appear as springs . . . The quantity which it has been proposed to collect from springs and rivulets at Hindhead and Leith Hill in *part* represents this. But only in part, because no one has hitherto attempted to estimate the whole quantity which these rivulets carry off."

"The Lower Greensand is traversed by a series of flexures and anticlinals which must necessarily exert a great influence upon the underground passage of water. What effect such disturbances may have must be determined by each particular case, and the effect will certainly vary along the strike of each line of disturbance. . . ."

"An anticlinal line probably cuts off the supply, when valleys along this line reach down to the retentive bed. It certainly does so when the valley runs along the strike of the anticlinal . . . but to a very large extent it does so when the valleys *cross* the anticlinal. Whether or not the supply is cut off when the retentive bed is not reached by small valleys along the anticlinal will depend upon the height of the water level at the escarpment and major valleys, and the distance of each from the place in question."

"With a simple *flexure* the case is different; this probably serves to carry the water quickly down below the level of springs and streams. But a flexure has the effect of narrowing the outcrop, and therefore lessening the . . . collecting ground. . . ."

"The most important area of Lower Greensand, as regards the water supply of London, is that of Hindhead and Leith Hill (up to Dorking) . . . We cannot safely calculate on any portion of the area south of the Hindhead anticlinal; there are some rather strong springs to the south of this, about Haslemere, through which much of the absorbed rain re-appears, whilst the rest probably drains to the south and west. Some of the water which runs underground to the west . . . may work its way round to the north and so avail for the supply of London; but the greater part, probably, goes to the Hampshire Basin."

"The small flexure running through Thursley probably has no great effect on the water system, but on the north of that the beds, flat for awhile, rise very slightly towards the Hog's Back flexure. Upon the exact amount of this rise and the height of the line (plane) of saturation will depend the amount of water which passes over the anticlinal-flexure towards London. The strong springs near Moor Park seem to be thrown out by this flexure; and on the east, at Compton, the same disturbance brings up the Atherfield Clay and Weald Clay, thus effectually cutting off the supply in that direction. It is likely that this anticlinal flexure on the west of Pease Marsh does not completely cut off the underground supply, but it probably checks it considerably."

"On the east of the River Wey . . . to Dorking, it is probable that very little of the Lower Greensand water runs underground to the north. The springs over the district are abundant and strong, and it is likely that careful and exhaustive gauging would show that the rainfall over this area can be nearly all accounted for . . . The fault which ranges from the Chalk, past Park Farm (Wotton), and eastwards to the south of Berry Hill, probably aids the underground passage of water, as it throws down to the north."

"Probably much of the rain which falls on the Folkestone Beds, on the north of the line of disturbance, passes away northwards (underground); and if much of the water from the large area of the Hythe Beds goes in the same direction it must be along the line between Albury Park and Wotton."

He then turns to the narrower tract between Dorking and Limpsfield and says:—"The flexure at Dorking . . . and that further east at Nutfield, serve only to carry the water rapidly down to the north."

On the whole evidence Mr. Topley came to the conclusion "that the amount of water passing northwards below the Gault from the Lower Greensand of Kent and Surrey has been considerably exaggerated. Yet, when all possible deductions are made, there will probably remain a large quantity of the rainfall unaccounted for. This will doubtless pass northwards, and *may* be available for the supply of deep wells. But this is by no means certain. It is known that an underground ridge of old rocks exists near London, and that the Lower Greensand must thin away along the flanks of this ridge."

It should be noted that although the above remarks were made in regard to the supply of London they are applicable also locally.

In 1880 the hydrogeology of the Lower Greensand of Surrey was treated of in a paper by Mr. J. Lucas,[1] who says:—"There is a general absence of fissures in the Hythe beds, on account of their clayey admixture; and, save in the Leith Hill district, there seems to be no barrier to the vertical passage of water . . . In the Leith Hill district there is a bed of clay . . . about 100 feet above the base of the Hythe beds, and immediately beneath the sandstones . . . This clay serves to hold up water, and from

[1] Proc. Inst. C.E., vol. lxi, pt. iii.

this issues a little spring, 230 yards north of the tower, as well as the springs at Shootlands . . . This clay can be traced by its effects for six miles west of Leith Hill," and it "can be seen throwing out a weak spring on Hambledon Common . . ."

Turning to the Sandgate Beds, the outcrop of the fullers' earth eastward of Redhill "is marked by a line of ponds, fed by weak springs issuing from the bed of sandstone immediately above it. There are no less than eleven of these spring ponds in a distance of 3½ miles between Redhill and Brickkiln farm, Bletchingley."

"Upon the uppermost of the sandstones there lies a bed of clay, about 3 feet thick, which also acts as a barrier. Between this clay and the bed of fuller's earth . . . the Sandgate beds contain a small local compound water system, independent of that of the Hythe beds below and of the Folkestone beds above. It is of service to a limited number of local wells, and throws out a few springs on the north; but . . . can only have a small quantitative value." He notes the occurrence of a clayey bed westward (in a tract where the Sandgate Beds are not shown on the map) at Chilworth and Puttenham, which forms the site of ponds at Puttenham Priory and in Peperharrow Park. Westward "the same bed of clay underlies the Folkestone sands, holding up the water, which serves a few wells at Crooksbury, and throwing out the springs at Charles Hill . . . It is, however, . . . inconstant . . . It exists under the Folkestone beds under part of Farnham Common, serving a few shallow wells . . . On the whole, the water held up by it is so inconstant that it cannot be taken into account."

"Of all the divisions . . . the Folkestone sands are the freest from argillaceous admixture . . ."

"There are . . . within the greensand area several . . . folds and dome-shaped elevations. Some of these exercise an important influence upon the extent and configuration of the river basins." Some have been already noticed (*see* TOPLEY, pp. 24, 25), all, and their effects, are duly described, in about four pages, by MR. LUCAS, who then treats of the water-system of the Wey, in which account he says:—"Taken as a whole the surface of the lower greensand country is not nearly so pervious to water as that of the chalk. The heavy rains run off at once . . . and actually feed the floods. The variation in the waterline (plane) are insignificant compared to those of the chalk, and it would seem as though a very measured quantity percolates to the deep springs."

In speaking of the tract eastward of the Mole there is a slip in saying that the water from the Lower Greensand near Blechingley finds its way to the Darent: it goes to the Eden.

The underground water-contours are described, and these "serve to moderate the expectations as to what might be accomplished by enterprising the artesian system of the lower greensand."

A table of the Lower Greensand wells in Surrey fills 9 pages, and gives the following particulars: height and depth of well, water-level (mostly on two dates, 1878, and 1879, often on three, 1877 also). The arrangement is under the headings of the river-basins (Wey, 5½ pages; Arun, 2 entries; Mole, over 3 pages; Darent, which probably should read Eden).

The map, on the scale of an inch to a mile, represents the broad outcrop of the Lower Greensand, to a little east of Dorking. It shows the sites of wells on various formations, and gives the underground water-contours, those in the artesian part being distinguished: these start at 140 feet and go, by intervals of 10 feet, to 280 and then to 700.

Evidence to hand of late years has shown that where the Lower Greensand is reached by deep borings in the middle part of the London Basin, westward of London, the water from it rises (at first at all events) to a great height, much above that from the Chalk. The latest evidence of the sort is from Surrey, given by the very deep boring at Ottershaw Park, Chertsey (*see* p. 134).

Like evidence of a high rise of water from a very deep-seated source is given by the Richmond boring (*see* p. 218), though in this case the water comes from Jurassic beds and from the red sandstone below. Nevertheless it seems likely that the water may have got into those older formations from the Lower Greensand, which must somewhere communicate with them: it does so indeed at Richmond if it is really present there.

Hastings Beds.

This series, which contains the lowest water-bearing divisions to come to the surface in Surrey, is practically of no importance in the county, not being used for any public supply. The only division that has any appreciable outcrop is the upper member of the Tunbridge Wells Sand, and this has been reached, by boring through the Weald Clay at Lingfield and Reigate (Eastwood Asylum).

Many other references to Surrey water are to be found in the Reports of Royal Commissions and of other enquiries.

RAINFALL.

By Hugh Robert Mill, D.Sc., LL.D.,

Director of the British Rainfall Organization.

The data from which to compile a rainfall-map of Surrey are more abundant than in the case of any other county in England of equal area; but unfortunately the proportion of long records is very small. It was considered expedient, in order to secure uniformity in the average values, to adopt the long period of 35 years (1868-1902) which had been used in dealing with the rainfall of other counties in the Water Supply Memoirs; but short records extending down to 1909 were utilized by extending the Tables of comparison of long records.

The rainfall-observations utilized in this Memoir have been collected by the British Rainfall Organization and published in "British Rainfall" since its initiation by Mr. G. J. Symons fifty years ago. Special mention must be made of the admirable work done by the Meteorological Committee of the Croydon Natural History and Scientific Society, which publishes monthly tables giving the daily rainfall at a large number of stations in the north-east of Surrey and the neighbouring border of Kent. At numerous stations the records are under the charge of Waterworks Engineers; but by far the largest number of observers measure rainfall on account of their interest in horticulture or in the study of the weather, and the rapid development of Surrey as a residential district has led to the great increase in the number of records recently established. Observations at no less than 205 stations within the County were worked up in the course of compiling the map, almost as many as were available in the case of Kent or Sussex, counties which have twice the area of Surrey.

The large number of rainfall-stations established from time to time in close proximity to each other made it possible to overcome the difficulties arising from the absence of individual records running through the whole period of 35 years. It was possible to utilize five records on the borders of the county (in London, Hampshire and Kent) which ran unbroken since 1868, and to supplement these by ten records within the county which fell short of the complete period by some years, the figures for which could be supplied from neighbouring stations yielding closely accordant values for the years during which they ran together. These fifteen constitute the standard stations used for the correction of short records to the average of a long period. For this purpose the rainfall of each year at each of the fifteen stations was expressed as a percentage of the average at that station. The resulting figures show the relative wetness or dryness of the years and they were combined into three groups representing the three natural divisions of the County. The means for each group are given in Table I. and the ratios of Division A were used in correcting short records from the Lower Thames Valley, those of Division B for the stations on the North Downs and those of Division C for stations in the district south of the North Downs. The last column, giving the mean ratios for the county, is compounded of the three divisions, thus $\frac{1}{4}$ (2A + B + C), the division north of the North Downs receiving twice the weight of the others on account of its greater area.

The figures in the last column give the best representation of the relative dryness and wetness of the years from 1868 to 1909 for the whole of Surrey. They show that, as in most parts of England, a series of eight consecutive years with rainfall above the average occurred from 1875 to 1882 inclusive, the mean excess being 13 per cent. per annum. The longest period of deficient rainfall was eight consecutive years, in none of which was the average exceeded, from 1895 to 1902, the mean deficiency being 9 per cent. per annum. It will also be noticed that for 21 years from 1888 there was a tendency for the recurrence of wet and dry years in a sequence of three, one relatively wet year being followed by two relatively dry years; and the same order held good before 1875. In all cases except two the relatively wet years exceeded the average, and in all but one the relatively dry years fell short of the average. The wettest year between 1868 and 1902, as in most parts of England, was 1872, when there was an excess of 35 per cent., and the next wettest years in that period were 1877 and 1879 with an excess of 22 per cent.

But the wettest year on record, as in the whole of the Lower Thames Valley, was 1903, just beyond the period dealt with, when the excess amounted to 47 per cent. for the whole county and to 53 per cent. for the northern division.

The driest years were 1884, 1893 and 1898, each with a deficiency of 21 per cent., and next to these 1887 (which was the driest in most parts of the British Isles) with a deficiency of 17 per cent. The three driest consecutive years were 1897-1899 with a mean deficiency of 11 per cent.; but the three years 1900-1902 were equally dry if the value is given to the nearest unit.

As there has been much discussion as to the share which a diminishing rainfall has had in the sinking of the water-level in the Chalk it is worth pointing out that although the annual rainfall was on the whole falling off from the time of the very wet spell in the seventies to 1902, it has shown since that time a tendency to return to the average of the 35 years. It would be interesting to compare the years of the flow of the bournes with the years of high and low rainfall as given in the Table.

The short records which it was necessary to utilize were rarely less than ten years in length and they were reduced by the ratios given in Table I. to the equivalent of the 35-years average. After this was done a correction was applied, in the very few cases where it was necessary, for the height of the receiving surface above the ground. It has been established that for heights between a foot and 10 feet the catch of an exposed rain-gauge is reduced by wind-eddies in the proportion of 1 per cent for every foot of height above a foot.

The mean rainfall at the 205 rain-observing stations having been corrected and reduced in this manner the figures to the nearest half inch were plotted on a map on the scale of half an inch to a mile and isohyetal lines were drawn in accordance with the data. It was found occasionally, though rarely, that a figure was quite out of harmony with those surrounding it, and relying on the principle that the exceptional value is more likely to be erroneous than the accordant values, such figure was disregarded in drawing the lines. In a few cases where the data were insufficient to determine the course of an isohyetal line the most probable form was adopted, relying on the proved relationship between rainfall and configuration. The resulting map shows the distribution of rainfall over the county, and by measurements of the areas between successive isohyetal lines and evaluation by inspection of the mean rainfall of each zone the general rainfall of the county was determined. The data are given below:—

Zone.	Area: square miles.	Per cent. of total area.	Mean Rainfall of zone. Inches.
Below 25 inches ...	108·08	14·9	24·4
25 – 27·5 „ ...	190·52	26·4	26·1
27·5 – 30 „ ...	267·64	37·1	28·8
30 – 32·5 „ ...	117·96	16·3	31·2
32·5 – 35 „ ...	33·16	4·6	33·3
Above 35 „ ...	5·4	·7	36
Total ...	722·76	100	

The general rainfall deduced from these figures is 28·1 inches, or taking it to the nearest quarter inch 28 inches. Applying this figure to the values in Table I we get:

1868-1902.	Average general rainfall of Surrey,	28·1 ins.
1872.	Maximum general rainfall of Surrey,	37·8 „
1884, 1893, 1898.	Minimum general rainfall of Surrey,	22·2 „
1897-1899. 1900-1902.	Driest Three Years rainfall of Surrey,	24·9 „

Although the year 1903 falls outside the period for which the average is calculated it is right to say that in that year the general rainfall of Surrey was greater than in any other year on record, amounting to 41·16 inches. The excess for that year, which was greatest in London, affected Surrey much more than it did Kent or Sussex.

The rainfall-map shows the same close dependence of rainfall on configuration and on wind-direction that was so prominent in the other south-eastern counties. The county falls into roughly parallel rainfall-zones running from W.S.W. to E.N.E. The axis of highest rainfall lies along the highest land from Hindhead to Leith Hill and the North Downs. On the north the rainfall diminishes to the plain of the Thames and on the south it diminishes to the plain of the Weald, rising again in the extreme south-east. Rainfall below 25 inches only occurs on the north, close to the Thames, while rainfall exceeding 30 inches only occurs on the Lower Greensand Hills and the Chalk Downs.

The isohyetal of 25 inches enters the county near Staines in the north-west, runs south-westward up the valley of the Bourne to near Pirbright, runs north-eastward and then south-westward round the low ridge on which Woking stands, between the Bourne and the Wey, makes a similar turn towards Weybridge round the ridge separating the Wey and the Mole, follows the low valley of the latter stream southward beyond Stoke D'Abernon and then continues eastward along the base of the Downs through Chessington, Sutton and Croydon. The immediate neighbourhood of the Crystal Palace may also receive more than 25 inches. There is evidence of an isolated patch of rainfall just exceeding 25 inches on the high ground near Kingston and Wimbledon; and the observing stations are sufficiently numerous to allow us to state in a general way that in Surrey north of the Downs a rainfall of 25 inches is found about the 100-foot contour; below that level the rainfall is usually less and above it usually more.

The isohyetal of 27·5 inches north of the Downs runs roughly parallel to the 25-inch line, and although it cannot be said to show an equally close relation to height its average position is not far from the 250-foot contour. South of the Downs a strip two or three miles wide, from Edenbridge westward to a point south of Red Hill, has probably less than 27·5 inches of rain, the low rainfall of the Weald of Kent extending farther to the west than was formerly supposed. Data are lacking for the very interesting bit of country near the Hog's Back, but it is most probable that the highest part of that ridge has more than 27·5 inches of rain and it is so shown on the map. Additional data have proved that the lines in the north-east of Hampshire must be slightly altered as shown on the margin of Surrey.

The isohyetal of 30 inches is very interesting and important. Unlike the lower lines it does not run continuously across the county but defines four areas of very unequal size. The first of these is the south-western corner of Surrey, the 30-inch line running nearly in a semicircle, convex to the north-east, from Frensham on the Hampshire border to the Sussex border south of Chiddingfold. In the west the 30-inch line runs at a height of about 350 feet, but in the east of this area it descends to nearly 200 feet. The position of the 32·5-inch line on the western area cannot be exactly fixed; but the wettest part of Surrey, round Hindhead, is encircled by a 35-inch line. Possibly a mean rainfall exceeding 37·5 inches occurs on the highest part of Hindhead, but as there is no rain-gauge there this must remain uncertain for the present.

The second area with more than 30 inches is indicated by the record at one station on the high ground between Godalming and Dunsfold, and the third area is a very narrow strip on the borders of Sussex and Kent on the south-east.

The fourth and most important area includes the Chalk Downs and the Lower Greensand Hills from Cranleigh and Albury on the west to the Kent border at Tatsfield. Along the northern side of the North Downs the isohyetal of 30 inches runs at a height of about 400 feet in the west, but gradually rises towards the east, being about 500 feet between Epsom Downs and the Caterham Valley and reaching 600 feet at the Kent border. On the south the 30 inch isohyetal runs round Leith Hill at a distance of between two and three miles from the Tower and follows the Brighton Railway north almost to Dorking, the mean position of the isohyetal being about the 250-foot contour. From Dorking it runs along the South Eastern Railway to Merstham, at about the same elevation, and thence between 300 and 400 feet to the Kent border. The 32·5-inch isohyetal surrounds Leith Hill at an approximate height of 450 feet, and there can be little doubt that on the summit the rainfall must reach 35 inches at least, but there is no rain-gauge to record it. The rainfall diminishes to something less than 32 inches in the valley between Leith Hill and the North Downs, and it certainly exceeds 32·5 inches, and probably exceeds 35 inches, on the section of the Downs between Guildford and Dorking, though there are no records from the highest portion. Areas with more than 32·5 inches occur on the Downs between Dorking and Merstham, and to the east of the Caterham Valley: the former has more than 35 inches at the highest point, and it is probable that this would also be found to be true of the land over 800 feet high north of Titsey, if there were more records available.

The most interesting feature brought out by the map is that along the North Downs rainfall of the same amount occurs at a much lower height on the southern than on the northern slopes and at a lower height in the west than in the east.

In Table 2 the annual rainfall at a number of stations in Surrey is set out, the selection having been made so as to represent all parts of the county equally, and as far as possible all heights from less than 20 to more than 800 feet above the sea. It is much to be regretted that there are so few records available from the highest parts of the county that it is difficult to test the value of the figures by intercomparison, and it seems probable that the record at Botley Hill, Titsey gives too low a figure.

It is necessary to have much longer records to give satisfactory averages for monthly than for annual rainfall, and sufficiently long-established stations are not numerous enough to represent all the natural divisions of the county. Table 3 gives particulars of mean and extreme monthly rainfall at Haslemere in the south-west, at Red Hill on the southern slope of the North Downs, and at two stations on the Thames, one of which is just over the border in Buckinghamshire. The extremes quoted are those which occurred between 1868 and 1902, but the monthly rainfall of some later years was more extreme and it is desirable to place these on record. April was wettest in 1907 at Haslemere with 5·24 inches, and at Slough in 1903 with 3·28. June was wettest at Haslemere in 1905 with 7·26 inches, at Red Hill in 1903 with 5·43, at Kew in 1903 with 7·21, and at Slough in 1903 with 5·96. September was driest at Haslemere in 1907 with ·55 inches. October was wettest at Haslemere in 1903 with 9·21 inches, and at Slough in 1903 with 7·14. The total annual rainfall was greatest in 1903 at Red Hill with 40·99 inches, at Kew with 38·18 and at Slough with 36·4.

In order to compare the monthly incidence of rain at stations of different rainfall the values have been given for each of the four stations and their mean calculated as percentages of the annual fall. The last column shows that October is the wettest month for the county as a whole and that March and April are the driest months. The subsidiary maximum in July or August, which is prominent in other parts of England, does not appear, though it is suggested by the fact that August has the same amount of rain as July. Thus, although the last three months of the year are less wet than in Kent and Sussex, and the Spring-months rather less dry, the type of seasonal distribution is similar in the three south-eastern counties. It is noteworthy that while September and October have the same percentage of the annual rainfall at all four stations, the southern stations, Red Hill and Haslemere, have a higher proportion of rain in November and December and a smaller proportion in April and May than the northern stations, Kew and Slough.

TABLE 1.—SURREY RAINFALL. AVERAGE=100.

Year.	A. Lower Thames Valley.	B. North Downs.	C. Weald.	Mean for County.
1868	107	110	102	107
1869	105	105	103	104
1870	81	83	82	82
1871	93	95	88	92
1872	135	138	132	135
1873	91	94	93	92
1874	89	98	95	93
1875	117	110	105	112
1876	111	110	109	110
1877	118	126	127	122
1878	111	101	103	107
1879	127	117	117	122
1880	122	115	116	119
1881	104	102	105	104
1882	108	109	110	109
1883	95	97	99	96
1884	79	79	78	79
1885	104	102	99	102
1886	108	108	113	109
1887	81	83	85	83
1888	106	105	104	105
1889	90	93	94	92
1890	88	88	93	89
1891	117	118	120	118
1892	94	89	91	92
1893	79	79	81	79
1894	120	120	119	120
1895	91	90	91	91
1896	98	101	101	100
1897	97	97	94	96
1898	79	80	80	79
1899	91	93	93	92
1900	94	100	106	99
1901	83	85	86	84
1902	87	80	86	85
1903	153	144	137	147
1904	90	90	94	91
1905	92	90	91	91
1906	101	101	104	102
1907	97	96	91	95
1908	96	98	98	97
1909	107	110	107	108

Table 2.—Mean Annual Rainfall of Surrey.

Stations.	Height above Ground.	Height above Sea Level.	Period of Observation.	Number of Years.	Arithmetical Mean.	Computed Average for 35 years.	Computed Average corrected for height above ground.
	ft. in.	ft.			inches	inches	inches
Haslemere, Courts Hill	4 0	481	1868–1902	35	35·16	35·2	36·2
Dunsfold, Durfold	1 0	225	1900-1909	10	28·53	28·5	28·5
Oakwood Vicarage	0 9	285	1900–1901, 1903, 1907–1909	6	30·9	29·7	29·7
Capel, The Cottage	1 0	271	1894–1899	6	28·93	30·1	30·1
Farnham Castle ...	1 0	300	1892–1909	18	27·38	28·2	28·2
Godalming, Charterhouse	1 0	310	1898–1909	12	28·39	29·2	29·2
Wonersh, Shamley Green	1 0	400	1889–1909	21	28·85	29·7	29 7
Dorking, Holmbury	0 6	553	1876–1891	16	35·38	34·2	34·2
Edenbridge, Lyden Croft	1 0	212	1894–1909	16	28·2	28·6	28·6
Outwood, The Orchards	1 0	280	1908-1909	2	26·66	26·	26·
Reigate, Doods ...	1 6	365	1882–1900	19	28·83	29·9	29·9
Dorking, Denbies	1 0	610	1871–1909	39	32·21	32·	32·
West Horsley, Woodcote Lodge	0 6	650	1895–1909	15	31·32	32·3	32·3
Pirbright Camp ...	1 0	201	1895–1906	12	23·93	24·8	24·8
Woking, The Grange	0 8	78	1900–1909	10	26·07	26·1	26·1
Titsey, Botley Hill	1 0	870	1880–1883, 1885–1887	7	34·28	33·5	33·5
Chipstead, Shabden Park	1 0	550	1895–1909	15	29·58	30·5	30·5
Warlingham, Egremont	1 0	614	1893–1909	17	30·76	31·6	31·6
Leatherhead, Oxshott	1 0	206	1892–1905	14	23·46	24·4	24·4
Windlesham, Erlwood	1 0	220	1891–1903	13	24·92	25·3	25·3
Chertsey, Long Cross	1 9 3 0	168 205	1880–1891 1900–1909	22	24·15	24·1	24·5
Weybridge, West Oaks	1 0	36	1896–1909	14	23·48	24·1	24·1
Worcester Park, Parkside	1 0	80	1897–1901, 1903–1909	12	23·99	24·4	24·4
Croydon, Waddon New Road ...	1 0	146	1891–1909	19	25·14	25·6	25·6
W. Molesey, Chelsea W. W.	1 0	32	1895–1909	15	22·85	23·5	23·5
Egham, Cooper's Hill ...	1 1	280	1875–1896, 1898–1900	25	25·11	24·8	24·8
Wandsworth Common	1 0	100	1892–1909	18	23·48	24·2	24·2
Kew Observatory	1 9	19	1868–1902	35	23·46	23·5	23·5

Table 3.—Monthly Rainfall. Surrey 1868–1902.

Month.	Haslemere. From 1868–1872 the record was taken at Weycombe.				
	Mean.	Wettest.	Year.	Driest.	Year
	In.	In.		In.	
January	3·32	8·76	1872	·68	1892
February	2·69	8·81	1900	·03	1891
March	2·29	6·17	1897	·33	1893
April	2·11	4·69	1871	·04	1893
May	2·07	5·01	1869	·19	1871
June	2·2	5·66	1879	·33	1895
July	2·91	6·94	1888	·4	1885, 1898
August	2·93	7·07	1881	·51	1899
September	3·17	7·98	1896	·73	1895
October	3·97	8·8	1891	·69	1897
November	3·83	7·62	1877	·61	1871
December	3·67	9·17	1876	·64	1873
Year ...	35·16	49·09	1872	26·72	1884
	Redhill, Oxford Road.				
January	2·71	6·86	1877	·51	1880
February	2·13	4·85	1900	·0	1891
March	1·98	4·65	1897	·64	1899
April	1·85	4·13	1871, 1877	·04	1893
May	1·84	4·66	1886	·26	1896
June	2·16	4·99	1879	·33	1870
July	2·54	5·7	1888	·24	1885
August	2·52	5·88	1878	·69	1893
September	2·63	7·72	1896	·43	1898
October	3·35	7·48	1880	·53	1897
November	3·19	6·5	1877	·78	1901
December	2·91	7·24	1876	·63	1873
Year ...	29·81	39·07	1877	22·59	1898
	Kew Observatory.				
January	1·82	4·89	1877	·44	1880, 1892
February	1·56	4·12	1879	·09	1891, 1895
March	1·42	3·61	1897	·23	1893
April	1·59	3·99	1878	·1	1893
May	1·66	4·1	1886	·17	1896
June	1·9	4·18	1879	·23	1895
July	2·26	4·88	1880	·48	1885
August	2·19	6·5	1878	·44	1899
September	2·16	5·06	1896	·42	1898
October	2·62	5·95	1880	·58	1897
November	2·18	3·98	1899	·47	1901
December	2·1	5·84	1876	·4	1873
Year ...	23·46	33·08	1877	16·64	1870

Month.	Slough, Langley. From 1868–1871 the record was taken at Eton.				
	Mean.	Wettest.	Year.	Driest.	Year.
	In.	In.		In.	
January	1·98	4·39	1877	·36	1880
February	1·74	4·13	1900	·02	1891
March	1·47	3·24	1896	·13	1893
April	1·46	2·92	1882	·05	1893
May	1·56	3·7	1886	·28	{ 1871 1880
June	1·88	5·53	1879	·38	1895
July	2·17	5·34	1890	·29	1885
August	2·23	5·91	1879	·48	1899
September	2·16	6·26	1896	·44	1900
October	2·68	5·75	1893	·77	1879
November	2·3	4·24	1895	·42	1871
December	2·23	5·02	1876	·55	1873
Year ...	23·86	33·27	1879	17·00	1901

Month.	Mean Monthly Rainfall expressed as Percentage of Annual Average Rainfall. In inches.				
	Haslemere.	Redhill.	Kew.	Slough.	Average.
January	9·4	9	7·8	8·3	8·6
February	7·7	7·1	6·6	7·3	7·2
March	6·5	6·7	6·1	6·1	6·3
April	6	6·2	6·8	6·1	6·3
May	5·9	6·2	7·1	6·5	6·4
June	6·3	7·3	8·1	7·9	7·4
July	8·3	8·5	9·6	9·1	8·9
August	8·3	8·5	9·3	9·4	8·9
September	9	8·8	9·2	9	9
October	11·3	11·2	11·2	11·2	11·2
November	10·9	10·7	9·3	9·7	10·2
December	10·4	9·8	8·9	9·4	9·6
Year ...	100	100	100	100	100

[It is right to call attention to the Reports on the Meteorology of Surrey that have been contributed by MR. F. CAMPBELL-BAYARD to the Annual Reports of the Medical Officer of Health for the county.

Reference has been made above to the meteorological work of the Croydon Natural History Society. One may add that these Reports started in 1877 and have been prepared by MR. CAMPBELL-BAYARD from 1888 onward. Under him they have grown to be a very detailed record for a large district around Croydon, probably the fullest publication of the sort issued by any local Society. Not only are they included in the Yearly Proceedings of the Society; but, in the first case, they are issued monthly to subscribers.

It is to be hoped that so useful a record may be extended over the administrative county by the County Council, as it is clearly a work of public usefulness. W.W.]

SPRINGS.

General Remarks.

One cannot perhaps do better than to repeat (though not altogether in the same words) what has been said of the neighbouring county of Kent, the circumstances of which, in the matter of springs, are much the same as those of Surrey.

There are very many springs in Surrey, most of which are caused in the usual way, by water that after passing down through a permeable bed is thrown out by an underlying impermeable bed. This generally occurs at or near the junction of the two beds, and mostly on a slope, though sometimes in the bottom or at the head of a valley.

There are some springs however which rise from the top instead of the bottom of a permeable bed, where it is overlain by an impermeable one. This occurs at places where the junction is in low ground at the foot of a long slope, when the underlying permeable bed is saturated with water. Consequently underground water flowing down from the higher ground of the outcrop cannot flow further down, beneath the impermeable overlying bed, and so is forced to escape at the surface.

Another sort of spring occurs along the courses of streams, at places where the underground water-plane rises up to the ground-level. Many of these springs are therefore inconstant, occurring only at such times as the underground water-plane is high, that is after wet seasons. They are the sources of bournes, or intermittent streams, and will be described under that heading.

Mineral springs too, that is those containing an unusual amount of mineral matter and of more or less medicinal value or once supposed to be so, will also be separately described, as there are several notable examples in the county.

In dealing with our ordinary springs, which depend on the relations between permeable and impermeable beds, the stratigraphic order of formations will be adhered to, beginning at the base and working upward.

As regards water-supply it must be remembered that the yield of springs varies greatly according to the season; so that it is risky to assume that a large supply can be got from any spring or set of springs unless a record of the flow has been kept for a considerable number of years: it is the record of low yield that is important. This seasonal variation of springs is generally well known and often is of very great extent; but a much smaller though more frequent change has been noticed in one district and must be of a general kind.

In a paper read to the British Association in 1881[1] Mr. Baldwin Latham gave the results of some observations on the flow of the Croydon Bourne made in the spring of that year. He found "selecting periods when there was no rain to vitiate the

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[1] *Rep. Brit. Assoc.* for 1881, p. 614; 1882.

results, that whenever there was a rapid fall in the barometer, there was a corresponding increase in the volume of water flowing, and with a rise of the barometer, there was a diminution in the flow. The fluctuations in the flow . . . due to barometric pressure, . . . had at one period exceeded half a million gallons a day. The gaugings of deep wells also confirmed these observations . . . at that period of the year when the wells became sensitive and the flow from the strata was sluggish, a fall in the barometer coincided with a rise in the water-line, and under conditions of high barometric pressure the water-line was lowered. Percolating gauges also gave similar evidence . . . The conclusion arrived at was, that atmospheric pressure exercises a marked influence upon the escape of water from springs. The increase in the flow of the water was attributed to the expansion and escape of the gases held by the water under low barometric pressure, which caused the water to escape more freely, while with high barometric pressure there was a condensation and inward flow of the gases which led to a retardation in the flow of the water."

Two years later MR. LATHAM noted further observations, especially some made at an overflowing well (with a boring into the Chalk) at Mitcham. Here "a length of iron pipe was fixed on the bore-pipe so as to bring it some feet above the ground level" and the observations showed that when there was a fall in the barometer the water in the pipe rose, and when there was a rise the water fell.[1]

The following notes of springs are of such as have come under my own observation, or of which I have found records. In Surrey, as in other counties, there is need of careful observation and I hope that this interesting subject will be taken up by local workers; so that there may be considerable addition to my record of observed cases.

WEALD CLAY.

During an excursion of the Holmesdale Natural History Club, in April, 1911, I saw a good example of a spring in the Weald Clay in the wood on the western side of the road about a quarter of a mile NNW. of the old farmhouse of Highridge, in the parish of Oxted, just at the 300 feet contour-level.

The wood had been partly thinned and so had become a perfect garden of wild flowers down that part of the westerly slope, and the ground was brilliant with the blossoms of celandine, primrose and wood-anemone. The spring-head, within the bend of the contour-line on the map, and the southern side of the stream were open to the sun, whilst on the other side the carpet of flowers showed up clearly beneath the thin underwood.

The spring-head is in a little, but well-marked, circular hollow, and though there had been dry weather, was yielding a small flow. It is an example of the occurrence of water, enough to furnish a small local supply, and probably is owing to the

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[1] *Rep. Brit. Assoc.* for 1883, pp. 495, 496; 1884. These papers are referred to in his "Croydon Bourne Flows" of 1904.

presence of a permeable bed in a formation of a generally impermeable character, and partly perhaps to a thin gravelly capping. There must be many other like springs.

Lower Greensand.

The escarpment of this formation is naturally a source of springs, thrown out, on the flank of the slope, from the permeable Hythe Beds by the underlying Atherfield Clay, and Mr. J. Lucas tells us "There are ninety-two springs breaking from the base of the Hythe beds between Haslemere and Limpsfield parishes; eight springs, or groups of springs, in the inliers of Atherfield clay near Hind Head; and nine around the Compton inlier of Weald clay . . . Many of these springs generate considerable brooks. Some few are appropriated to water supply."[1] Of a few of these some details will be given. Some have already been noticed (pp. 20-23, 26).

Of the springs flowing down the escarpment, or in valleys that slope down to the escarpment, one, known as Mag's Well, near Dorking, is noticed further on. But the only others of which I have notes are at the far east of the county.

At the south-eastern corner of the wood northward of Oxted Mill I have seen a spring, in the base of the little valley which there breaches the escarpment. Southward of Limpsfield there are springs within the eastern border of the wood named The Alders, westward of Paine's Hill and less than a mile from the church; and those at Paine's Hill (in the hollow a little NE. of Bolthurst Farm) once formed the public supply, and can still be used, I believe. These latter are marked on the six-inch Ordnance Map (sheet 28) as also is another set of springs a little SE. in the wooded hollow NE. from Grant's Farm. When at the Waterworks in June, 1899, I was told that these were dry though the others were flowing.

Over the broad part of the outcrop springs also occur, inland from the escarpment, and their waters flow away from it.

Sundry of these are marked on the six-inch Ordnance Maps, as for instance at Hindhead, in the valley eastward of Beacon Hill, and in the Devil's Punchbowl.

A little northward of Stella Cottage, south-east of Moor Park, Farnham, is the well-known Mother Ludlam's Cave, or more correctly Ludwell. Writing of this Manning and Bray[2] say "There is a copious discharge of a pure, transparent water, issuing from the foot of a hill, and in the bed of a natural grot formed in the sandy rock . . . From this spring the several offices of Waverley Abbey, near half a mile distant, were supplied with water by ducts for that purpose, which conveyed it under the channel of the river. By some means, in the year 1216, the course of this stream was intercepted, not by any breach in the ducts . . . but by a diversion of the smaller springs."

[1] *Proc. Inst. C. E.*, 1880, vol. lxi, pt. iii, Appendix A.

[2] The History and Antiquities of the County of Surrey, vol. iii, p. 140, Fol. *Lond.*, 1814.

From a modern work we learn that "one of the monks . . . opened up the ground in order to find new springs. These after much labour he discovered, and uniting them by an underground pipe, brought them to a spot where it is said that they sprang up 'in a copious perennial fountain.' It henceforth was known as St. Mary's well,"[1] and is marked as such on the Ordnance Map, sheet 30. An analysis of the water is given on pp. 286, 287.

In August, 1889, I saw a well, only a few feet deep, in the marsh near High Mill, eastward of Farnham, the water of which rose to a little above the level of the adjoining water-course, into which it flowed.

Mr. G. W. Young, in speaking of St. Catherine's Hill, Guildford, "an eastward-facing river-bluff formed by the cutting through by the river Wey of a well-marked ridge of Folkestone Sands" says:—"A copious spring breaks out at the base of the north-east corner of the hill, and is said never to fail in the driest summer."[2] This however is not marked on the Ordnance Map.

Prestwich noted that "some very large and fine springs of excellent water issue from the base of the Lower Greensand [Hythe Beds] near Weston Street," a name that does not appear on the newer map (285) where the place is made the village of Albury.[3]

As the "Report of the General Board of Health on the Supply of Water to the Metropolis," already alluded to (pp. 6, 20) may not be generally accessible it may be well to reproduce the gaugings of the Lower Greensand springs and rivulets, given in Appendix III (p. 7) by the Hon W. Napier, premising that the figures (gallons a day) may be questioned. In no case is the hardness of the water given as more than 2°.

Hindhead and Blackdown.		Hascombe Hills.	
Holy Water ...	1,350,000	Sweet-water Pond	1,066,795
*Bramshot ...	13,399,714	Bush Bridge ...	529,200
Down Lands ...	540,000	Chapel Copse ...	224,697
*Headley Down ...	239,731	Hascombe ...	229,116
*Barford Mills ...	3,880,000		
Devils Jumps ...	360,000		
Punch Bowl ...	299,995	Leith Hill.	
Coxford House ...	674,928		
Gray's Wood ...	84,240	Totsford	1,799,798
Kotchet	32,568	Watton	890,956
Five other springs	127,562	Rookery	1,436,400

* These are or may be over the border, in Hampshire or Sussex. Possibly others also. Some of the localities I have not identified.

There is a difficulty in differentiating between spring and rivulet. It is unlikely that any spring could give the highest two figures. Of course rivulets are equivalent to combined springs; but they may also include more, such as surface-drainage.

Some further details of gaugings are given in the "Return" of 1852 (*see* pp. 21, 22) but these are avowedly stream-measurements, both for the Lower Greensand and for the Bagshot Sand.

[1] Homeland Handbooks, No. 13. Farnham and its Surroundings, ed. 2, 1902–3, pp. 75, 80.
[2] *Proc. Geol. Assoc.*, 1907, vol. xx, pt. 3, pp. 174, 175.
[3] Water-bearing strata of the Country around London, 1851, p. 163.

Upper Greensand.

Mr. J. Lucas has recorded the springs from the Upper Greensand in Surrey, from west to east.[1] He divides them into those from the Malm Rock and Firestone, above, and from the Grey Beds (clay or marl, sometimes with bands of sandstone) below. The springs are in the following parishes.

Farnham (Dippenhall and Bourne Mill); Seale (Quarry, Crickets' Hill, east of the same, and another); Puttenham (ponds); Compton (east of Down Farm, west of Conduit Farm); St. Martha's (Tyting Farm); Dorking (Coombe Farm and Landbarn Farm); Betchworth (Pudding Hole and Broome Park); Buckland (Rectory, Kemp's Farm and Hill Farm); Reigate (Colley Copse, Underhill Park, Stone House, Dennis Grove and east of Green Lane); Gatton (The Serpentine, Fish Pond); Merstham (Well Head); Chaldon (Picket's Wood), Farzefield Wood and Quarry Farm); Blechingley (Conduit Well, Whitehill Farm, north-east of and west of North Park Cottage); Godstone (Flinthall Farm, north of Godstone Corner Wood and Quarry Farm); Oxted (Rye Wood); Titsey (near the house in the Park, near Limpsfield Lodge Farm and south-east of Pilgrim's Lodge Farm).

In a later paper he speaks of a fault, not shown on the geologic map, "north and south through Puddingholes, and along the course of the Mole past Betchworth Castle. The fault throws down on the west, the bottom of the grey beds of the upper greensand . . . being thrown down about 20 feet below the top of the Folkestone sand at Puddingholes . . . a steep face at the sharp angle of the Mole (northward of the castle). On the east side of the fault the Folkestone sands are exposed, whereas the . . . gault goes below the bed of the river on the west side. On the opposite sides of the fault there are two springs. The one on the east side breaks out at the river level, close to the fault, and never fails; whereas the one on the west side, which is sometimes dry, breaks from the base of the grey beds, about 30 feet above the river, and also close to the fault. The existence of this fault seems to have determined the direction of that part of the course of the Mole."[2]

Prestwich gives us the following record:—"A very good spring, much resorted to formerly, flowed just below the church at Merstham. The cuttings for the railway have now diverted it."[3]

Chalk.

In Surrey, as elsewhere, the Chalk has two independent sets of springs, issuing from the top and from the bottom of the formation under different conditions and forming streams that flow in opposite directions from their points of origin. We have, along the base of the great escarpment of the North Downs, springs from the bottom part of the Chalk, owing to the occurrence of more or less impermeable beds beneath more or less permeable beds; and we have, along the line where the topmost beds of the Chalk pass beneath the Tertiary beds, another line of springs that are simply the overflow of the saturated Upper Chalk at its lowest points.

[1] *Trans. Inst. Surveyors*, 1877, vol. ix, pt. vii, pp. 175, 176.
[2] *Proc. Inst. Civ. Eng.*, 1880, vol. lxi, pt. iii.
[3] Water-bearing strata around London, 1851, p. 168.

The springs of the first set have but a narrow gathering-ground from the top to the bottom of the escarpment, whilst those of the second set have the far wider gathering-ground of the dip-slope, from the top of the escarpment northward, and consequently are greater in number and of a more powerful kind. Along the Hog's Back, where the dip is high and therefore the outcrop narrow, of course this does not hold: there the gathering-ground on either side is small, and springs are fewer.

Springs along the Escarpment.

The most westerly spring to be noted is at the narrowest and least conspicuous part of the Chalk, where indeed there is little in the way of escarpment. Mr. G. W. Young says that westward of the fault marked on the map there is a small fault, not marked on the map, along the low ground east of Farnham, where there is a gap in the chalk-ridge. "In this gap lies the Farnham Sewage Farm, close to which a strong spring emerges at the base of a small chalk bluff. This is the source of the Bourne Mill stream, and I suggest that the spring marks the position of this second fault."[1] The fault and the spring are marked on his map (p. 437), some further notes on this spring are given under Swallow Holes and Intermittent Streams (pp. 60, 61).

About half a mile N.N.W. of Albury church is the well-known Silent Pool, or Sherbourn Pond, where the water flows out in a pretty wooded dingle into a large deep pool.

Mr. J. Lucas[2] notes another spring, at Brockham Lime Works (in the parish of Betchworth, more than a mile north-westward of the church).

These apparently are all the Surrey Chalk-springs of this kind that have been noted, whereas in Kent many have been.

Springs along the Line of Outcrop.

One of the most notable features in Surrey is the long line of springs that come out along the outcrop of the Chalk from beneath the Tertiary beds between Guildford and Croydon. It is of course the occurrence of these springs that has led to the human settlements along that line, to the growth of the many villages which mark both the junction of the two great geologic series and its water-bearing character. This narrow band between those two towns with 17 places, some of considerable population, contrasts strongly with the wider but more sparsely populated ground both of the Chalk to the south (except where a public water-supply has altered things) and of the bare London Clay to the north. Nowhere indeed is this particular kind of spring better illustrated than in Surrey.

In a few cases the water rises in Tertiary sands, but in these probably it comes really from the Chalk beneath, those sands having too small an area of outcrop to form anything but the smallest of gathering-grounds. They will therefore be noted here.

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[1] *Proc. Geol. Assoc.*, 1908, vol. xx, pt. 6, p. 434.
[2] *Proc. Inst. Civ. Eng.*, 1877, vol. xlvii, pt. i.

The most westerly springs, as recorded by MR. J. LUCAS,[1] are at Poyle Park (west of Tongham) and at Wanborough, the only two westward of Guildford, both rising from the Reading Beds.

At West Clandon there is a spring in the park, close to the house, which MR. LUCAS also credits to the Reading Beds; but I am rather in doubt. I saw it one winter, long ago, and the temperature of the water was about 50°, as usual with springs from the Chalk.

His next record is Little Bookham Bourne, from the Reading Beds.

At Fetcham, on the left bank of the Mole, a fine spring occurs and has been described by MR. J. W. GROVER. It is "close to the railway, rising in a mill-pond of 7 acres, and having a fall of 11 feet 5 inches into the River Mole. This spring, in March 1883, was yielding 3,619,000 gallons of excellent chalk-water daily at a level of about 110 feet above Ordnance datum. The mill-pond is embanked all round, and, being above the general level of the valley (bottom), does not admit any surface-water. The spring bubbles up from a deep pit in the bed of the pond."[2]

Four years later he again referred to this spring, known as the Blue Pool, and said that another spring occurred at Effingham.[3]

The springs in the Mole above Leatherhead are noted further on (p. 67) in a general description of the part of that river in its Chalk valley. Just at the southern end of the village however there is a spring a little above the river, on the western side of the Dorking road, at Elmbank, where a considerable flow may be seen. Presumably it is this which has been referred to by MR. J. W. GROVER, in the paper above quoted, as having "yielded about 500,000 gallons of water a day in 1883."

MR. J. LUCAS has noted that:—"Between Leatherhead and Epsom . . . four miles, not one single spring breaks from the chalk at its junction with the tertiaries. From this circumstance the inference may safely be drawn that the chalk at the base of the tertiary beds is very far from being saturated . . . On the other hand from Epsom eastwards as far as Croydon the top of the chalk gives rise to five separate streams, two of which unite and form the Wandle."[4] In table xii he gives a list of the springs along this line, eleven in number, of which two, at Epsom, are intermittent. In a later work he names only eight.[5]

The first two are in Church Street and Worple Road, Epsom. They are intermittent, and, with the next, form the headwaters of the Hog's Mill Stream. They are said to rise from the Thanet Sand.

The Ewell springs are also thought, by MR. LUCAS, to start from the Thanet Sand; but I doubt this, at all events as regards the higher ones, which seem to come direct from the Chalk. When there in July, 1910, the highest flow was on the western

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[1] *Proc. Inst. Civ. Eng.*, 1877, vol. xlvii, pt. i.

[2] *Proc. Inst. Civ. Eng.*, 1887, vol. xc, pt. iv, p. 168.

[3] Special Report from the Select Committee on the London Water Commission Bill. Fol. *Lond.* 1891, pp. 79, 114, 115.

[4] Horizontal Wells, 1874, p. 34.

[5] *Proc. Inst. Civ. Eng.*, 1877, vol. xlvii, pt. i, table 2.

side of High Street, nearly 220 yards S.S.W. of the church, though the exact spot of origin could not be seen, owing to enclosures and coverings. At the small pond on the other side of that street a little northward (some 140 yards from the church) a great number of bubbling springs were to be seen in the bottom, through the clear water. There may be other springs in the fish-ponds northward and north-westward.

Mr. Lucas mentions springs in Nonsuch Park and Cheam Park, the latter of which is one of the head-waters of the Beverley Brook, and says "At Little (or Lower) Cheam another bursts up through the permeable Thanet sands, and flows over the Reading beds and London clay," forming another of the feeders of the Beverley Brook.

"From Carshalton eastwards, as far as Croydon, spring various sources of the Wandle; and, demonstrating the complete saturation of the chalk in that locality, the river at Waddon flows upon chalk itself for half a mile."[1] There are two branches of this river, one flowing north-eastward and northward from Carshalton, the other flowing westward from Croydon, the two joining in the northern part of the former place.

The most westerly springs of the western branch are in ponds at Carshalton House. Near by, in the pond at the corner of West Street and Pond Street, "is another pretty spring, known as Lady Margaret's Pool . . . Here Ruskin . . . caused the pool to be properly cleansed, and the banks laid out, and invested the sum of £300 to provide for its proper maintenance."[2] Just eastward is a set of ponds, in which Mr. Kirkman says there are "springs many of which may be seen welling up from the shallow sandy bed . . . There was formerly one lake, across which ran a ford from High Street to North Street, but, during the last century a causeway was built on its site." Ann Boleyn's well (by the church) must be a feeder of the most easterly pond. The other springs are in the Park, at Hogpit Pond and at the Grotto, the latter with a long northerly channel, in the upper part of which there was no flow when I was there in October, 1903. The Grotto Spring is the highest of all the Carshalton springs, and the Hogpit Pond the next highest.

We must ever thank Ruskin for the work done at St. Margaret's Pool, and it is interesting to reproduce his fulmination against the inhabitants of more than forty years ago. His words are as follows:—

"Twenty years ago (?1850) there was no lovelier piece of lowland scenery in South England . . . than that immediately bordering on the sources of the Wandle, and including . . . the villages of Beddington and Carshalton, with all their pools and streams . . . The place remains (1870) nearly unchanged in its larger features; but . . . I have never seen anything so ghastly . . . as the slow stealing of aspects of reckless, indolent, animal neglect, over the delicate sweetness of that English scene: nor is any blasphemy or impiety any frantic

[1] Horizontal Wells, 1874, table xii and p. 34.
[2] S. M. Kirkman, *Home Counties Mag.* 1907, vol. ix, p. 161.

saying, or godless thought, more appalling to me . . . than the insolent defiling of those springs by the human herds that drink of them. Just where the welling of stainless water . . enters the pool of Carshalton, cutting itself a radiant channel down to the gravel, through warp of feathery weeds, all waving, which it traverses with its deep threads of clearness . . . just in the very rush and murmur of the first spreading currents, the human wretches of the place cast their street and house foulness; heaps of dust and slime, and broken shreds of old metal, and rags of putrid clothes . . . to diffuse what venom of it will float and melt, far away, in all places where God meant those waters to bring joy and health. And, in a little pool behind some houses farther in the village [?westward], where another spring rises, the shattered stones of the well, and of the little fretted channel which was long ago built and traced for it by gentler hands, lie scattered each from each, under a ragged bank of mortar, and scoria, and bricklayer's refuse, on one side, which the clean water nevertheless chastises to purity; but it cannot conquer the dead earth beyond: and there, circled and coiled under festering scum, the stagnant edge of the pool effaces itself into a slope of black slime, the accumulation of indolent years . . . nor will any joy be possible to heart of man, for evermore, about those wells of English waters."[1]

Luckily however the above-noted evils are now of the past and the final prophecy may be cancelled. The ponds are now in good order, and as has been lately said "the chief attraction of Carshalton lies in its clear springs and picturesque lakes. Facing the parish church . . . the Wandle swells into a lake . . This ornamental water is fed by innumerable springs which bubble up from the chalk in the lake itself or flow from . . . adjoining property. The water emerges at a temperature of 48 degrees, and the lake never freezes over. Beautifully clear and transparent, inhabited by numerous waterfowl and fine trout, and backed by foliage and flowers, among which the kingfisher may often be seen, these pools form one of the prettiest scenes imaginable, and give to the centre of the town a charm . . . difficult to describe."[2] One may demur however to the use of the word lake.

The following gaugings of the Carshalton springs are given by F. Braithwaite, and are of interest as showing a former condition of things. The figures stand for gallons a day.[3]

Grotto Spring Pond. 1st Average, 3,550,410. 2nd Average, 3,377,250.

Hogpit Pond, etc. (including Anne Boleyn's Well). 1st Average 1,955,160. 2nd Average, 2,233,260.

Ordnance or Upper Town Pond (must include the Carshalton Park Springs and Lady Margaret's Pool) 1st Average, 7 740,450. 2nd Average, 7,100,100.

Mr. Sawyer's Mill-head (? toward Wallington). 1st Average 4,6[illegible]3,890. 2nd Average, 4,413.870.

Total, 1st Average, 17,909,910. 2nd Average, 17,124,480.

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[1] Introduction. or Preface, to "The Crown of Wild Olives." From Ed. 3, of 1873, pp. 1–3.

[2] F. Richards. Sutton . . and Carshalton. Homeland Handbooks, No. 49, 1906.

[3] *Proc. Inst. C. E.* 1861, vol. xx, p. 196.

Turning to the easterly and longer branch of the Wandle, the old springs in the low part of Croydon are things of the past, and the first visible sign of water is at the culvert by the Waddon New Road, north-westward of St. John's Church. The occasional springs of the Bourne, higher up the valley southward, are described further on (p. 68, &c.). The old springs of Croydon have been described by MR. F. BRAITHWAITE, in his paper on the Wandle, to which the reader is referred for particulars.[1]

The highest spring to be seen is at the eastern end of the pond just east of Waddoncourt Farm. In July 1898, I saw this nearly dry. There is also a big funnel-shaped spring in the eastern part of the pond, close to the footpath, about 280 yards northward.

At Beddington there is a line of springs along the southern side of the stream. The highest of these was northward of Beddington House and had a surrounding of brickwork; but when there in 1910 I found that this had been lately destroyed and the site covered by a new road over the stream. The others are just below, and the water can be seen oozing out in several places along the footpath, apparently from the very top of the Chalk. Near the parish-boundary, about 600 yards westward of the church, some small springs occur at the eastern end of the Mill Pond, where the stream flows into it.

One set of Carshalton springs feeds this branch of the Wandle. These are a little northward of Wallington House, and the water-course from them joins the main stream almost directly, at Wallington Bridge.

TERTIARY BEDS.

As above noted there are springs which, though issuing from the Lower London Tertiaries, yet seem to get their water from the Chalk; but there are others the water of which is of purely Tertiary origin, being thrown out by the occurrence of impermeable beds beneath permeable beds, and these will now be noticed.

Lower London Tertiaries.

It is only where there is a fairly broad outcrop of this series and where great part of that outcrop consists of permeable beds, with clayey beds beneath, that anything notable in the way of springs is to be seen: that is to say in the tract eastward from Croydon, beginning with a number in the eastern part of the borough, which are of interest as having formed an important source of supply, some being still partially used.

Two sets occur on the northerly dip-slope of the Blackheath Beds, and these I visited three times during the winter of 1910, 11. The most westerly set is in a triangular enclosure marked on the six-inch Ordnance Map (14) and the springs therein are about 300 yards southward of that part of the Addiscombe Road that is between Outram and Ashburton Roads. The ground is still open

[1] *Proc. Inst. C. E.* 1861, vol. xx, pp. 193, 194.

fields, and Dr. H. F. Parsons has said:—"Here there are some springs, issuing from the junction of the Oldhaven Pebble Beds and Sands and the Woolwich Clays, which formerly constituted the source of water supply to Addiscombe College. Around these springs is a patch of swampy ground in which a number of marsh plants grow."[1] A good deal of the old brickwork for the purpose of collecting the water remains, and Mr. B. Latham has noted that the supply was used in 1907 for the house named "Woodbury," in the Addiscombe Road, and I believe that a photographic record of this supply to a former great institution will be kept. The springs at the western and eastern ends of the triangular swamp, which were well-marked at the time of my visit, seem to have been collected together into a receptacle in the middle part.

Rather more than a quarter of a mile eastward is a smaller set of springs, in a little pond marked on the Ordnance Map, and these once gave a supply to Ashburton House.

Turning now to the face of the small escarpment, in and near the park belonging to Coombe House is a particularly interesting set of springs, inasmuch as we can see the birth, the course, and the end of a wee stream-system. About 700 yards north-westward of the house and about 950 eastward of the water-tower (on Park Hill) a spring starts and its water is taken into a covered brick tank, which with the spring next to be noticed once gave a supply to Combe House and Farm (still used for cattle). The water flows south-westward down the slope, gathering other water by the way, and, after passing through the little wood, gradually loses itself in the Thanet Sand just beyond, when the flow is comparatively small, or running on a little further, to the Chalk, when the flow is greater, and then sinking at once, not in anything that can be called a swallow-hole, but in a small temporary pool, below which all is dry, as I saw on December 24, 1910, after which date the flow decreased.

The ground south-eastward of the spring-head above noted is very springy, with much water coming to the surface; but the ditch up the slope northward was dry for a long way when I was there, the water from above soaking away in a little pond, whilst further up, at the southern part of a little wood, is another spring with a covered brick tank, also for the use of Coombe House and Farm. It seems then, as this tank is a good deal higher than the first noted, that here there is more than one level at which water flows out, and also at which it again sinks into the ground.

In the wood close to the southern side of Conduit Lane, south of Coombe Lodge, and only just within the borough-boundary, springs are marked on the six-inch Ordnance Map. These used to supply Coombe Lodge, the overflow going to the small pond by the road east of that house. Now, I believe, all goes to the pond, which used to be a mere roadside affair, but some ten or twelve years ago was made into a very ornamental piece of water, with rocks and plants.

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[1] *Proc. Croydon Nat. Hist. Soc.* 1909, vol. vi, p. cxxiv.

On the southern side of Oaks Road, between this pond and Shirley, is a well-marked spring, forming a little enclosed pond, presumably thrown out from the Blackheath Beds by clay of the Woolwich Beds. This too, I understand, was used for supply.

We have then, in the eastern part of Croydon, a set of springs that, under former conditions, were of considerable economic value, supplying large houses that had not then the benefit of a public supply. These springs depend on the presence of a clayey bed in the middle of the Lower London Tertiaries. Where, on the other hand, there is no such bed, but the Blackheath Beds have cut across the Woolwich Beds until they rest direct on Thanet Sand, as at Croham Hurst, there are no such springs and the ground is dry, from top to bottom.

Mr. C. C. Fagg, who alluded to the subject in *Proc. Croydon Nat. Hist. Soc.*, 1911, p. lii, has given me the following notes of the ground eastward of the above, made in working the woods botanically for some time, during which he has seen springs along the escarpment in Addington Park, and two of these are marked on the six-inch Ordnance Map (Sheet 14), one as Hollybush Spring, nearly 300 yards north-eastward of the house, the other about 300 yards northward of the church. He says of Threehalfpenny Wood, which reaches up to the county-boundary, "I have come upon numerous springs, which rise roughly at the junction of the Oldhaven Beds and the Woolwich Beds. They flow down over the latter and, after a short course, sink into the Chalk in the meadows at the foot of the hill, sometimes directly and sometimes after running through small ponds. One or two of the streamlets are of quite recent origin, while some old deep courses are now practically dry, indicating a shifting of the underground drainage-system." This line of springs continues over the county-border into what is well-named Springpark Wood. There are also springs on the dip-slope to the north, in the same way as at Addiscombe.

London Clay and Bagshot Beds.

Such springs as occur in the London Clay are often of a mineral or medicinal character, and some notable ones are described further on (p. 53, &c.). The thick mass of the Bagshot Sand naturally gives rise to many springs, as already alluded to (p. 6). We may add here the gauging given long ago by the Hon. W. Napier[1] of springs and rivulets, some of which however refer to places in Berkshire and Hampshire, as those marked *. The figures stand for gallons a day, and the hardness of the waters is 1° only.

Easthampstead Plain.		Chobham Ridges.	
Wishmoor ...	388,308	Pirbright ...	810,000
*Broad Moor ...	176,840	Railway ...	460,000
*Sandhurst ...	54,000	Cow Moor ...	90,435
*Ambarrow Hill	75,888	Coldingley ...	758,160
*Barkham ...	101,088	Folly	256,492
*Wokingham ...	599,904	Bagshot ...	630,000
Bull Brook ...	113,320	Bristow Farm	14,999

[1] Report of the General Board of Health on the Supply of Water to the Metropolis. Appendix iii, 1851 p. 7.

Farnham.

Aqueduct ...	45,848	Castle Bottom	270,000
*Minley ...	134,928	Farnham Hill (put under the heading "North") ...	685,454
*Northfleet ...	6,426,000		
*Long Bottom...	31,809		
*Bramshill ...	43,372		
*Eversley ...	74,779		

I am not sure as to some of the sites. Northfleet probably refers to Fleet Pond, and, if so, the high figure is explained as representing the combined drainage from various springs, reinforced with surface-drainage. Here, as with the Lower Greensand (p. 40), we want differentiation between springs and rivulets.

A large amount seems to be taken from Bagshot springs at Frimley, *see* p. 100.

Of St. Ann's Hill, Chertsey, MANNING and BRAY say:—" Near the top, on the North side of the hill, is a spring, lined on the sides with hewn stone, not now used for any medicinal purpose. It rarely freezes when *other* springs do."[1] It is also referred to by AUBREY, who adds " On the *East* Part of this Hill is a Coppice, call'd *Monke's* Grove, wherein was a Spring, much celebrated for its Virtues."[2]

In 1887 MR. W. H. HUDLESTON drew attention to a spring at the British camp on St. George's Hill, southward of Weybridge, and this was again alluded to by MR. H. B. WOODWARD in 1911.[3]

The first author says " The system of northern outworks, besides affording defence on the weakest side, is so arranged as to include a spring of water in the northern gorge. This must have been of great consequence to the occupants, since the question of ' what they did for water,' when hard pressed on these dry and limited upland tables, has often exercised the military mind," and he suggests that the water is either thrown out by hard pan at the base of the gravel or by a clayey bed of the Middle Bagshot (Bracklesham Beds). The later author takes the latter view.

It is interesting to be able to record prehistoric waterworks from a spring in the county.

Drift. Gravel and Sand.

Wherever a mass of gravel or sand is underlain by an impermeable bed, there will be small issues of water at the margin of the Drift and sometimes definite springs; but these are not likely to be of importance, except very locally.

There must be much of this sort of thing in Surrey, and there is one notable case, where gravel-springs have been used for the supply of a large house some miles off in another county and on the other side of the Thames.

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[1] The History and Antiquities of the County of Surrey, vol. iii, p. 226. Fol. *Lond.* 1814.

[2] Natural History of Surrey, vol. iii, p. 185. 1718.

[3] *Proc. Geol. Assoc.*, vol. ix, no. 8, p. 543, and vol. xxii, pt. 4, p. 239.

Describing this old supply MR. E. W. BRAYLEY says[1]:—"These springs, locally termed the Coombe Water, were first collected into a conduit, or reservoir, on the Coombe estate, for the supply of Hampton-court palace, by . . . Cardinal Wolsey . . . The water is conveyed through a double set of strong leaden pipes, each . . . two inches in diameter, into a second conduit at Surbiton . . . and thence . . . into a corresponding reservoir on the Middlesex side." As the top of Hampton Court is much below the level of the springs "the entire palace is amply supplied . . . with but little aid from artificial hydraulic agency." There is a specimen of the leaden pipe in the Parkes Museum of the Royal Sanitary Institute.

There still exist, at the south-western margin of Coombe Warren, in the parish of Kingston-on-Thames, the works put up by Cardinal Wolsey. The sites of the conduits and reservoirs and the lines of feeders and of pipes are duly recorded on the six-inch Ordnance Map (Sheet 7). MR. C. H. COOPER, of Wimbledon, was kind enough to take me over the ground in 1910, and I then had the pleasure of seeing the two well-preserved conduits.

The Coombe Conduit, in the grounds of Coombe Springs, is close to the northern side of Coombe Road, just west of Coombe Farm, and consists of a spring-house above, on the east, and a larger building, on the west, a good specimen of Tudor brickwork, the two being connected by a gallery.

The Gallows Conduit, over half a mile to the north-west, is also in private grounds at Fieldhead, Gallows Hill. It is smaller, but like the other consists of two buildings, one higher up than the other, and also of Tudor brickwork. The overflow has been used to form a pretty little water-garden.

Presumably the line of feeders, between these two conduits, caught other springs in its course.

AUBREY, writing of Kingston, says: "About half a Mile from the Bowling-Green at the *West* End of the Town, is a Spring that is cold in Summer, and warm in Winter; it bubbles up, and is called *Seething-Well*. The Inhabitants thereabout do use to wash their Eyes with it, and drink of it."[2]

DR. H. F. PARSONS has described some springs at Wimbledon Common, as follows:—"At the junction of the gravel and [London] clay there is a line of springs which form streamlets and boggy patches, and have excavated the escarpment in to a series of undulating wooded hollows. One of the springs, called Cæsar's Well, is surrounded by a massive granite kerb. . . Another spring feeds a considerable sheet of water called Queen's Mere."[3]

MINERAL SPRINGS.

In times past Surrey was a noted county for mineral springs, and consequently it has a literature on this subject, a literature

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[1] History of Surrey, vol. iii, p. 55, 4° *Lond.*, 1850.
[2] Natural History and Antiquities of . . Surrey, vol. i, p. 46 (? 1718 or 1719).
[3] *Proc. Croydon Nat. Hist. Soc.*, 1910, p. xxii.

that naturally contains frequent repetitions, some of the early accounts of springs being of venerable age. It would be a long task to wade through all of it: enough now to give such notice of the various places as can be got from the accounts that have come before me.

The Surrey Spas are now nearly all things of the past; of those that remain but very little use is made. The use of mineral waters is now indeed confined to various favoured places, all away from our county. It is curious that in an old treatise on the subject[1] Harrogate comes at the end of the list, in order of importance (whereas it is now probably at the head), being preceded by many Spas now extinct, or practically so.

Nevertheless, dead or decayed as the Surrey mineral springs may be, they seem to have enough interest for a separate heading here. In noticing them the alphabetic order of places will be followed, but the London springs will be massed together, at the head, London being an exception in most things.

London.

The mineral springs of that part of Surrey that is included in London have lately been described in a book more or less devoted to that subject,[2] and it will therefore be convenient to quote therefrom rather than to hunt up old works on the subject (which are moreover noted therein) except where that process had already been started, or where the old authority is not noted in Foord's book.

It will be convenient to take the London springs in alphabetical order of the boroughs or places to which they belong.

Bermondsey.—The earliest note of this spring that I have seen is by A. Booth;[3] but it tells us little. Mr. Foord (pp. 190, 191) says:—" About 600 yards east of the station, where the Grange Road intersects the Spa Road, a chalybeate spring was discovered about the year 1770, either in the grounds of the Waterman's Arms Tavern, or on some waste land adjoining," but " Bermondsey was never a Spa, except in name."

Camberwell.—Mr. Foord says (p. 210 of his book):—" As a proof of the prevalence of mineral springs in the London area, the recent discovery of one of these within the borough of Camberwell should be mentioned. An account of this . . . was given in the *Daily Telegraph* of June 5, 1906. It appears that the spring in question was tapped by the artesian well . . . to supply the water for the new public baths in the Old Kent Road. ' The discovery came about,' says the narrator ' in consequence of complaints made by bathers, and others using the baths that the water was dirty. It was a most unfounded charge, as investigation soon proved. The water, it is true, quickly discoloured, and after being warmed or exposed to the air it was found to assume a rusty tinge.' The fact was . . . that the

[1] Dr. R. Russel. Dissertation on the Use of Sea Water, etc., ed. 5, 1769. I have not seen the earlier editions.

[2] Foord, A. S. Springs, Streams and Spas of London, 1910. Beginning at p. 190, ending at p. 237.

[3] *The Mirror*, vol. xxi, no. 599, pp. 228, 229 (1833).

water contained not dirt, but iron." DR. BOUSFIELD, who analysed it said that it "is unusually rich in iron, being comparable in this respect with the Tunbridge Wells water." Several people suffering from rheumatism said that they had relief from the use of the baths.

Dulwich.—DR. J. MARTYN, writing in 1740, says[1]:—"The Purging Springs, which have been esteemed for about a hundred Years, and which are commonly known by the Name of *Dulwich Waters*, have been improperly so called:" they are in Lewisham "There has not been any medicinal spring observed in Dulwich, before that which is the Occasion of this Discourse."

In 1739 MR. COX had a well dug at the Green Man, about a mile from the village. "The first 20 Feet in Depth seemed to be only the Clay, which, in a long Tract of Time, had been washed off from the steep Hill, at the Foot of which his House is situated. It was intermixed with Pieces of Roots and Leaves, and with other Fragments of vegetable Substances. In digging 40 Feet deeper, the Clay was found of various Colours, brown, blueish, and black; with a considerable Number of *Pyritæ* or Copperas Stones" etc.

"The Well being digged to the Depth of 60 Feet, and no Water appearing, Mr. Cox caused it to be covered up . . . The following Spring, on my coming down, it was opened. I found 25 Feet of Water of a sulphureous Smell and Taste, which went off, after the Well had been opened some Days."

After trying a variety of experiments, he "was satisfied, that this new Spring was really a Purging Water, as it has since been found by Experience. Some of MR. COX's Family drank of it with Success, which encouraged several other Persons to try it, to their great Advantage."

He continues:—"it purges quickly, not sinking, but raising the Spirits. It is found to be very diuretic."

Since MARTYN's time of course the district has been almost wholly altered; indeed, since the time when I carried out the first Geological Survey enough has been done to make the position of sites described by me hard to fix. As has been said the landmarks noted in "The Geology of London" (1889) and which were therein repeated from an older Memoir (1864) have disappeared, so that the writers of a paper on some sections at Dulwich began by translating my localities into more modern language.[2] But the site of the Spa is described by MR. FOORD (p. 212) as "where now Dulwich Common Lane meets Lordship Lane, and about a mile south-east of Dulwich College," apparently where the Grove Hotel now stands. The use of the water soon declined, after 1780.

Lambeth.—The following particulars of springs in this parish are from MR. A. S. FOORD's book (pp. 193-196). The purging waters here seem to have been opened for public use in 1696.

"On the side of the road from Vauxhall turnpike to Wandsworth, on the right hand, was a spring called Vauxhall Well.

[1] *Phil. Trans.* 1744, vol. xli, pt. ii, no 461, pp. 835–837.
[2] T. LEIGHTON and J. B. OGLE. *Proc. Geol. Assoc.*, 1891, vol. xii, pp. 8–10.

The water was esteemed highly serviceable in many disorders of the eyes. In the hardest winters it never froze."

"The (Lambeth) wells consisted of two springs . . . in Three Coney Walk, now called Lambeth Walk." They "remained in some degree of credit till about 1736, when they met with a rival in those of St. George's Spa on the borders of the parish," and some twenty years later they ceased to be used. "The wells themselves, though long closed to the public, were existing in 1829."

Less than half a mile north-eastward from the springs in Lambeth Walk, near the Dog and Duck, "were mineral springs of an aperient quality, known as early as 1695," and about 1731 these were dignified as "St. George's Spa."

According to an old work, by DR. R. RUSSEL, the Dog and Duck was in St. George's Fields. "The Fields about it are flat and level, and the Soil is pretty deep; below which there is Gravel, and a Bed of Clay, intermixed with Pyrites. The Water is clear, and has very little Taste. According to the Experiment of *Dr. Fothergill*, a Gallon of this Water yielded two hundred Grains of Sediment, and *Dr. Rutty* tells us he gained ninety-six therefrom."[1] It is interesting to find that analyses differed considerably then as now.

Streatham.—MR. FOORD says (pp. 229, 230) "It is a somewhat remarkable fact that the mineral springs in Streatham have continued to supply their waters uninterruptedly for nearly two and a half centuries, while most others in and near London have either been drained away into the sewers or the wells formed from them filled up. The first account of the *Streatham Wells* is given by Aubrey." The site is in a field "on the south side of Streatham Common . . . in the grounds just below Wellfield House," now The Rookery.

"In the early Spring of 1660 the land was being ploughed, and the horses, floundering in a quagmire, suggested the existence of an underground spring. 'Afterwards at weeding time,' to use Aubrey's words, 'the weeders . . . drinking of it, it purged them, by which accident its medicinal virtue was first discovered.'" Before the end of Charles II.'s reign the waters "had come to be generally used. Three wells were formed and they possessed contrary properties: one acted as an emetic, and another was valued as a specific in the removal of intestinal worms." Truly the inhabitants of Streatham are (or were) blessed.

A history of the spring is given, with references to other writers, to which may be added the book by DR. RUSSEL and the paper by MR. BOOTH, above quoted.

An interesting account of the springs and the effects of their waters is given by AUBREY,[2] who tells us that one patient is said, by their use, to have got rid of four worms, the least 5 feet long and one 8¼. There were giants in those days!

An analysis of the water is given on p. 290.

[1] Dissertation on the Use of Sea Water, etc., ed 5, 1769, pp. 265, 266.

[2] The Natural History of Surrey, vol. i, pp. 215–217 (1718?).

Cobham.

Dr. R. Russel says "The Water has a sensible Taste of Iron. . . . A Gallon of it will yield seven Grains of a Substance like Oker. It is a strong Chalybeate."[1] But he does not give the site.

Croydon.

The Beulah Spa Spring, Upper Norwood, which is in this borough, has often been described, last of all by Mr. A. S. Foord.[2] It is in the grounds of The Lawns, between Leatherbottle Lane and Sylvan Road, nearly 400 yards W.N.W. of All Saints Church, Upper Norwood, and a visit to it has been described by Mr. L. S. Jast.[3] The work of Dr. Weatherhead (*see* p. 326) seems to be the chief authority, and the analysis given therein is reprinted on pp. 285, 286.

Mr. Foord speaks of it as "one of the purest and strongest of the saline spas in the country." He adds "There used to be another mineral well about half a mile to the north-west of Beulah Spa, at Biggin Hill, the water from which gushed up at the rate of seven gallons a minute. In 1898 it was closed. . . . The site of the spring was . . . at the bottom of the hill, and there is still (1907) some masonry in existence. . . . The reason of its being blocked was that it is alleged to have poisoned some domestic animal."

An analysis of the water from a well, perhaps from the same source, is given on p. 296.

Dorking.

The following particulars of Mag's Well are taken from an old anonymous book, which got most of the information from the "Gazette of Health," of January, 1818.[4]

The well is at a farm called Meriden (Lower Merriden of the Ordnance Map), about three miles S.S.W. of the town, but in the parish. The spring has been described by Aubrey and others as having powerful medicinal qualities, and it was used for a bath as well as internally. The water had no perceptible taste, except a slightly ferruginous one. Analysis showed it to be slightly impregnated with sulphate of magnesia and iron. In 1818 the building at the spring had been neglected for some time; but Mr. D. Leighton, who has lately (1911) visited the site, tells me that there is still a brick structure round the spring.

The water probably comes from the base of the Hythe Beds.

East Molesey.

Mr. H. G. Daniels has given the following record of a spring at East Molesey:—"Spa Meadow is the name of the field lying between the Mole and the Ember where the Esher Road crosses

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[1] Dissertation on the Use of Sea Water, etc., ed. 5, 1769, p. 286.
[2] Springs . . and Spas of London, 1910, pp. 221–228.
[3] *Croydon Guardian*, 21 May, 1910.
[4] A Picturesque Promenade round Dorking. 12mo. *London*, 1822, pp. 178–182

the two bridges. It takes its name from the fact that a chalybeate spring formerly existed here, and would no doubt exist still if it were properly bored and looked after. A slight depression in the middle of the field marks its site. It is said that the well in former days had some reputation for healing properties, and was much resorted to by the gallants and ladies from Hampton Court." But there is no "mention of it in Contemporary Memoirs."[1]

East Sheen.

Mr. Foord tells us that "in the north-west corner of Palewell Common . . . adjoining Palewell Park, is a well, the water of which, some forty years ago, was, in the recollection of an old inhabitant, much used by people of the neighbourhood for bathing the eyes, and for the legs. . . . The spring, which was reputed to contain some mineral constituents . . . helps to feed a pond close by." The water "is clean and pure."

Epsom.

The mineral spring at this town is probably the most noted in the county, and has given the common name of Epsom Salts to the sulphate of magnesia which is its characteristic mineral constituent. Singularly enough, in a table of analyses in a book[2] on Mineral Springs, the magnesia in the Epsom water is given as 0!

The water comes from the London Clay, being one of many such aperient waters, and in common with its brethren, has fallen into disuse. It has a considerable literature, to which there is no need to refer, and the following particulars are taken from trustworthy accounts.

The springs are "on the common, between Epsom and Ashstead, to the north-west of the turnpike road."

"The spring was found in 1618, by one Henry Wicker, who observing a small hole in the ground full of water, in a dry summer, enlarged it for the purpose of watering his cattle, but they would not drink the water," which led to inquiry as to the reason.

"It was at first used externally . . . but about 1630 was found, by some labourers who accidentally drank it, to be purgative."

"These waters, however, from 1704 to 1715, gradually lost their reputation," it is said, through the establishment (about 1708) of what was called the New Wells, which "allured the company from the old wells."

"The water of the new wells did not, however, possess any virtue," and this caused the old wells also to get into disrepute. There was a temporary renewal of prosperity in 1720.[3]

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[1] Homeland Handbooks, No. 65. East and West Molesey, ed. 3, p. 16. No date. (Ed. 1, 1907.)

[2] Dr. M. Gairdner. Essay on the Natural History . . of Mineral and Thermal Springs. 8o. *Edin.* and *Lond.*, 1832, p. 415.

[3] Some Particulars relating to the History of Epsom . . By an Inhabitant 8°. *Epsom*, 1825, pp. 56, 64, 65.

Mr. G. Home tells us:—"To-day the well is shaded by fruit trees near the tennis lawn of the garden surrounding the modern house now called 'The Wells.' One piece of the original brick-work . . . has been incorporated into the back wall of a green-house."[1]

Frensham.

"At Holt Common . . . is a Medicinal Spring of the Nature of that at Ebbisham (Epsom), but lately discover'd."[2]

Godstone.

"In this Parish, three miles below the village, is a well of water which has been found very efficacious in curing the Gout." It is by the roadside near the foot of Tilbarstow Hill, and "a neat house" was made over the spring.[3]

Lingfield.

Aubrey says "In the Common is a fine Spring . . . . issuing out of a Freestone Basin"; it "has the same Virtue with that at Tunbridge (T. Wells?); the mud of it is like yellow Oker."[4] This chalybeate water is also referred to in Manning and Bray's work (vol. ii, p. 340).

Newdigate.

"In the *Eastern* Part of this Parish is a Medicinal Spring, of the same Nature with Epsom."[5]

Peperharrow.

Mr. P. Row says that in Peperharrow Park "is the Bonfield Spring, over which a picturesque cell, designed by Pugin, was erected in 1843 by Viscount Midleton. The water is considered to be medicinal."[6] Presumably it comes from Lower Greensand.

Richmond.

Mr. Foord[7] says, "About the year 1689, or . . . earlier, a saline spring was discovered at Richmond in grounds subsequently occupied by Cardigan House . . . on the slope of the hill." No trace of it can now be seen. According to one account it "is an aperient water, possessed neither of much reputation nor efficacy."[8]

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[1] Epsom: Its History . . (The Homeland Library, vol. ii.) Small 4to. *Lond.*, 1901, p. 62; and Homeland Handbooks, vol. 17. A Guide to Epsom . . 1902, p. 51 (with a figure of the well as now).

[2] Aubrey, Natural History of Surrey, vol. iii, p. 367 (1718).

[3] Manning and Bray. History and Antiquities of Surrey, vol. ii, p. 322, Fol. *Lond.*, 1809.

[4] Natural History of Surrey, vol. iii, p. 48 (1718).

[5] Aubrey, Natural History of Surrey, vol. iv, p. 268.

[6] Homeland Handbooks, vol. 14, Godalming and its Surroundings, ed. 2, 1906 p. 62.

[7] Springs . . and Spas of London, 1910, pp. 238, 243.

[8] A. Booth. *The Mirror*, 1833, no. 599.

Stoke D'Abernon.

Jessop's Well, on Stoke Common, is noticed by the REV. S. HALES,[1] who found that the bottom-water of the well (about 10 feet down) near the spring was stronger than the surface-water. He says that "the Quantity of purging Salt in this Water is considerably greater than in any other," and that it is "observed to exhilirate those who take it."

"When *Jessop's Well* was cleaned . . . after about half a Foot Depth of black muddy Filth was taken out, then the natural fat sandy-colour'd Clay-Bottom appear'd; thro' several Parts of which the Water ouzed up at the Rate of 160 Gallons in 24 Hours." . . .

"It was very observable, that the Man who stood about three Hours bare-legg'd in this Well-Water to clean it, was purged so severely for a Week, that he said he would not venture, on any account, thus to clean the Well again. And it was the same with another Man, who cleaned the same Well about twelve Years since." One hardly sees how the exhilaration spoken of above comes in!

DR. RUSSELL, who quotes the above account of the "extreme Penetrability of this Water,"[2] says "it appears that this Water contains a large Proportion of calcarious Nitre, a little Sea Salt and calcarious Earth, and probably a little Natron."

A like account is quoted by BRAYLEY in his History of Surrey, vol. i, p. 191.

Witley.

"Here, in a Field called BONFIELD, is a Well, which cures sore Eyes and Ulcers, and is called the *Bon-Spring*."[3] Can this be the same spring as the one entered under Peperharrow?

Worplesdon.

AUBREY says that at a private house "in this Parish, is a medicated Spring or Well, of the same Nature with that at Ebesham" (Epsom).[4]

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[1] *Phil. Trans.*, 1750, vol. xlvi. no. 495, pp. 448–450.
[2] Dissertation on the Use of Sea Water, etc., ed. 5 1769, pp. 225 etc.
[3] AUBREY, Natural History of Surrey, vol. iv, p. 39 (1718?).
[4] *Ibid*, vol. iii, p. 326.

SWALLOW-HOLES.

At an early date Surrey gave the material for a paper specially devoted to this subject, when MR. H. L. LONG described the swallow-holes of Farnham Park. (*See* following description.) As it happens it is in this part of the county only that the relation of the beds to the form of the ground, along the outcrop of the Chalk, is such as to facilitate the formation of swallow-holes at the junction of the Tertiary beds and the Chalk. I have drawn attention to the fact that elsewhere the conditions are not favourable for the existence of swallow-holes in that position, the one in which they commonly occur in neighbouring counties[1]; and as a result I have been able to add only one other locality in the county, Headley on the Hill, where, on the two conspicuous Tertiary outliers (which produce favourable conditions), there are swallow-holes close to the junction of the Tertiary beds and the Chalk. The distance between these two groups of swallow-holes is about 22 miles.

Of another kind of swallow-hole our county contains a well-known example, that is the loss, partial or otherwise, of a stream in passing over a permeable bed. The River Mole is perhaps the most oft-quoted example of this, the name of the river being even credited to its behaviour, and its literature goes back far. Indeed, AUBREY speaks of the Mole as " The River SWALLOW," and says that " in dry Summers one may ride in the Channel as in a Lane."[2] But it will be more convenient to treat of the behaviour of the Mole in passing over the Chalk as a whole, under the heading Intermittent Streams, for which *see* p. 62.

In 1839 MR. H. L. (wrongly entered as G.) LONG described " Numerous Swallow Holes near Farnham,"[3] and said of the hill-range, " On the north side . . . several springs are thrown out; but on the south there are landsprings only, which occupy the gullies for the greater portion of the year, and occasionally become formidable torrents. These rivulets pour down the tertiary clays until they arrive at the chalk, where they plunge into the ground and disappear, except during very heavy rains, when the surplus waters are carried off by gravely channels in the chalk."

He notes seven swallow-holes. " They occur in Clear (Clare) Park—Lower Old Park Gully—Clay-pit Gully—near the Potter's Clay-pit—in the Hop-grounds, above the turnpike a little west of the Odiham-road—near the entrance of the pleasure ground in Farnham Park—and near the end of the avenue at the east of Farnham Park." Of these the first is a little way over the border, in Hampshire, and the second must be near the county-boundary. They art not clearly marked on the six-inch map (Sheet 30, old ed.), but the last two can be distinguished thereon, one being

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[1] *Roy. Com. Metrop. Water Supply*, 1893, Appendices, pp. 432, 433.
[2] Natural History of Surrey, vol. iv, p. 172 (1718 ?).
[3] *Proc. Geol. Soc.*, vol. iii, no. 62, p. 101.

about a third of a mile north-eastward of the castle, and the other about that distance south-westward of Hale. The fifth may be a little northward of the castle, just before getting to the sharp bend in the road.

Mr. Long continues, " The water absorbed by the holes in Farnham Park is supposed to reappear at Bourne-Mill-stream; and though soft where it sinks into the chalk, it is hard and unfit for use, where it again breaks forth. The existence of underground currents was further proved by a well sunk at Hale Farm " (*see* p. 161), where, at a depth of 100 feet or more, " a spring was reached, which was supposed to be the Bourne-Mill-stream."

In 1850 Mr. J. M. Paine made the following remarks[1]:—" One series of these swallow-holes in the old park (covering about an acre of land which is full of them), must lead to a very extensive subterranean cavern . . . under the chalk-hill adjoining Crondall lane; for after heavy thunder-storms, when immense bodies of water are brought down from the hills . . . during the space of an hour or two, the whole of the water is absorbed in these holes; and when the underground basin is nearly filled, part of the stream passes over the holes, and then flows on in an ordinary channel. These swallow-holes, however, take in all the water that usually runs from the hills above."

I have seen the most easterly swallow-hole, close to the eastern edge of Farnham Park, where, as far as I remember, the water runs into a more or less conical depression, and in 1908 Mr. G. W. Young marked the sites of this and the other in the park, as well as of the one in Clay-pit Gully, on a map, and gave an account of the whole, from which the following remarks are taken.[2] They show that things are much as they used to be.

" Usually the whole flow is absorbed, but after a heavy rain the 'swalet' cannot always cope with the increased quantity, and then the surplus water flows away down a definite overflow channel, the gravelly bed of which is quite dry at other seasons. The local name for these swallow-holes is the very appropriate one of 'soakage.'"

" Claypit Gully lies in a bifurcated valley, which, although short, is deeply cut, with sides that are remarkably steep considering that they are of clay. Just where the water disappears there has been some recent slipping, which temporarily interfered with the proper working of the swallow and caused a slight overflow. The disappearance of the water is not well shown . . . but the soaking away can be distinctly heard. The overflow channel is well marked. . . . It crosses the whole width of the chalk as a dry gully, eventually joining a permanent stream which is fed by springs thrown out (from the Upper Greensand) at the outcrop of the Gault."

Of the swallow-hole by the Odiham road we are told that an ill-defined overflow channel is beginning to be formed.

Of the more westerly swallow in Farnham Park, " close to the path leading to Upper Hale," he says:—" The hollow is deep

[1] In E. W. Brayley's History of Surrey, vol. v, pp. 19, 20, 4to. *Lond.*, 1850.
[2] *Proc. Geol. Assoc.*, vol. xx, pt. 6, pp. 437–440.

and cup-shaped, and a large oak tree is growing in it. The stream is very small, and is all absorbed, there being no overflow channel."

Of the eastern and larger swallow-hole, MR. YOUNG says:—"The stream which enters it is formed by the union of several small ditches which carry off the surface water of the larger portion of Farnham Park. . . . The actual swallet is a marshy area, overgrown with nettles and enclosed with railings."

"The swallet consists of a cluster of holes or fissures down which the water soaks. . . . The 'storm-water' gully, at first underground, suddenly appears about 30 yards lower down the valley."

As regards the question of the flow of water from the swallow-holes in Farnham Park to the Bourne Mill stream, MR. YOUNG seems to be in doubt, and says, "Certainly on each of my visits the quantity of water emerging at the spring has been far greater than that which was being absorbed at the swallow-holes, and it is evident that the supply is not dependent on that source alone." But this does not in the least invalidate MR. LONG's suggestion as to underground communication between the two, it only leads to the conclusion that the stream is aided from other sources. MR. YOUNG continues, "On the other hand, if, as I suggest the Bourne Mill spring rises in a fault-plane, it is possible that part at least of this water does come from the swallow-holes." What other outflow can the water from the swallow-holes have? Probably it would not be difficult to settle the question by experiment. The fact of the water becoming hard in its passage through the Chalf is surely what is to be expected.

A later note of MR. YOUNG's is noticed further on (p. 62).

The outliers at Headley round which I have noted swallow-holes are those in Noar (or Nower) Wood, in the more easterly of which is a marked one about a third of a mile north-westward of the church.

The swallowing up of streamlets, flowing over Tertiary beds, on reaching the outcrop of the Chalk also occurs at and eastward of Croydon (*see* pp. 47, 48), though without any definite hole being formed.

INTERMITTENT STREAMS OR BOURNES.

General Remarks.

In this subject Surrey perhaps takes the first place amongst the counties, not however because of the number or size of its *Bournes* (to use the general name for the occurrence), but because more marked attention has been given to two of them than to any others in the kingdom. These two occur along the courses or in the valleys of the Mole and of the Wandle, for the Croydon Bourne, as it is usually called, is only an upward lengthening of the Wandle.

They are, moreover, of totally different type, the Croydon Bourne being of the sort so commonly found in Chalk-tracts, that is, the gradual extension of a stream higher and higher up what is usually a dry valley, an extension that follows a wet season. The intermittence of the Mole, on the other hand, is not at any of the heads of the stream, but in its middle part, and it occurs only in dry times, when the water gets less in quantity and at last is small enough to be absorbed by the Chalk, in its passage over that formation, at a time when the underground water-level is low; and this summer-dryness happens every year, whereas the ordinary bournes occur only at intervals, depending only on high rainfall during the winter-months. It must be for that reason that in some parts these are known as Winterbournes.

The neighbouring counties of Hampshire, on the west, and Kent, on the east, both with a much larger Chalk-tract than that of Surrey, have naturally a greater number of bournes, and these have been described in the Water Memoirs on those counties. All these are of the same character as the Croydon Bourne.

Mr. J. Lucas has noted that in 1873, after high rainfall, the intermittent springs, thrown out from the top of the Chalk at the base of the Tertiary beds, became active as " between the months of February and July at Cheam, Epsom, and Little Bookham, and water rose into chalk-pits at Sutton, Cheam, and Clandon Park."[1]

Farnham.

Mr. G. W. Young[2] believes that the Bourne Mill Spring rises " in the plane of a dip-fault." On June 20th, 1908, there was, at the foot of the steep bank, a considerable outflow of water.

Thence across the fields towards Farnham Park there is a dry watercourse, " the overflow gully from the eastern swallow-hole in the park. On all the maps it is shown as a permanent stream, but in the part between the swallow-hole and the point where it joins the stream from Bourne Mill Spring, some 300 yards, it is only after heavy rain that any water flows."

Of the two swallow-holes in the park, he says, " Owing to the dry weather (June, 1908) only a small quantity of water was coming down the streams, and in each case this was entirely absorbed by the swallow-hole, which was obviously capable of

[1] *Proc. Inst. Civ. Eng.*, 1877, vol. xlvii, pt. 1.

[2] *Proc. Geol. Assoc.*, vol. xxi, pt. 1, 1909, p. 32.

swallowing much more. Between the two streams the ground . . . . forms a flat on which water so frequently stands that baulks of timber are placed along the path at the worst spots for people to walk over." *See* also pp. 59, 60.

The Mole.

The singular behaviour of this river in the matter of the disappearance of its waters has caused it to be the theme of various writers for a long time. Poets have waxed eloquent on it, from Spenser onwards; county-historians and topographers have discoursed on it; it has figured in many guide-books; and it has not escaped the notice of geologists.

Mr. J. E. Morris, in comparing the Mole with the ordinary bournes, has well put it:—"These intermittent springs, however, are obviously quite different from the wholesale swallowing up of a full-grown river."[1]

Naturally enough, sundry mistaken statements have been made; but there has been no excuse for any such since the appearance, in 1809, of the second volume of Manning and Bray's History of Surrey, in which there appeared a large scale map (dated 1810) of the course of the stream, from Boxhill to Leatherhead. This map shows the following things:—"Two hollows in Burford Park in the bottom of which the water of the River appears running. The Swallows or apertures into which the water of the River runs. Parts of the River in which in dry Seasons no water appears. Stagnant Pools, occasioned by being below the level of the Swallow holes. Several Springs, by which the River is again formed into a current."

The scale of this map seems to be a little less than six inches to the mile; but in places where the features of the river-windings differ considerably it is difficult to compare it with the Ordnance six-inch map.

The Mole is certainly a peculiar river. Like the Wey, the Darent, &c., it rises in various parts of the great Wealden tract (including therein all the various beds below the Chalk), and then flows northward across the Chalk and (as the Wey) over the Tertiary beds to join the Thames; but it acts differently to the other streams over the Chalk.

Starting in various places from the Wealden drainage of part of Surrey, and of a very small part of Sussex, it then receives small tributaries from springs rising from the Lower Greensand, from the Upper Greensand, and from the Lower Chalk, at the foot of the great escarpment of the North Downs.

All the streams from these various sources, east and south of Dorking, combine close to that town, and then in one river flow northward over the Chalk in a well-marked valley, in places with sharply sloping sides, regular river-cliffs, indeed.

It is not until the waters have been collected into the one channel that anything remarkable occurs. Then, and not till then, is the river subject to what is practically total loss, and men can at certain times walk along its bed in certain places.

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[1] Homeland Handbooks, vol. 44. Dorking and Leatherhead, 1906, p. 31.

In the winter months, of course, there is a full stream, and indeed the alluvial meadows in the bottom of the Chalk valley are liable to flooding, though, except at such times, the water is confined to the more or less deeply-cut channel, along which a considerable quantity of water flows. Some of the overflowing water finds its way into swallow-holes by the side of the stream (*see* pp. 64-66).

In the dry summer-time, however, it is very different. There is still a stream entering the Chalk-tract from the south; but on reaching the Chalk the water soon becomes subject to absorption, and as the underground water-level in the Chalk sinks below the level of the river-channel in places, there the absorption approaches totality and the channel dries. What is usually a stream of considerable size becomes a small one, and in great part is represented only by occasional pools. This condition lasts until a point is reached where the saturation-level in the Chalk again comes to the surface and the stream starts again.

There is perhaps no better evidence of the water-absorbing power of the Chalk than this, and of course it is chiefly due to the presence of fissures. Whether all the water that is absorbed comes out again in the springs lower down, I cannot say; but I am inclined to think that some of it passes underground below the Tertiary beds.

The first systematic account of the Mole seems to be that by Manning and Bray,[1] and is as follows:—

"The soil, as well under the bed of the River, as beneath the surface on each side, being of a spongy and porous texture, and by degrees probably become formed into caverns . . admits through certain passages in the banks and bottom, the water of the River. In ordinary seasons, these receptacles being full . . . the water of the River does not subside, and the Stream suffers no diminution. But, in times of drought, the water within these Caverns being gradually absorbed, that of the River is drawn off into them; and, in proportion to the degree of drought, the Stream is diminished. In very dry seasons the current is in certain places (particularly at *Burford* Bridge . . . and . . . between that and *Norbury* Park gate, and at that gate and *Norbury* meadows) entirely exhausted and the Channel remains dry [except here and there a standing pool. By the bridge at *Thorncroft* it rises again in a strong spring, and after that the current is constant]. At a place called the *Way-Pool* . . . on the side of the River next to *Box Hill*, the method in which the Water is thus occasionally drawn off is visible. . . . It hath here formed a kind of circular basin about thirty feet in diameter, which is supplied, in the ordinary state of the Current, by an inlet from the River of about two feet in breadth and one in depth. This inlet being stopped, the water in the basin is soon observed to subside; and, in less than an hour, totally disappears; when the chasms, through which it passes off, at different depths

[1] The History and Antiquities of the County of Surrey. . . By the Rev. O. Manning and W. Bray, vol. i. Fol. *Lond.*, 1804, pp. iii, iv.

from the upper edge of the basin, may easily be discerned." This presumably is a description of the Fredley swallow.

In the second volume of this work (1809) we are told of the Mole:—

"It does not disappear at once, and then burst forth at once, as some rivers in *Derbyshire* do, but in a dry summer, in various places . . . it is absorbed and lost in the porous bed through which it runs, leaving in many places the naked gravel, and in others forming a stagnant pool. There is no good reason for supposing that it forms an underground current; there is however a spring by Thorncroft Bridge, a small distance from the river, from which a constant current issues and runs into it. It is said that in *Mickleham* attempts have been made to preserve the current by putting Clay in those places where it sinks in, but that the wells at *Westhumble* (a hamlet near *Burford Bridge*) became dry after making the experiment," pointing to a communication between those wells and the stream.

On his map (referred to above) MR. BRAY says that he has often seen the stream dry at Burford Bridge.

Another county-history has a long account of the Mole,[1] also with a map, which at one part differs less from the Ordnance Map than does that of BRAY and with a ground plan of the Fredley Swallow-hole and a view of the same. The description herein given was made from an "inspection of the bed and banks of the river, at different times in the months of August and September, 1840," and from enquiries. It is useful to note what was seen at that time.

The swallows "occur in numerous places along the banks and bed of the river between Castle mill (Betchworth Park) and Mickleham; but they are scarcely to be found elsewhere. It frequently happens, that when the current is high, the Swallows in the upper parts of the stream get surcharged, and are then lost to the sight, by the water flowing over them, although the quantity which they engulph is very great . . . In the winter season, when the waters flow in a full stream, the open channel becomes a *continuous* river, and the ingurgitating action of the Swallows ceases, the gullies beneath being then overcharged; but at other times, when the river is low, and the gullies are again in operation, the water is drained off by the receiving apertures, until it wholly disappears; and this happens at different points of its course, accordingly as the stream is more or less copious. In very dry seasons," the stream is "engulphed by the Swallows under Box-hill, before its arrival at Burford bridge."

"In one instance (in the summer of 1840) the current was altogether lost . . . about half a mile below Burford bridge: here its last rill trickled into a small crevice under the western bank of the river. On another occasion, the stream flowed on until it reached a spot, somewhat to the north-west of . . . *Cowslip Cottage*, where, in the banks and bed of the river, there

[1] E. W. BRAYLEY. The History of Surrey, 4to *Dorking*, 1841, or A Topographical History of Surrey. 4to *London*, 1850, vol. i, pp. 175–185.

are . . . apertures, both large and small; and into these the whole of its remaining waters were poured down. In the last instance, at a time when, after some heavy rains, the river was nearly a foot higher than in the former cases, the current extended to a more distant spot; yet even then, it was entirely engulphed by the Swallows before it could arrive at the angular turn of the channel near Cowslip Farm " (?a little north of Cowslip Cottage).

" There are said to be two or three Swallow holes between the Castle mill and . . . the Shingles (?by Pixham) . . . yet these can seldom be observed in action, as the Mole, in this part of its course, generally flows over them in a brisk current." From Castle Mill down to the railway is on Gault, and here there can be no swallows; but from the railway to Pixham is Upper Greensand, into part of which water might sink, though there is more likely to be an overflow. The succeeding Chalk Marl is not likely to form swallows. I therefore think these supposed swallows doubtful.

He continues, speaking of his Swallow No. 1, apparently the first marked on the six-inch Ordnance Map, 25, S.E., on the right side, about 390 yards south of Burford Lodge (but the maps don't agree) " There is a channel, or gutter, in the bank, . . . communicating with a large oval-shaped pool, . . . within which are several crevices; and into these the water pours with much rapidity."

" Beyond, at a short distance, . . . on the same side, are two other Swallows; the lowermost of which (his No. 2, which I cannot place on the Ordnance Map) includes an opening, the size of a large barrel. There is another, but smaller Swallow, on the opposite side, . . . just beyond the stepping stones (?Ford of Ordnance Map) by which the river may be here crossed when the water is low. Some other apertures are occasionally visible between this point and . . . Burford bridge."

" In the grounds at Burford Lodge there are several large and deep hollows . . . which are reputed to have sunk . . . through the cavernous nature of the subsoil. In two or three of these (called the *hold-waters*) when the Mole is swelled by the floods of winter, the water rises by a kind of upward percolation, and is retained within them until the stream subsides,—thus evidently showing a subterraneous communication with the river. The same fact is indicated by other hollows . . . near Burford Bridge (presumably in the grounds of Fredley); . . . these, in times of flood, receive a part of the overflowing waters, which again slowly ooze through them as the river-current resumes its confines."

The Swallow marked on the six-inch Ordnance Map, on the left side of the stream about a third of a mile south of the house at Fredley is not shown on the maps of Bray or of Brayley. It is small.

Mr. Brayley describes the Fredley Swallow, on the right bank a little above the railway, in some detail. He says that there " are two large and deep pits, or rather pools, . . . in which are many Swallows; and these may almost constantly be seen in operation." The size of the outer pool is about 46 feet by 20, and that of the inner about 36 feet by 18; the irregular channel between them is about 25 feet long, that connecting the outer pool with the river being about 20. "Within, and around the area of both pools, are numerous crevices of variable size, down which the water rushes . . . and in some places, it may be distinctly heard in its transit to the gullies beneath. When the supply is greater than the fissures in the outer pool can at once convey under ground, the water rises, and flowing along the intervening channel into the second pool, is there carried off by other apertures."

It was found from measurements and calculations, that when both pools were in action, the outer engulphed 259,200 gallons an hour and the inner 82,800. (This gives a total of over 8 millions a day.) When the outer pool only was in action it took in nearly the same as the quantity above given for the inner pool.

"In proceeding down the river, several large Swallows may be discovered below the banks on the Norbury-park (left) side . . . Indeed the apertures both in the bed and at the sides of the stream, in this part of its course, may be said to be thickly clustered." One only (No. 4) is shown on the map.

A swallow-hole (No. 5) northward of Swansworth (?the one just above the railway) is described as "a large aperture."

Between the foot-bridge (now destroyed, but marked on the old Ordnance six-inch map, Sheet 25), east of Bocketts Farm down to Thorncroft bridge, "within the space of three-quarters of a mile, innumerable springs burst forth, both from the bed and the banks of the channel."

Having lately visited the Mole, for the purpose of conducting an excursion of the Geologists Association (on March 25, 1911), I may as well notice the phenomena shown below Fredley, in terms of the six-inch Ordnance Map, which is of course a standard of exact topography.

In February 1911 I walked along the Mole, from Box Hill to Leatherhead, in the company of Mr. Hutchings, game-keeper to Mr. Salomons, of Norbury Park, and his knowledge of the river enabled me to put together the following notes of that part of the stream from below the swallow-holes on the left bank, just west of the railway, by Camilla Lacey. These swallow-holes are in an old course of the river, as is shown by the maps both of Bray and of Brayley, and this violent bend is marked, as a dry channel, on the modern Ordnance Map (25, S.E.).

For a little way the stream is sometimes dry (in summer), but below, by the wood called Nicols Field, it is not so, until reaching the northern part of that wood, when summer-dryness again sets in for a little way.

There is a swallow-hole on the left bank, on passing the sharp bend where the river turns northward, at the foot of the Chalk cliff of Ham Bank. This can be seen only when the stream is very low, as is also the case with the swallow-holes lower down.

A little further downstream, by the northern end of the cliff and a little before reaching the foot-bridge, south of Lodge Farm, Norbury Park, is another, which, however, cannot be seen though the water can be heard going down it.

From just above the foot-bridge down nearly to the spot where the railway crosses the river, the latter is subject to summer-dryness.

There is a swallow-hole on the southern bank at the sharp bend a little south of east from Lodge Farm, and, if I remember rightly, there is another on the left bank north-west of Swanworth Farm. Yet another occurs on that bank, just before reaching the railway.

From a little above the road-bridge, at the entrance of Norbury Park from Mickleham (about half-way between the bridge and Longbury Wood) the stream is subject to summer-dryness for a long way down, that is to a point about half a mile north-west of Givons Grove, below which there is always water.

There is a swallow-hole south-east of the Priory and about 650 yards east of north from Mickleham Church, and the lowest one is a little further down, on the right bank, at the bend north-eastward of the Priory.

Just below the long stretch of the stream, subject to summer-dryness, north-eastward of Givons Grove, the first spring starts, on the right bank, but there was nothing to be seen at the time of my visit. A little lower down, in the bend a little south of west from Valelodge Farm, powerful springs could be seen in the stream, by the left bank, the water being much agitated over a considerable space; but it was too turbid to allow one to see through to the bottom: the whole of the river, indeed, along the course described, was dull, from suspended matter.

We have, therefore, seven swallow-holes, below the ever visible ones near Burford Bridge, and probably there are also very many other spots at which water sinks into the Chalk without any clear sign. It is notable that of the seven that S.E. of the Priory is the only one that does not occur at a marked Chalk cliff. This is what one might expect, as it is at such places that an open face of Chalk is presented to the stream.

Despite their interest it has been remarked, by MISS ELLEN SMITH, that "the swallow-holes of the Mole, the most considerable of which are near Burford Bridge, do not make any distinct feature in the topography of the region," though "they so seriously affect the flow of water."[1]

EPSOM.

A small bourne, which breaks out at Church Street, Epsom, is noticed by MR. J. LUCAS,[2] and the following older note must refer to this among others.

"The most striking feature exhibited by these beds of sand and gravel (above the Chalk) . . . is an occasional flow of water, locally denominated 'The Earth Bourn,' which permeants

[1] The Reigate Sheet of the One-inch Ordnance Survey. 8vo. *London*, 1910, p. 31.

[2] Horizontal Wells. 4to. *Lond.*, 1874, pp. 44, 50–53.

(permeates) them in every direction—usually rising within a foot or two of the surface, and sometimes oozing out even above ground."

"Its duration and the time of its recurrence are alike irregular, although it seldom fails to succeed a wet summer. Sometimes, however, it does not appear for three or four years, and sometimes it flows for two or three years successively. Its duration varies from four to eight months. It generally commences running soon after Christmas, and disappears about May or June."

It is said to appear at about the same time as the bourne at Smitham Bottom (*see* p. 77), "and it is also observed in a deep pit near Nonsuch Park."[1]

THE CROYDON BOURNE (WANDLE). (*See* also p. 337.)

This Bourne has been observed and described with a thoroughness that leaves nothing to be wished for, thanks chiefly to the long and careful investigations of MR. BALDWIN LATHAM, which will be largely used in the following description. Having had the pleasure of conducting many excursions to the bourne, during its last three outflows (1897, 1903, 1910), and having now lived in Croydon for more than 15 years, I can also claim to speak from fairly long personal knowledge of the Wandle Bourne.

In his paper of 1904 on "Croydon Bourne Flows," MR. LATHAM has given an account of the literature of bournes generally and of that one in particular, noting the various superstitions regarding them; so that it is needless here to refer to all past records and enough to give the table on pp. 74, 75. It is of interest to note that the curious view put forward by AUBREY, in his Natural History of Surrey, that the outbreak of the bourne was followed by some great public event of a more or less unpleasant kind, met with a very proper rejection in the later work of MANNING and BRAY, in which it is said:—"The fact is, that in a wet summer, without any alteration in church or state, a bourn rises in *Birch Wood* in *Marden Park* . . . and runs into that valley which goes to Croydon; and when the superfluous water is discharged it disappears."[2] It is satisfactory to find that the true origin of the bourne was understood more than a hundred years ago. There are however some papers specially referring to this bourne, in later times, which should be noticed, and these will be taken according to date.

The first systematic account seems to be a paper by MR. C. W. JOHNSON in a pamphlet published in 1865,[3] a remarkable essay, which must be noticed at some length (some words being inserted in brackets). He says:—"The Bourne first makes its appearance in a little hollow at Birchwood, by the side of the private road to Marden Park (referring I presume to the highest, not to the

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[1] Some Particulars relating to the History of Epsom . . . . By an Inhabitant. 8vo. *Epsom*, 1825, pp. 114, 115.

[2] History of Surrey, 1809, vol. ii, p. 362.

[3] DR. E. WESTALL. On the Advantages to be derived from . . the "Local Government Act," as exemplified in Croydon. 8vo. *Lond.*

earliest, outburst). In the winter of 1860-61 it first came out of the chalk close to an ash tree, but other springs, as usual, soon joined it as it flowed towards the Park Lodge, on the Croydon and Godstone road, and thus a copious bright stream was soon formed, which flowed at the rate of between three and four miles an hour towards Foxley-gate."

Mr. Johnson clearly and fully states the true theory of bourne-flows, that is as resulting from the rise in level of subterranean water, after the heavy rainfall, with consequent outflow, rejecting such explanations as that of the siphon-theory, and his is the first detailed statement of the sort that I know of. As he puts it, "the subterranean watercourse (along the bottom of the valley) is *choked* and filled up with *water*, and that as effectually as if it were filled in with any impermeable material: and the water which is thus diverted from the usual channel must of necessity find a new one, which it retains until, by slow degrees, the underground watercourse is restored to its normal condition."

The average yearly rainfall of Surrey being given as "about 24 inches, or 2,400 tons per acre," of which 14 inches are allowed for evaporation and 10 inches for percolation, we have then the normal conditions; but when an unusual fall of say 30 inches occurs, "a very different state of affairs takes place. 3,000 tons of water per acre now descend upon the land. The *evaporation* remains nearly the same . . . whilst the *drainage* water (meaning that which percolates underground) is increased from 10 to 16 inches, or from 1,000 to 1,600 tons per acre; an outlet, therefore, is needed, that will convey 600 tons of water per acre more than in years of average rainfall . . . it ought to follow that the Bourne at Croydon, and other places of irregular outpourings, should make their appearance soon after any unusual annual rainfall. Now we find that whenever the rainfall in one year is about 30 inches, the Bourne makes its appearance at the close of the year, or early in the ensuing spring; and that whenever the rainfall considerably exceeds 30 inches in the year, as in 1818 (33·4), 1821 (34·5), 1824 (36·3), 1841 (33·3), 1852 (34·2), the Bourne flows copiously."

He gives a table of the rainfall from 1815 to 1864, noting the bourne-flows, which are included in the fuller list on p. 74.

"Certain remarks recently made in the Godstone stone quarries . . . tend to support this explanation." This may be so; but not, I think, in the sense suggested, that the water from these underground quarries, which are in the Upper Greensand, flows by underground channels into the Bourne: it flows out southward to the outcrop and not northward through the Chalk. It will be seen later on that Mr. B. Latham deals with this question.

"In 1860 the Bourne first rose near the side of Riddlesdown (?at the usual place, a little below the Rose and Crown) in November, but it did not rise at Marden till February, 1861, where at this time it was discharging about 600 gallons per minute; whilst that near Riddlesdown poured forth about 1,400 gallons . . . The united streams (it is really all one stream) lost, however, considerably in their course by soakage into the ground, for below Riddlesdown (?how far) they only flowed at the rate of 1,500 gallons per minute. The water they thus lost evidently descended into the soil, and united with the constant under-ground stream, . . . for at the very time that the Bourne water was flowing at the rate of only 1,500 gallons per minute below Riddlesdown, the water from the mouth of the Bourne culvert (in Croydon) was pouring into the Wandle at the rate of 3,500 gallons per minute," according to MR. BRAITHWAITE (Proc. Inst. Civ. Eng., 1861).

"The composition of the Bourne water is chemically the same as that of the other water of the chalk, but its temperature is rather lower than that of its ordinary springs." He gives temperatures, January 13th, 1861, rising from 32·8° at Birchwood, to 37° about 100 yards lower down, 41° at Marden Park Gate, 40·9° at the culvert nearly opposite Whyteleafe, 41·2° issuing from the pond near (? above) the Rose and Crown, 45° by a farm lower down (probably near the fullest outflow) and opposite Kenley railway-station. "After this the stream . . . began to decrease both in volume and temperature," the latter of course being the more affected by surface-temperature.

The following is from MR. JOHNSON's concluding paragraph:—"The course of the Bourne . . . especially during its early flow, is through the bed of porous gravel, which at the bottom of the valley rests on the chalk . . . It is only when that gravel becomes supersaturated with its waters that the Bourne rises to and flows on the *surface* of the ground, and thus in former days was wont to arrive at, and inundate the old town of Croydon (Old Town is the name of the lowest part in the valley). It was to intercept and divert this source of discomfort and disease that the Croydon Board of Health . . . constructed the Bourne culvert—a capacious brick drain . . . a mile and a quarter in length" up the valley-bottom. "This great drain, from its lower portion being made with uncemented bricks rapidly draws the water from the bed of gravel it passes through."

I am the more pleased to quote this paper, as through it I first got to understand the true explanation of bournes, very many of which I have since seen in various Chalk-districts. It was duly noticed in my Memoir on the London Basin (1872) with other references to bournes.

It may be well to introduce here the following quotation from a paper by MR. J. LUCAS,[1] which is of interest as showing the great amount of variation in water-level in the Chalk, the place of observation being just above the highest point of outbreak of the bourne that I have seen (1903). "In November 1874, a well at Bughill Farm, in the Marden valley, which overflows when the bourne is flowing, and which is 125 feet deep, was quite dry," so that the amount of variation in the water-level there is 125 feet or more

The second special paper to be noticed was read by MR. H. H. FRENCH in 1883.[2] He gave an historical account of the subject;

[1] *Proc. Inst. Civ. Eng.*, 1877, vol. xlvii, p. 78.

[2] Sutton Scientific Society. A Paper on Bournes. 8° *Sutton*, 1884 ?

showed the insufficiency of the syphon-theory, as an enormous cavity would be needed "to store the large amount of water discharged by the Bourne," and large caverns in the Chalk are not known; and adopts the theory of overflow from water-logged Chalk. Referring to records of rainfall he says "there are certain years in which the rainfall during October, November, and December *exceeds* 10 *in.*; and . . . those years are marked by the flowing of the Bourne. And this is no mere coincidence; for a heavy winter rain *is* the origin of the Bourne; and the reason why a large amount of rain falling in the winter is more effective than an equal quantity . . . in the summer months . . . is that almost all the summer rain is absorbed by vegetation or is evaporated, so that scarcely any finds its way downwards . . . Whereas in winter . . . scarcely any is absorbed by vegetation, but little is evaporated, and the rest percolates through the soil and adds to the amount already stored below."

The third special paper is the one by MR. BALDWIN LATHAM above alluded to (p. 68), which was read in May, 1904.[1] He refers to a letter written in 1877 to the *Croydon Chronicle*, in which he deals with "the mythical allusion, which has been frequently referred to at different times (*see* p. 69), with regard to the connection between the amount of water in the Godstone Stone Quarries and the flow of the Bourne," the statement made being that when there was from 11,000,000 to 15,000,000 gallons of water in the quarries the bourne would flow. He "had all the high-water marks which had been put up from year to year . . . in these quarries . . . levelled and reduced to ordnance datum (*see* p. 18), when it became manifest that there were years when there has been a large quantity of water stored in the Godstone Quarries, and no appearance of the Bourne has taken place," as in 1849, while in 1866, the year of the largest recorded bourne-flow, the level was only 2·22 feet higher. In 1876, when the bourne flowed, the level of the water in the quarries was nearly 17 feet lower than in 1849, whilst in 1854, "when there was a very low water year in the country and there was no Bourne flow," the water-level in the quarries rose to about five inches higher than in 1866, "clearly showing that there is no direct connection between the volume of water in the Godstone Quarries . . . and the flow of the Bourne." Nevertheless "the greatest height of water recorded in Godstone Quarries was in 1853 . . . at the time of a large Bourne flow."

"It may be ordinarily taken that the volume of water in Godstone Quarries is an indication of the height of the water in the ground, and there are times when it may be used as an aid in judging of the likely appearance or not of a Bourne flow. It is possible also since these quarries have been worked to a greater extent than in the earlier years that the water does not now rise so high in them as formerly . . . at the same time their capacity for holding water has been increased."

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[1] Croydon Bourne Flows. Privately printed. Also issued with *Proc. Croydon Nat. Hist. Soc.*

"These quarries . . . have ceased to be worked . . . and are now devoted to the cultivation of mushrooms" and access to them is not so readily granted, I believe.

Mr. Latham well puts the case of bournes as follows:—"Underground water is subject to exactly the same laws and influences as water flowing over the ground, but is slower in its movements . . . A Bourne flow is nothing more than a flood in the underground water passing down from the higher to the lower portions of the district swelling out of its ordinary underground channels over the surface."

With the Croydon Bourne, "when the flow is small in passing down the valley the water enters the ground and disappears from sight (lower down), as the passages are there large enough for its conveyance without appearing at the surface." I should think, however, that this goes also with the lowering of the underground water-level being more than the fall in the valley-bottom in its downward course. "The largest surface flow . . . always occurs immediately below the 'Rose and Crown' . . . from which point down the valley it diminishes."

"The Croydon drainage area, which supplies the Bourne and the underground waters to the Croydon branch of the River Wandle, contains an area of 24 square miles. Of this area in ordinary times 14 square miles should discharge their waters from Purley Junction down the Brighton Road Valley directly into the head of the Wandle at Croydon, while 8 square miles drain under the intervening high grounds, and discharge into Waddon Mill Pond; the waters of the remaining 2 square miles have been diverted by the Oxted Railway Tunnel. In times of the Bourne flow large proportion of the flow passes in the direction of Croydon and a lesser volume flows to Waddon; at all other times, unless interfered with by pumping, the yield of the respective areas is identical."

Mr. Latham discusses the rainfall of the district, and points out "the enormous difference in the rainfall at the top and bottom of the drainage area of the Croydon branch of the River Wandle" an average of ten years (1878 to 1887) at the highest ground (over 870 feet) being 34·68 inches a year, whilst at the bottom (130 feet) it was only 24·68.

"When it is considered that the temperature in all the higher parts of the district is considerably lower than at the lower parts . . . it follows that the amount of evaporation would be less in the higher districts, and therefore the quantity of rain percolating the ground would be proportionately greater."

"Owing to the very much larger amount of rain which falls on the higher district, and its less liability to waste, it has been found that the water in the deep wells in the higher parts . . . always begins to rise before the water of the wells in the lower part . . . This may appear rather curious . . . that the top of the basin should begin to fill before the bottom, but when it is considered that a much larger amount of water percolates into the ground in the higher district, and that there is considerable resistance offered by the strata to the water flowing away from the upper part of the basin, it is sufficient to account for what really occurs which enables the Bourne flow to be predicted some considerable time before it breaks out.''

" With the same height and fall of the water in the ground the quantity of water yielded by a particular area will always be the same, and knowing the height to which it is necessary for the water to rise before a Bourne will make its appearance, this height may probably be determined some two or three weeks earlier by the rise of the water in a well in the upper portion of the district. . . . The period of high water in a well at Cambrian House, Caterham, has been ascertained to be from twenty to forty-five days before the time of high water in a well at the ' Rose and Crown ' . . . close to the place where the Croydon Bourne first breaks out.'' He also found that when the water " at Cambrian House well rose to a level of 340 feet above ordnance datum there would be a small Bourne flow in Caterham Valley, and when the water in this well rose to 370 feet . . . then the flow would increase and extend up the valley and there would be a flow in Marden Park.''

" It is the rain that falls immediately preceding a Bourne flow which really governs its future appearance and volume."

Mr. Latham says that the coldness of the bourne-water is due " to the circumstance that the chalk water is brought up to or near the surface of the ground when the Bourne flows, and that the Bourne ordinarily flows in a cold season . . . when the . . . ground at or near the surface is cold, and thus the temperature of the Bourne conforms to the temperature of the ground.'' He gives a table of temperatures and analyses of waters of the district at the time of a bourne-flow, by Messrs. Wigner and Harland.

Mr. Latham's account of his own first acquaintance with the bourne is amusing and serves to show the danger of coming to a conclusion over quickly. In 1866 he was Surveyor to the Croydon Local Authority and a set of plans for the building of the Royal Oak was submitted to him. The proposed work would have blocked up the bourne-channel, and, on his objecting to this, he was told " that the Bourne was not likely to flow again ''; but his objection was quickly justified, for " while the matter was under consideration the Bourne broke out to the surprise of all parties, and as a consequence provision was made for continuing the Bourne channel past the site of the house in question.'' Presumably Mr. Latham's respect for the bourne was at once established, and he saw the advisability of getting together information as to its ways.

From his gaugings we learn that " on the 27th February, 1866, the quantity flowing into the Bourne culvert at the ' Windsor Castle,' . . . which was then the upper end of the culvert (for the protection of the lower parts of Croydon from the bourne), was at the rate of 1,800 cubic feet per minute, and the volume flowing out of the mouth of the Bourne culvert into the Wandle . . . was 3,212 cubic feet per minute, this being the largest flow of the Bourne of which there is any record.'' Other lower flows are recorded, the lowest being for April 1, 1873, when no water flowed into the bourne-culvert, but 864 cubic feet a minute flowed out of it.

On the 11th of January 1877, MR. LATHAM wrote a letter to the *Croydon Chronicle* "predicting that a Bourne flow would take place immediately below the 'Rose and Crown,' . . . the flow commenced on the 18th."

From that year to 1904 he "has predicted . . . both the volume and date on which all the subsequent Bourne flows have made their appearance." These numbered thirteen "and there have been no Bourne flows or anything approaching a Bourne flow in any of the intermediate years."

The large flow of 1877 was peculiar in being "a recurring Bourne, that is, it rose to a high point and then fell and rose again." He gives diagrams of this flow and notes that the water-levels in wells "some distance from the Bourne flow show a corresponding rise and fall . . . with the flow of the Bourne, but the wells near . . . to the flowing stream, and all wells below the level at which the Bourne breaks out, show no fluctuation in flow, as the overflow by the Bourne prevents the water rising."

Various particulars of the flows of successive bournes are given. In 1881 "for the first time the quantity of water flowing out of the Bourne culvert at Croydon at the maximum period of flow was considerably less than the surface flow . . . below the 'Rose and Crown,' and in this year there was a considerable volume of water which found its way into the new sewers in Brighton Road." And the like is recorded of the large bourne of 1903-4, the flow out of the culvert having been "not more than one-half of the flow below the 'Rose and Crown' at Coulsdon" and adding the flow out of the new culvert "the total flow into the head of the Wandle at Croydon on the 23rd February of this year (1904) was . . . a considerably less quantity than was flowing at Coulsdon."

"There can be no doubt that the waters of the Bourne have been transferred from the ordinary channels . . . into the Croydon sewers."

This exhaustive paper contains a map and section of the bourne-flow of 1877 and two photographic views of the flow of 1904.

The following table of the flows of this Bourne (with the authorities) is compiled from the above quoted paper, pp. 2, 9, 12, 20, 21, with the addition of two later entries and of some words in brackets:—

1472 (1473 new style). DR. J. WARKWORTH's "Chronicle" (Camden Soc.).
1660, 1665, 1668. AUBREY's "Natural History . . of . . Surrey," vol. iii, p. 17. 1723.
1818, 1821. Both copious. C. W. JOHNSON.
1824. Very copious. C. W. JOHNSON.
1829, 1836. Both moderate. C. W. JOHNSON.
1837. Abundant. E. W. BRAYLEY, "History of the County of Surrey," 1847.
1840. Moderate. C. W. JOHNSON. ("With unusual force," according to HUGHES' *Treatise on Waterworks*, Ed. of 1882, p. 50.)
1841,2. 1852,3. Both copious. C. W. JOHNSON. (? 1852. Moderate.)
1860,1. J. FENTON. (1860. Moderate. C. W. JOHNSON.)
1863. Small. C. W. JOHNSON.
1866. Very large. B. LATHAM.
1873, 1876. Both moderate. T. WALKER, B. LATHAM.
1877. Very large B. LATHAM (and all to 1903)
1878. Small.
1879. Moderate, but for a long period

1880, 1881. Copious.
1882. Moderate.
1883. Copious.
1887. Moderate.
1889. Small.
1891, 1892. Moderate.
1893. Moderate.
1895. Water just rose to surface.
1897. Moderate.
1903, 1904. Very large.
1910. Small. 1912. *See* p. 337.

As Mr. Latham says: " It is by no means certain, however, that the Croydon Bourne has not flowed very many times and has not been recorded, especially in the earlier periods. When there has been a Bourne flow out of the Orpington gravel pits there has usually been a Bourne flow at Croydon," and this might add the following years, 1795, 1799, 1809, 1811, 1812, 1817, 1825, 1828.

It can hardly be out of place to add to Mr. Latham's account of the bourne that he has almost made his own, the following remarks, made during an excursion:—" It was pointed out how, by fairly continuous measurements of the water-level in wells in and near the valley, the gradual rise of the underground water-level was recorded, and how, by this means, Mr. Baldwin Latham was able to predict when the outflow of this particular bourne was to be expected. As his predictions invariably came true, he would, in the good old times, have been duly burnt as a magician; now he was only regarded as a champion recorder of water-levels, a harmless and even beneficent character."[1]

It may be noted here that, in speaking in March of the Bourne of 1877, Mr. A. Taylor said that " near the Kenley Station . . . about seven million gallons per day were running," and the speed was " about $1\frac{1}{4}$ miles an hour."[2]

The fourth paper specially devoted to the Croydon Bourne is a Report by Mr. G. F. Carter, printed in the records of the Corporation, vol. xxii, no. 55.[3] In this we are told:—" The Bourne water appeared in Kenley Valley on the 23rd November, 1903, near the ash tree about 250 yards north-west of the ' Rose and Crown.' . . . The flow on the surface gradually extended, and reached Roke Farm (about $1\frac{1}{4}$ miles lower down) about the 8th December, 1903, although at the time the level (of the water) in the well at Roke Farm was . . . 21 feet below ground level."

" On the 15th December the water reached the builder's yard at the east side of the railway at Purley, where for a fortnight it continued to soak away." A weir for gauging the flow was made at the end of the culvert on the western side of the railway, " and on the 29th December the water passed over the weir, through the culvert in the East Surrey Water Company's Works, and along the ditch into the borough. The flow gradually increased until on February 24th, 1904, it reached the maximum of 8,553,600 gallons per day; it afterwards gradually diminished, and ultimately disappeared on the 18th May, 1904."

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[1] *Proc. Geol. Assoc.*, 1904, vol. xviii, pt. 7, p. 388.
[2] *8th Rept. Croydon Micr. Club*, 1878, p. 28.
[3] Bourne Water Flow, 1903–4. Report of the Borough Engineer

Notes are given of the levels of the water in various wells and holes and of the works done in the borough to deal with the flow. One of the two diagrams shows the flow, down to Purleybury. The other, partly by Mr. J. R. Downs, shows the daily flow over a weir at the Kenley Waterworks, which ranges up to a little over $11\frac{1}{2}$ million gallons (on February 17th, 1904), and also of the weir by the railway above mentioned.

I may here give some notes of my own on the flows of 1897 and 1904. In the former year the highest outbreak that I saw was at Wapses Lodge, a little south-east of Caterham Manor, where in March and April there were pools of water in the wooded hollow in the angle of the roads.

The larger flow of 1904 reached upward to Bughill Farm, where it started in February by the south-western corner of the field southward of the house, flooded the road under the railway and flowed as a continuous stream downward; and there was a slight reinforcement from the branch of the valley southward of Wapses Lodge, water breaking out a little south of that place and the ground being wet nearly up to Marden Lodge.

In conducting an excursion on March 12th,[1] the great increase in the flow of the stream down to Wapses Lodge was noticed, as well as the occasional spreading out of the stream beyond its proper channel from there downward (presumably, in part at least, due to local obstruction). At the chief part flooded, by the gasworks, "there was a small lake, in which a new gasholder was apparently taking a bath."

"About a quarter of a mile below Kenley Station a curious thing was seen. Here, close to the artificial channel of the bourne, was a small pit, in loamy soil and gravel to the depth of about seven feet below the water, and yet it was dry. A like thing, but to a less extent, was seen a little further down, and it seemed as if the stream had fairly puddled its channel."

The old gravel-pit at the Purley Works of the East Surrey Water Company was flooded, and there was a good deal of flooding near by houses just below.

The outflow of this bourne in 1910 has been recorded in various newspapers. The following notes are from letters by Mr. B. Latham and from my own observations:—

Mr. Latham wrote to me that the Bourne broke out on February 24th, and on the 28th was flowing at the rate of 491,500 gallons a day at a point just below the Rose and Crown, where the largest flow usually takes place.

On March 12th I took an excursion[2] to the Bourne, from Kenley Station upward, having seen, on my way to that place, that the stream continued down to just below Purley Church. We followed it upward, and found a strong flow up to the point where the first rise occurs, just below the grounds of the Rose and Crown, above which "the flow quickly lessened, and after a few chains came to an end."

In a published letter of March 22nd[3] Mr. Latham said that the maximum flow of water below the Rose and Crown, on

[1] *Proc. Geol. Assoc.*, 1904, vol. xviii, pp. 388, 389.
[2] *Proc. Geol. Assoc.*, 1910, vol. xxi, pt. 8, p. 456.
[3] *Croydon Advertiser*, March 22, 1910.

March 21st, "was only at the rate of 2,305,980 gallons per day. This bourne, although small, is travelling at an unusual rate down the valley, and this may be ascribed to the fact that it has not been allowed to fill up the gravel bed over which it usually flows, but has been diverted [in places] into culverts which have been constructed since the last bourne flow in 1904."

"This bourne had also made its appearance last week amongst the trees in the low ground about Wapses-lodge, and there are about two feet of water in this depression, but it had not risen sufficiently high to overflow by the culvert constructed under the road at this point."

In passing by rail, on April 2nd, I saw that the Bourne had increased in length upward, to some way above the Rose and Crown, "so that a pond was formed surrounding the large gas-holder in the bottom of the valley, as during the larger outflow of 1904."

Another branch of this bourne runs northward from near Smitham Bottom until it joins the main branch at Purley. MR. B. LATHAM has called this the Marlpit Lane Bourne, and in his above-quoted paper of 1904, says of it that it "has this year again flooded the lands at Red Lion Green, Smitham Bottom, and there disappears into the ground."

"The present origin of this Bourne is due to the construction of a culvert which conveys the water from Merstham Tunnel when the springs are high."

The water broke out again, however, lower down the valley, and I saw the gardens of some of the houses on the eastern side of the Brighton Road, a little above the Purley Pumping Station, in a state of flood. In very wet seasons, I take it, there might be a bourne here without the culvert above mentioned; at all events, water would be very near the surface along the narrow gravel-flat in the bottom of the valley.

This branch was also in evidence in 1910. MR. B. LATHAM says of it, "On the 8th of March it was only at the rate of about 191,000 gallons per day, since which it has increased, up to Monday last (21st), to 1,108,530. . . . This bourne is passing into the ground at Smitham Bottom."[1]

A word of caution must be said as to the Wandle Bourne, and probably as to others. After heavy rain there may be surface-flooding, following of course directly on the rainfall. Thus in November and December, 1911, accumulations of water were noticed on the main road at Purley, the drains not being large enough to carry off the water, as MR. H. B. WOODWARD noticed.

"At considerable intervals of time a stream bursts out from the foot of *Merstham* hill, commonly called *The Bourne*, and after a very short course falls into and swells the little stream. . . . It generally succeeds wet unfavourable seasons, and lasts for some months."[2] This is really a short flow southward down the escarpment.

[1] *Croydon Advertiser*, 28 March, 1910. Letter dated March 22.
[2] MANNING and BRAY, vol. ii, p. 253 (1809).

EFFECT OF PUMPING, &c., ON WELLS AND SPRINGS.

The effect of pumping at a well on the water in other wells or on springs has long been a subject of controversy, and has cropped up in the consideration of many schemes of water-supply.

As a matter of fact, no definite rule can be given. Pumping at one place may have a considerable effect on the neighbourhood, whereas at another place it may have but a small one. Heavy pumping at one place may even have less effect than much less pumping at another; in the former case the cone of exhaustion may reach further than in the latter. The question hinges on various things; the character and thickness of the beds from which the water is pumped, the amount of water contained in them and the direction of its flow, the site of the well and its relation to other sites. Each case indeed must be tried on its own merits; it is impossible to fix on any definite distance up to which the effects of pumping may reach.

In one direction from a well, moreover, the effect may reach further than in another. There is also sometimes a difficulty in finding out how much of the lowering of water may be due to seasonal variation (a natural cause) rather than to pumping.

All that can now be done is to notice cases that have been recorded as occurring in Surrey, and these will be taken in chronologic order.

Mr. R. W. Mylne, speaking of London wells, has noted "that there is an intimate connection between all that derive their supply of water from the sand stratum (above the Chalk). A striking instance of this is afforded by the well in Messrs, Calverts' brewery, in Thames Street, which is materially affected when Messrs. Barclay and Perkins work theirs in Southwark . . . on the opposite side of the Thames."[1] On this subject Mr. Taberner adds that these firms were compelled to work their wells on alternate days, but that there had been no recorded test since 1825.[2]

The effect of pumping at one well on the water in another well was alluded to by Mr. F. Braithwaite in 1850, and he gives two instances from Surrey. A well at Messrs. Tritton's Brewery, Wandsworth, was said to have drawn the supply from a neighbouring well, and this was the subject of a law suit. "The other occurred at the Kingston union well, sunk to the sand-spring 425 feet, where the water rose to within 7 feet of the surface, which, when lowered by pumping to 25 feet, affected Mr. Palmer's well, which was about 200 yards distant, also sunk to the sand-spring." The latter is somewhat lower than the Union well, and the water overflowed, "but when the water at the union well was lowered . . . ceased to do so."[3]

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[1] *Trans. Inst. Civ. Eng.*, 1842, vol. iii, p. 231.

[2] *Proc. Inst. Civ. Eng.*, 1850, vol. ix, p. 169.

[3] General Board of Health. Report on the Supply of Water to the Metropolis. Appendix ii, p. 97.

J. Lucas, treating of the well at Russell Hill School[1] (*see* p. 113) says:—"The depression caused by the pumping is very great . . . The well at Tudor Cottage, distant . . . rather under half a mile, is scarcely if at all affected," but in another direction, by Keeper's Lodge and New Barn Farm, the effect "can be traced nearly to Windmill Cottage, and one mile in the direction of Beddington."

Mr. Baldwin Latham has recorded some observations made at Croydon,[2] and he says "a most careful and continuous series of experiments, now extending over two years, show that in every fluctuation in the iron-bound well (Surrey Street Works), there is a corresponding fluctuation in the surface water, diminishing in degree as we leave the site of the waterworks. In order to more carefully observe these fluctuations, I have caused five wells of observation to be sunk in the immediate neighbourhood of the Croydon Waterworks, besides having made use of some of the existing wells in the town . . . in September, October and November, 1876, I caused daily observations to be made during a period that the Croydon Local Board were sinking a new well, and pumping occasionally large volumes of water therefrom, when the gaugings of the Wandle showed most conclusively that every day, when a quantity of water was pumped from the wells in question, the springs diminished to a like extent." *See* also below pp. 98, 99).

Mr. G. F. Carter tells me that the cone of depression of the Surrey Street Works (those above referred to) was measured in March 1884, with the following results, the figures on the right representing the rise of the water at the various places after six hours' cessation of pumping at the Works:—

Wandle Road 722 feet south of wells, 2½ inches.
" 106 " easterly, 10 inches.
Overton's Well, 160 feet north, 2 feet 4 inches.
Towards Valley, 156 " westerly, 1 foot 1 inch.
" 302 " " 10¾ inches.

The completion of the deep boring at Streatham (*see* pp. 234-238) gave rise to some correspondence, &c., in the *Times* of September 27 and 30, and October 9, 1884.

A letter by Hydrogeologist (Mr. J. Lucas), dated September 25, says:—"The effect of the pumping operations commenced there last Saturday (20th), and, maintained night and day since, made itself felt among the many overflowing . . . borings at Tooting yesterday (24th) and to a still greater degree to-day. The boring near Tooting Church, which was sunk by the inhabitants in 1822 into the . . . sand above the chalk, and the water from which originally rose 15 feet above the ground, was the first to cease running. . . . This spring has been yielding from seven to ten gallons a minute very steadily for years, until yesterday, when it ran dry. To-day a very much stronger spring

[1] Horizontal Wells, 1874, p. 54.

[2] Report (to the Mill Owners' Association) on the Metropolitan Board of Works' Scheme for furnishing a Supply of Water to the Metropolis. Fol. *Lond.*, 1878, Privately printed? (p. 21).

near the Broadway, from a boring into the chalk, followed suit, and many others are seriously reduced. There are more than 130 of these artesian borings. . . . The distance from the well to Tooting Church is one mile, and to the Broadway one mile and one-third."

The other letters do not add to the facts; but a public meeting was held, early in October, to consider the matter, and in the account of this we are told "that upwards of 500 houses in the parish which had hitherto been supplied from artesian wells . . . were now without water . . . a committee was appointed to take steps to ascertain the proprietary rights of the inhabitants," but I do not know with what result.

The subject was referred to twelve years later, and more especially with regard to a neighbouring district, by Mr. C. H. Cooper, who says[1]:—"Whilst the boring . . . was taking place the level to which the water rose in many of the Wimbledon wells was so reduced that about 100 houses lost their supply. . . . After operations . . . ceased, about 1888, the water level of the Wimbledon wells rose nearly to its former level, till continuous pumping at the rate of one and a half to two million gallons a day was commenced in July, 1895, when the level fell considerably, and continued to fall till about June of 1896."

"The greatest depression caused by pumping at Streatham is fifty feet, while the amount that the water line (plane) has been lowered at the 'Willows,' Summerstown and at the Wimbledon Sewage Works may be taken at about fifteen feet."

"This lowering of the water line (plane) has been the means of doing away with the Artesian Wells in Wimbledon, Merton, Tooting, Mitcham, and Wandsworth, except in a few cases." . .

"That the number of wells sunk from time to time has reduced the level to which the water rises there is no doubt, but the effect of borings for small supplies does not produce the destruction of wells that the pumping at Streatham has brought about."

The effect on neighbouring springs of pumping from a well was illustrated in 1906, when the London and Brighton Railway Company made a well by the side of the line between Sutton and Carshalton. The result of pumping on the neighbouring springs at Carshalton came out before the Parliamentary Committee on the Sutton District Waterworks Bill of that year (at which I was present), and has been described by Mr. W. V. Graham,[2] who says:—"The boring having been completed, a three days' test of its yield by continuous pumping was carried out. One of the smaller of these springs issues from the ground in the Carshalton Convent Garden between 700 and 800 yards from the boring, and is led in a two-inch pipe to a well from which the private water supply of the Convent is pumped."

"Upon this pipe a recording meter was fixed," and a diagram showing the discharge of the spring from June 22 to July 2 proves "that the discharge of the Convent spring fell from 700 gallons

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[1] *Journ. San. Inst.*, 1896, vol. xvii, pt. iv, pp. 586, 587.
[2] *Trans. Inst. Surveyors*, 1907, vol. xxxix, pt. ix, pp. 330, 331.

an hour to 400 (after about two days) . . . and rose again when the pumping ceased."

"During the period of pumping, the lake in the Convent grounds, which is fed by other springs, fell about one foot and rose again in the same way."

"The above, and measurements of other springs of a less exact character, accounted for more than half the quantity of water pumped." . . .

"As a consequence, the railway company's well was abandoned." *See* also pp. 321-323.

On the other hand, the far stronger occasional springs which form the Bourne, in the usually dry upper part of the Wandle Valley, have not been stopped (though they may have been affected) by the still heavier and continuous pumping of the East Surrey Waterworks at Kenley and Purley, aided possibly by the Croydon pumping, lower down the valley.

However much this bourne-flow may have been affected, it is clear that a season of high rainfall can fill the underground basin to overflowing, and thus make up (for a time at least) for any depletion that may have been caused by pumping. It will take a good deal more pumping to bring the outbreak of the bourne to an end, and that outbreak is by no means a blessing, or at all events it is a much disguised one.

Another way in which the flow of underground water has been altered, and to the extent of diversion from one drainage-area into another, is by the making of railway-tunnels through an escarpment, as in the case of the Sodbury tunnel of the Great Western Railway through the Jurassic rocks of the great escarpment of the Cotteswolds, and of the Sevenoaks tunnel, through the Lower Greensand escarpment of Kent. In these cases an underground water-ridge has been cut in such a manner that water which naturally flowed in the direction of the long dip-slope, that is inward from the escarpment, has found a readier flow in the direction of the sharper and shorter slope of the escarpment.

In Surrey we have a good case of this in the Chalk, where the railway southward of Woldingham Station is carried in a tunnel through the high ground. In 1882 Mr. B. Latham said that the effect of this tunnel "was equivalent to taking two square miles out of the water area (of the Wandle). . . The tunnel . . . falls from north to south . . . and the quantity of water flowing out of the south end of the tunnel . . . was rather more than $1\frac{1}{2}$ million gallons per day,"[1] the original flow of most of the water having been northward. In 1904 Mr. Latham said of this that he "had the quantity of water flowing out of the Oxted Tunnel regularly gauged during the last 24 years, and has found the largest quantity that . . . has flowed away was during the present year, when on the 19th February 326·03 cubic feet per minute flowed away from the Croydon area." This means a transfer from the drainage-area of the Wandle to that of the

[1] *Proc. Croydon Micr. Nat. Hist. Club*, p. lxx.

Eden, and this "does diminish the volume of the Croydon Bourne, and may prevent some small flows from taking place."[1]

Of another place Mr. Latham says[2]:—"It is recorded that when sinking the shafts in connection with the Merstham Tunnel (the older one), water was met with, which obliged the contractors to drive an adit trough the gault below the bed of the tunnel to tap the springs, and that when this was done the springs in the neighbourhood were drained. The Merstham Mill Head was dry for some years till the tunnel was finished. Afterwards the water from the adit from the tunnel was turned into the Old Mill Head, and now the mill works again not from the original springs but from the tunnel."

For other cases of the effect of pumping, &c., referred to in later pages, *see* Index.

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[1] Croydon Bourne Flows, p. 36. [2] Croydon Bourne Flows, p. 35.

CONTAMINATION AND RISK THEREOF.

General Remarks.

Something must be said on this subject, although there may now be no very bad cases in Surrey. In past times, however, questions of importance have arisen and various investigations have been made. Years ago the subject of pollution of water was far less understood than now, and naturally less care was given to it.

It is now usually with small supplies that the liability to pollution is great: supplies for villages, where each house or group of houses has its well, more or less accompanied by cess-pits, and for scattered cottages, farms, &c.

Such evils have been in great part done away with where a public supply has been established, and especially is this the case where an undertaking strong enough to supply a large district with good water has extended its arms far and wide. Of this we have in Surrey two notable cases, those of the East Surrey and of the Sutton Companies, which have done a great sanitary service both to the populous and to the rural tracts southward and westward of Croydon, in the same way as the South Hants Company has done to the districts round Southampton.

Not only have these undertakings saved various places from the risk of a contaminated water-supply, but they have also made habitable, on a large scale, high healthy tracts which, without a public water-supply, would have had comparatively few houses, and those few dependent on deep wells, costly things to make and to use, and in some cases open to risk of pollution from the immediate neighbourhood. It is not too much to say that the beautiful sites studded with good houses along the slopes and higher grounds of the Kenley and Caterham Valley would have had but a scant population were it not for the existence of a public water-supply, with its power of lifting water to the highest levels. Similar too is the case of some of the high ground southward of Sutton.

Naturally these companies do not act from philanthropic motives; nevertheless their work deserves credit. Despite their predatory action on the higher waters of the Basin of the Wandle, they have not yet destroyed the Bourne, even with the help of Croydon, and the water taken by them is better used for public supply than for any other purpose.

Of course it is a most important thing to get a good public supply; but it is hardly understood how important it is, having got such a supply, to take care that its good quality is not impaired. The protection of public water-supplies from pollution is, however, a subject that is coming to the front, and I heartily wish to do what I can in its favour.

It should be clearly understood that many of the following descriptions refer to matters of the past, which are really done away with now. It is interesting, however, and I think important, that records of former conditions should be got together, not only to show what progress has been made, but also because like conditions still hold in other places. The records of the past in various places serve as a warning to other places in the present and in the future.

The first two papers to be noticed are of a general character, the rest are more or less local, and these will be taken in order of date for the most part. Cases at Beddington and Sutton, at which latter place the water was not in fault, are noticed on pp. 292, 239.

Mr. A. Smee, in his letter to Lord Onslow,[1] in speaking of Chalk water, says:—"The quality has been prejudicially affected by the reckless manner sewage farms and the cemeteries of public institutions have been dumped down. . . . Chalk, although it may act as a filter to coarse particles, is not . . . a purifier of the products of the decomposition of animal organic matter deposited in the soil above the permanent water level. The only means for the destruction of these products is the very limited quantity of oxygen carried down by the rain, consequently we may expect that the chalk soil will become slowly and surely impregnated with decomposing organic matter. . . . This pollution of the chalk is increasing year by year, and there is an imminent risk of the water supply . . . being affected."

I think, however, that Mr. Smee took too gloomy a view and undervalued the power of nature in the destruction of harmful matter, and in 1907 Dr. E. C. Seaton, the County Medical Officer of Health, in discussing the subject of connection between typhoid fever and water, says that "the evidence with regard to the contamination of the chalk area and its effects on subterranean sources of water supply by the pollution at great distances through fissured chalk, seems absolutely negative."[2]

Dr. H. M. Richards has so well alluded to the dangers of cesspools,[3] from the point of view of the Medical Officer of Health, that I cannot do better than quote him. "The question of cesspools on the gathering ground . . . deserves more consideration than it seems to receive from the Local Government Board. At present the Model Building Bye-Laws . . . insist on builders making cesspools watertight; but it is a matter of common knowledge that . . . local authorities do not attempt to put this bye-law into operation. Under certain circumstances and in many situations no harm is likely to result from sewage percolating into the soil from cesspools. Where such cesspools are constructed on the chalk or are made to pierce the impervious stratum overlying the chalk there can be no justification for a departure from the regulations of the model bye-laws. It is true that a watertight cesspool soon becomes full, but this difficulty can be met . . . by arranging for the overflow on to or just below the surface of the soil. Under such circumstances the disposal of sewage on the gathering ground of public water supplies may be continued without risk, but it is far otherwise when cesspools are allowed to be built in defiance of bye-laws, and in such a way as to encourage the direct flow of sewage under 20 or 30 feet of pressure

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[1] Privately printed, pp. 3, Folio, 1896.
[2] Surrey County Council. Ann. Rep., 1906.
[3] Ann. Rep. on the Health . . of Croydon, for 1908, pp. 70, 71. 1909.

into porous chalk. Of course it may well happen that even under such circumstances sewage may percolate into the chalk and may not find its way into any water supply on account of the chalk at that particular spot being comparatively free from fissures, but the unsatisfactory point of the whole matter is the absolute impossibility of guaging this risk without undertaking prolonged investigation of each cesspool under varying conditions. I am therefore strongly of opinion not only that the water authority should take all possible steps within its own area to prevent unpurified sewage finding its way into the wells, but that the Local Government Board should assist in preventing contamination from sources outside the Borough by insisting that cesspools should not be in direct communication with water bearing strata from which drinking water is derived. It has been suggested . . . that there is some hardship in asking owners and occupiers of houses not to turn unpurified sewage into the vast underground reservoir from which wells in the chalk derive their supply. Such a contention would I believe be regarded as monstrous were the reservoir situated in the full light of day so that all could see what damage they are doing to their neighbours . . . all populous places on the chalk should be sewered . . . all isolated cesspools should be made watertight, and arrangements made either for their periodical emptying or for their overflow to discharge on to the surface of the soil where it could undergo purification without risk ''

Local Cases.

Turning now to the consideration of local cases, and leaving out London, the study of which is a separate matter, our information comes almost wholly from the Local Government Board and from Medical Officers of Health.

The first case to be noticed is a Report on Guildford by my old friend and fellow-student Sir G. Buchanan, through whom I was first led to see the connection of geology with sanitary science, and from frequent association with whom I learnt much on this subject.

In his Report on Typhoid Fever at Guildford,[1] written in 1867, he gives an account of the state of the town at that time. "The water-line in the Chalk is much below the surface of the higher part of the town; at the lower parts water is easily reached at a level a little above that of the river surface; into the river considerable springs from the Chalk constantly pour. The water-level under the town undergoes no appreciable fluctuations, either from changes of season or of artificial influences."

"There is no recognised system of closet drainage in Guildford, but cesspools into the Chalk are almost universal."

The water-supply was partly from the waterworks, "fed by two wells sunk some 20 feet into the Chalk at the lowest part of the town," and an old one and a new one which supplied the

[1] Tenth Rep. Med. Off. Privy Council, 1868, p. 34. The remarks of the Chief Medical Officer, Sir J. Simon, are reprinted in "Public Health Reports, by J. Simon," 1887, vol. ii, pp. 328–330. They were quoted in advance by him in giving evidence before the Royal Commission on Water Supply, in 1868.

higher parts. But of the 1,675 houses only 928 were supplied from these sources, 747 getting water from private wells or in a few cases from the river.

Whilst the few cases of fever that had previously happened "had been scattered through the poorer low lying parts of the town, this sudden outbreak was restricted . . . to the high levels," and "only one condition was to be discovered generally coincident in distribution with the outbreak, and that was the *high service of the town water supply,*" which came from the new well.

Of 264 cases of fever 177 were in the 330 houses that were supplied from the high service mains, and even these figures do not fairly represent the difference between the high and low supplies.

Analyses by Dr. Miller showed that "the aeration of water from the old well is perfect; *that from the new well very defective,*" and the latter "appears to have contained some putrescible or rapidly alterable substance, which has absorbed a large quantity of the dissolved oxygen."

Buchanan continues:—"The new well is supplied by a different spring in the Chalk from that which feeds the old well . . . the new well gets its water . . . from a fissure . . . for at the time of construction . . . very little water was obtained, till, somewhat suddenly, an abundant supply was reached. . . . Now into this fissure or into the Chalk around the well, it was certainly easy for excrementitious impurities to have entered," and that sewage-matters had got into the well was shown later, on opening the ground close by, when a sewer was found to be leaking, "and the soil between it and the wall of the engine house was saturated with sewage": moreover, the iron delivery-pipe of the high service passed through that sewer. It seems also possible that some river-water may have got into the supply.

Not only the "new well, but many of the wells of Guildford, must be exposed to danger from sewage contamination," especially since liquid matters have gone into the cesspools.

Things are different in Guildford now; but the above shows how easily dangers to well-water may arise. Analyses of the waters of the old works are given on p. 301.

We now have another Report by Buchanan to the Local Government Board, which had succeeded the Medical Department of the Privy Council[1].

In treating of the epidemic of fever at Croydon in 1875, he came to the conclusion that "there is reason to believe that polluted water has played some part in the phenomena of the epidemic," and he noted that "The area supplied by Croydon water had had much more fever than other areas in the parish," the proportion of attacks being at the rate of 104 per 1,000 houses in the former and of only 7 in the latter, whilst the number of deaths per 1,000 houses were respectively 9·1 and 2·8. But he believed "that any minor sources of impurities in the water of

[1] *Rep. Med. Off., P.C. and L.G.B.*, 1876, n. ser., no. vii, p. 40. The pages referred to are 49, 56–58, 61–65.

the wells . . . have been wholly unimportant." And he concludes "that there is no evidence of the well water having been a vehicle of fever contagium," his opinion being that some fouling took place during the passage of the water through the mains, &c., especially perhaps during intermittent service. He summarises the matter thus:—"There is much reason to believe that impurities often get into Croydon water pipes, and that in the course of last year these impurities have been instrumental in spreading enteric fever. . . I fail to find any evidence to support the view that the general water supply as it leaves the wells and reservoirs of the town has been at fault."

In one of the Notes (a provisional memorandum) appended to the Report, analyses are given of the waters that were leaking into the upper part of the old well from 27¾ to 33 feet down. They are by Dr. Dupré, and led Buchanan to the conclusion "that the sources of impurity to the Old Well are definite and removable." Of course, he approves of "the action which the sanitary authority is taking in lining the Old Well with iron cylinders down to the level of the bore-hole, for keeping out of the well all water except that derived from the deeper parts of the chalk."

The further knowledge that has since been acquired might, however, have led Buchanan to take a less favourable view of the well-water, as to which *see* Dr. Richards' remarks on pp. 91, 92.

In his Report to the Local Board of Health, in 1877, Mr. J. F. Bateman makes some critical remarks on the above.

The next case formed the subject of a Report by Buchanan's successor as Chief Medical Officer of the Local Government Board, Sir R. Thorne Thorne, who was able to give clear proof of a water-borne fever-epidemic, the outbreak of which was definitely traced to the accidental pollution of a well by a workman in it, at Caterham.

The first case of fever occurred at that place in January 1879, and was quickly followed by other cases, spread over a wide area, but confined to persons who had used the water of the then Caterham Waterworks Company, no case occurring in the Caterham Asylum, which had its own supply, nor in the neighbouring barracks, also supplied from the asylum-well.

The fever spread also to Red Hill and Earlswood, places some miles off Caterham and under different geological conditions. Here again only those persons who had used the Caterham Company's water were attacked.

Now "the water supplied by the Caterham Company was held in high repute in the district . . . and the freedom from such diseases as enteric fever and diarrhœa which is stated to have been experienced . . . has been to a great extent attributed . . . to the wholesome water-supply. Since the third well has been begun and prior to the epidemic . . . certain complaints were indeed made with regard to the water, but they were . . . due . . . to conditions resulting from the recent boring operations, which led to unavoidable turbidity in the supply, which had also prevented the process of softening from being regularly carried out. There is, however, no reason to believe that this unavoidable turbidity or temporary hardness of the water prejudicially affected those consuming it. In short, considering the deep sources of this water, and the previous history attaching to its use, it was by no means apparent how it could latterly have been the means of producing an extensive epidemic of enteric fever."

Enquiries showed that pollution did not occur in the mains or in the reservoirs. Nor could anything be traced to the additional supply which had been got on several occasions from the well at the Caterham Asylum and from that of the then Kenley Waterworks Company. Again, the three neighbouring cess-pits (from 270 to 1,100 feet from the wells) seemed to have been no danger.

However " by way of caution as to the construction of cesspools in this locality in the future " the following occurrences are noted. " Within the cones from which these wells are supplied the flow of water is, owing to the existence of fissures in the chalk, if not, also to other causes, at times in other directions (than the usual northerly one). Thus, during the boring operations . . . it was found necessary to pump into the bore itself about 3,000 gallons of water every hour, to facilitate the process of boring, and special arrangements had been made to receive the water as it rose from the bore into tanks . . . however it was found that although this bore is situated to the north of the other wells the whole of this water escaped through a fissure which had been reached in the chalk, . . . and through this fissure the water found its way in a southerly direction through the intervening 90 feet into the other wells. This it was that led to the tubidity in the supply which had been complained of. Somewhat similar occurrences have been observed with regard to water which has been allowed to run to waste on the surface. On one occasion the waste water was pumped into a hollow spot, about 170 feet to the east of the wells; here it disappeared, but it was soon ascertained to be returning into the wells at a depth of 420 feet, that is about the level of the upper spring supplying them, and it was found necessary to discontinue the process. On another occasion the waste water was led by means of a trench to a spot on the slope of the hill to the east of the works, and about 320 feet from the wells. From this point also it found its way back to the wells. Under the circumstances narrated it is clear that . . . a system which allows, within the drainage area of a well, of soakage from cesspools, is obviously one calling for immediate remedy."

Finally pollution of the water was shown to have arisen from a workman suffering from fever, with much diarrhœa (the nature of whose illness seems to have been unknown at the time), being engaged underground in work connected with the driving of an adit. Some of his ejectamenta was accidentally spilt from a bucket containing it, or was otherwise brought into communication with the well, though he seems to have exercised some care against this happening.

Thus therefore the specific evacuations of enteric fever were introduced into the water-supply, and from them the widespread epidemic resulted, reaching all places supplied with the Company's water, though at Warlingham there was but one case, which is explained by the fact that this village really got the additional supply from Kenley wells, which was pumped into the Caterham

Company's main at the further end of the Warlingham branch, keeping out the Caterham supply.

The chain of evidence is complete. Up to the end of February the one case of fever had spread the disease to 352 people, and though "the majority of the cases were of an exceptionally mild character," alas, 21 were fatal!

Remedial measures were energetically taken by the Caterham Company to cleanse the well and the mains. But the works have since been abandoned by the East Surrey Company, which has absorbed the district, for engineering reasons.[1]

Sir T. Thorne's successor as Chief Medical Officer is our next witness, and he says:—

"York Town and Camberley are not provided with a public water service. The great majority of dwellings hereabouts get their water from wells. There are a dozen or two which, being Government property, are supplied from the College Waterworks, and other few are dependent on 'springs' or raintanks. The wells are numerous, and the quality of the water afforded by them varies according as it is drawn from the Upper or the Middle Bagshot Sands. Wells sunk in the latter formation are apt to contain much vegetable organic matter, and very often they get condemned by local opinion, as also by the analyst. What is more, wells of both sorts, especially in the more thickly inhabited quarters, are no doubt liable to contamination by organic matter of animal origin, and many of them cannot be regarded as affording a uniformly wholesome supply."[2]

Writing of the Hambledon Rural District, Dr. H. Airy says[3]:—

"The supply of drinking-water is almost everywhere . . . obtained from wells, sunk to various depths in the sands and clays which crop out to the south of the chalk hills."

The "northward dip of the strata may possibly have contributed to bring about the pollution of a well at a lonely farmhouse ('Half-penny Farm'), in the parish of St. Martha, standing on the southern side of a steep sandy hill, where an outbreak of fever occurred in . . . 1886. The well, said to be 70 feet deep, is situated seven paces distant from the north-east corner of the fold yard. Liquid filth soaking into the soil of the fold yard would be more likely to reach the well on account of the dip of the strata. In this case the privy was about 25 yards distant from the well, on higher ground to the north. [A second well, recently sunk not far from the first, also gives evidence of pollution]."

"The shallow wells which furnish the chief supply of drinking-water throughout the district are often found near privies or other possible sources of pollution."

"The lower part of Haslemere has been provided, by private munificence, with good water from a neighbouring spring brought in pipes to . . . the main street."

"The little village of Hascombe . . . has an abundant spring of good water, which is brought in pipes to . . . the road side."

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[1] Pages of the Report referred to, 79–90.

[2] Report to the Local Government Board, by [Sir] W. H. Power, 1887.

[3] Report to the Local Government Board, 1887.

"A cottage in Aldford has a perennial spring in its cellar."

In 1894 an outbreak of fever at the Caterham Asylum and at the Barracks was traced to the water-supply, from the asylum-well (*see* p. 130). I visited the site and in 1895 reported on the subject, to the following effect. Part of the land on which the sewage of the asylum was applied in the valley is not much more than 200 yards from the well, and I suggested that perhaps the sewage might "be distributed only on the more clayey land, and as far as possible from the well."

"A particularly ready access to the chalk seemed to be provided by an old chalk-pit . . . into which refuse water from the gasworks was running."

"Another source of risk is the cemetery (to the south) . . . Though this site is on clay and loam, yet the chalk comes near the surface in places, and is dug into in some graves."

To see whether there was free communication between the surface and the well the lithia-test was applied by Dr. Muter, and his lengthy experiments showed "that during the time in which it was carried out . . . no trace of the lithia salt, the solution of which was applied at the surface, was found in the water of the well."

"This proves that there is no rapid communication between those spots on the surface, where the lithia salt was poured in, and the well; but it should hardly be taken as proving that there is no communication at all . . ."

"The general result of the investigation however is, fortunately, to relieve the well from the stigma cast upon it" and to lead one to think "that the water must have been polluted somewhere above ground," and this was found to be the case.

In 1897[1] I drew attention as follows to a case that had been brought to my notice "as having been set up by a powerful body which, perhaps ought to have known better. A new station had been built for the Metropolitan Police in the bottom of the Chalk Valley at Kenley. . . . It had to be provided with a cess-pit, there being no drainage-system there, and this has been made more than 30 feet deep, so as not to need emptying. It is well that this is below instead of above the East Surrey Waterworks; but it is to be hoped that the District Council will take some steps to make the Metropolitan Police move on, in a sanitary sense."

Since this was published two events have happened, the drainage of Kenley has been diverted into the Croydon sewerage-system, thereby saving the water below from the further contamination of a host of cess-pits, and the East Surrey Waterworks Company has made a pumping-station lower down the valley, at Purley.

Dr. Parson, in his Annual Report as Medical Officer of Health of Godalming,[2] called attention to "the Bore-Hole in Peperharrow Road, one of the sources of water supply . . . and its proximity to the Charterhouse Sewage Ground."

He continues: "The distance . . . is about 580 feet, and

[1] *Journ. San. Inst.*, vol. xviii, pt. iii, p. 313.

[2] ? 1898. Referred to in Dr. Seaton's Annual Report to the County Council, 1899, pp. 75–77, from which my information is got.

I am of opinion that it constitutes a possible danger to the water supply." He gives a map of the sites.

The place was visited by SURGEON COL. LAKE and DR. SEATON, who agreed to the above. It is satisfactory to learn, from DR. SEATON'S Report of 1901, that "the removal of this possible source of pollution was finally secured" (p. 25 and p. 33).

This latter Report contains a set of extracts from the Reports of local Medical Officers of Health, from which the following notes are taken.

DR. PIERCE says:—"In Woking village . . . at least 50 families are supplied from shallow wells; these are in most cases situated in cultivated gardens, and are of old and imperfect construction, the ground around them having in time become more and more polluted by manurial matter." Probably by now the public supply has replaced these wells.

DR. BOWER refers "to the diminished risk of pollution from cesspools in the chalk" at Sutton. Those "within a quarter of a mile of the Company's wells were reduced to five. There are, however, still as many as 47 cesspools in use in the chalk."

In his Annual Report, as Medical Officer of Health, for 1905, DR. H. M. RICHARDS, in describing the water-supply of Croydon, noted the circumstances of the various wells as regarded risk of contamination to the water. The quotations are from pages 62-66.

Alluding to the refusal of the Local Government Board in 1898 to sanction a loan for a well at Waddon, he says, "this refusal was based on the fact that the proposed well was in an area of uncovered chalk that might some day be built over and that there was also a possibility that fissures might extend from Purley and Caterham to Waddon"; those two places then depending on cess-pits for their sewage-disposal.

"Practically the problem of the safety of a given water supply depends on what answer can be given to the following question. Is there any substantial reason for fearing that the water is or may become contaminated with the germs of enteric (typhoid) fever? In other words, can unpurified sewage gain access to the well? Unfortunately the answer to this question is specially difficult in the case of a well sunk in fissured strata such as chalk, and can only be given by the evidence afforded—(1) by the records of epidemics; (2) by inspection of the well and its gathering ground; (3) by regular chemical and bacteriological examinations of the water."

Of the outbreak of fever in Croydon in 1853 he says:—"At the time the epidemic was thought to be due to the disturbance of the soil consequent on the sewering of the town and to the emptying of cesspools. The possibility of pollution of the wells (Surrey Street) by these same sewerage works and by the Bourne, which was also flowing, cannot, however, be disregarded."

Of the enteric fever of 1875 he says: "Though drainage defects were thought at the time to have been largely concerned in the causation of the epidemic, there can be little doubt that the disease was for the most part waterborne. It is not quite clear, however, whether pollution occurred centrally or peripherally.

Both central pollution of the well itself (Surrey Street) and peripheral pollution of the watermains were shown to be possible. Probably both were concerned . . ."

"Shortly after this epidemic steps were taken to line the wells for a greater depth, and, from that time till now, enteric fever has never been epidemic in Croydon . . ."

"Unfortunately, however, the situation of the wells and certain analytical results render it very doubtful whether the reputation of the last thirty years can long be maintained . . . Well No. 2 has had to be abandoned because it has become contaminated and the connection between all four wells (at Surrey Street) is so intimate that there is no guarantee that the remaining wells may not suffer a similar misfortune . . . The reality of this risk is emphasised by the fact that bacteriological examinations already indicate occasional departures from the high standard of purity which should be maintained by wells in the chalk . . ."

He concludes therefore "that the water from Surrey Street wells requires filtration."

Of the Addington well he says:—"On no occasion has this well been suspected of conveying disease. Water from this well is usually extremely satisfactory from both a chemical and a bacteriological standpoint. Unfortunately, however, during recent years it has been found that the well is subject to intermittent pollution within 24 to 48 hours after excessive rainfalls," and this matter was gone into in great detail later, as will be seen in the account of the paper next to be noticed. He advises that the water from this well, as also that from the Waddon one, should be subject to sand-filtration, which has been arranged for lately.

In conclusion he says that "the time has arrived when the whole question of water supplies derived from the North Downs (Chalk) and the sewerage and sewage disposal of the gathering ground should be minutely investigated by some independent authority, which should not only advise as to the purification of present supplies but take steps to prevent the culpable contamination of our underground reservoirs which certain sanitary authorities not only permit but encourage," giving as an illustration that "In one district . . . builders are permitted to dig cesspools thirty or forty feet deep so as to get well into the chalk and avoid the trouble of emptying the sewage."

In a Report to the Local Government Board on the Hambledon District, in 1907, Dr. T. Thomson says that public supplies "have been provided for the more important villages . . . The supplies of Shalford and Chilworth Road are from the mains of the Guildford Corporation; those at Bramley, Milford, and Witley are from the mains of the Godalming Corporation; those of Haslemere, Chilworth, and Wonersh have been provided by the . . . Council; and that of Cranleigh is furnished by a local water company. In some of these places however, and more particularly in Milford, there are still not a few houses the inhabitants of which obtain their water from local wells liable to pollution of a dangerous sort. The Haslemere public water-supply is open to risk of dangerous contamination at its source

. . . A supply from another source, however . . . is in course of provision . . . Elsewhere in the district, water is derived from shallow wells. In all parts of the district, but more particularly in villages and hamlets, the water of these wells, which are commonly dry-steined, is not infrequently liable to fouling, either by drainage from manured garden ground, soakage from privies or cesspools, slop-waters, or surface washings. The quantity of water available from these wells is, moreover, generally apt to be deficient during times of drought in that part of the district that is situated on the Weald Clay. The small villages of Ewhurst and Alford are both supplied by local wells which, in many instances, yield water which is neither sufficient in amount nor of good quality. A more serious instance of like conditions is afforded by the village of Chiddingfold," in which rising place " shortage or complete failure of supply from local wells is the usual experience in summer months, while most of these wells are liable to dangerous pollution in one or other of the ways above-mentioned."

In 1908 Dr. H. M. Richards and Dr. J. A. H. Brincker[1] made an important contribution on the risk of pollution to underground water. Although the site of the well referred to is not given there can now be no harm in saying that it is the Addington well of the Croydon corporation.

They say:—" Though water derived from wells in the chalk is for the most part of excellent quality, it is common knowledge that on several occasions epidemics of water-borne disease have been traced to such supplies." They refer to the cases at Caterham, Worthing and Newport (I. Wight), the last two of which have been noticed in other Memoirs.[2] " In all these instances it is noteworthy that specific pollution had its origin in the immediate neighbourhood of the well, and might have been prevented by care in the construction of the well and the provision of a zone of protection of quite moderate size. On the other hand, the risks of more distant pollution are not fully appreciated, and it is for this reason that we wish to put on record certain observations and experiments that we have made during the last four years. We can do this with the greater freedom because, though no epidemic has occurred, the water authority concerned has admitted the risk and taken the necessary initial step to obviate the danger. The subject is important because there are many similarly circumstanced wells, and the great increase in population living on the chalk outcrop must necessarily add to the risk of similar pollution . . ."

" Within a quarter of a mile radius of the well there are only two cottages, both of which are supplied with earth closets carefully supervised by the water authority. As far as mere inspection can be relied upon the well is in as satisfactory a situation as can be found in the uncovered chalk, and from the time that the well was opened, in 1888, until June, 1903, the quality of the water was believed to be of uniform excellence."

[1] *Proc. R. Soc. Med.*, vol. i, Epidemiological Section, pp. 191–203.

[2] "The Water Supply of Hants," 1910, p. 150, and Supplement to "The Water Supply of Sussex," 1911, p. 150.

"Since 1897 a chemical and bacteriological examination of the water was made three or four times a year by Mr. Dibdin, whose verdict for the first six years was uniformly favourable, until we received the following report of a sample taken on June 16, 1903. For comparison the report made . . . in November 25, 1902, is also reproduced, together with a further report on a sample taken June 22, 1903."

—	25 November, 1902.	16 June, 1903.	22 June, 1903.
Appearance	Clear and bright.	Slightly milky.	Clear and bright.
Odour at 100° F.	None.	None.	None.
Total solids. Grains per gallon	23·2	21·9	22·3
Total solids. Appearance on ignition.	Very slight blackening.	Very slight blackening.	No blackening.
Phosphoric acid	None.	None.	None.
Hardness, Total. Degrees	21·1	16·9	17 05
Do. Permanent, degrees	3·4	4·05	4·05
Ammonia, Free. Grains per gallon	Trace.	·0014	·0008
Ammonia, Albuminoid. Grains per gallon ...	·0005	·0037	Trace.
Chlorine. Grains per gallon	·85	·72	·82
Oxygen absorbed from Permanganate at 80° F. in 15 minutes. Grains per gallons	·0015	·0219	·0038
Do. in 4 hours. do.	·0031	·0353	·0102
Organic elements.			
Carbon. Parts per 100,000	·039	·079	·054
Nitrogen. do.	·01	·027	·014
Total do.	·049	·106	·068
Nitrogen as nitrates, &c. Grains per gallon ...	·194	·489	·214
Bacteria.			
Cultivation on gelatine plates :— Colonies, per cubic centimetre	10	3820	635
Micro-filter, millimetres per litre	—	Trace.	Trace.
Pathogenic organisms ...	Not detected	B. coli communis present in 100 c.c. not detected in 20 c.c.; B. enteritidis sporogenes present in 50 c.c.	B. coli communis present in 100 c.c., but not detected in 20 c.c. B. enteritidis sporogenes not detected.
Microscopic examination ...	Nothing.	A clot of fibres with many free bacteria, some in zooglœa form.	Fibres and vegetable debris.

"Consideration of the physical appearance of the water on June 16 obviously suggested that the contamination must have been massive, as a vast volume of water (in well and adits) had been rendered distinctly milky and opalescent. The chemical data, especially the diminution in the chlorine, the marked increase in albuminoid ammonia and the comparatively small increase in the free ammonia figure suggested surface water contamination rather than sewage of human or animal origin."

There is "a spot where it was known that surface water sank very rapidly into the chalk . . . rather more than two miles directly south of the well and about 600 ft. above Ordnance Datum . . . a depression situated near that part of the gathering ground which is covered with 'clay with flints and loam.' At that time the depression received the natural surface drainage of a considerable tract of more elevated land lying still further south. Advantage had also been taken . . . of the readiness with which water soaked through the overlying soil, and all the surface water drains of the 'Mental Hospital', and of the adjacent road, were led to the same spot. In spite of the large accession of water reaching the depression in times of heavy rain, . . . water rarely produced any pooling, but passed through the soil as rapidly as it reached the depression . . . we were told that some fifty years ago there used to be a pond where the depression is now found, and that on one occasion the pond disappeared with a rushing noise, leaving a hole of some depth, which was subsequently filled in with soil . . . in January, 1899, four holes, measuring from 6 ft. to 20 ft. across, suddenly appeared (elsewhere) . . . Three of these holes have since been filled up . . . There is therefore evidence that the chalk . . . is subject to accidents of the kind indicated." The depression is "near the top of one of the valleys, which ultimately opens out near the well. As underground streams tend to run in valleys," water flowing into the depression "might reach a more or less defined channel and thus take a comparatively short cut to the well."

Experiments were made to test this; "1½ tons of salt were placed in the depression, and a similar quantity in a neighbouring part of the field, where the soil also seemed to allow of free percolation. About 40,000 gallons of water . . . was then pumped on to the salt. At the same time the pumps in the well were run day and night at their maximum capacity, so as to favour the flow of water towards the well and lower the water-level until the headings could be explored." Samples of the water "were analysed half hourly for chlorine." Of the first 58 two gave 1·1 parts per 100,000, 51 gave 1·2 and five gave 1·3. "The fifty-ninth sample, taken twenty-nine hours and a half after the beginning of the experiment, showed 1·3 parts . . . and from that time until seventy-five hours after the addition of the salt (the water) did not again show as low a figure as 1·2 parts. The highest figure reached was 1·6 parts, found at the thirty-eight and forty-first hour of the experiment."

Nearly two and a half days later "a further quantity of 1½ tons of salt was washed into the depression . . . This resulted in a further rise in the sodium chloride figures, as much as 1·7 parts (of chlorine) per 100,000 being found twenty-two and a half hours after the salt had been washed down the depression . . . In both experiments . . . the most definite results were obtained about twenty-nine hours after the addition of salt to the depression." The headings were examined and samples of the chief springs taken. "Only certain of the fissures yielded water with an excess of chlorides," but these included the largest springs. "The shaft itself was remarkably dry and presented no evidence of surface water finding its way behind the lining."

"A complete inspection was made of the . . . gathering ground and a house to house inspection . . . within one mile of the well . . . No other spot (than that above-mentioned) could be discovered where surface water was likely to enter the chalk in large volumes, nor could any cesspool be found so situated as to suggest risk of intermittent pollution of the well."

On enquiry it was found "that from June, 1897, to June, 1907, there were seventeen occasions on which the physical appearance of the water was noticed to be abnormal . . . excessive rainfall was measured twenty-four to forty-eight hours before the opacity was noticed on fourteen out of the seventeen . . . Again on examining the bacterial count previous to June, 1903, there were five occasions on which more than 100 organisms per cubic centimetre were found. On four . . . excessive rainfall had preceded the submission of the samples." But they could not make out the exact relation between rainfall and pollution.

"The mere discovery in well water of soluble salts or of colouring matter washed into the depression on the gathering ground is not in itself necessarily indicative of risk of pollution, though experiments with sodium chloride, lithia or fluorescine are often of service, in as far as they suggest sources of pollution and demonstrate the direction taken by underground streams. Obviously such experiments cannot prove the possibility of particulate matter following the same course. We therefore determined to ascertain whether it would be possible to recover from the well, known bacteria previously added to the depression." This was done, I believe for the first time, and the results were that in the first experiment made the particulate matter put into the soil at the depression was detected in the water of the well 78½ hours afterwards, and its appearance "was associated with a marked rise in the bacterial content of the water."

In a second trial, on a rather larger scale, some months later, when "the micro-organism used in the previous experiment had entirely disappeared," it was found that the "test organism was absent from all samples of water until sixty-seven and a half hours after the swallow was infected," and, again, its presence in the well water "was accompanied by a marked increase in its bacterial content." The maximum pollution "seems to have been attained about seventy-eight hours after infection."

The general conclusions come to are:—"That wells in chalk require to be safeguarded not only by an adequate zone of protection, but by careful inspection of the gathering ground to discover the presence of swallow holes or other weak spots . . . That danger is most likely to arise when the chalk is *partially* covered by an impervious stratum, so that the surface water tends to be concentrated at a few spots." That there is a "necessity of frequent bacteriological examination of chalk water even when the wells are apparently above suspicion." That there is a "necessity of providing some purification scheme if the water be bacteriologically or chemically unstable, or if inspection or experiment reveal any substantial risk."

Since the above was written the water from the source in question has been protected, by filtration, and is now safe. I have existed on the supply from the Addington well for many years, with great satisfaction.

The following remarks on the connection between water-level and health, by Mr. Baldwin Latham, find a place here, as the elaborate address from which they are taken[1] deals with various questions of pollution. The 89 pages of "Records concerning the Health of Croydon for the years 1539 to 1901" at the end of this must be one of the most perfect things of the kind.

"It is a remarkable fact that the low level of the subsoil water at Croydon is associated with every epidemic that has occurred in Croydon since the first waterworks were opened in 1851; that is, immediately preceding an epidemic period there has been a very marked state of low water . . . This was the case with the first epidemic outbreak of fever in 1852. It was preceded by a very low state of the underground water at Croydon, as it is on record that the water in the River Wandle was so low that the mills were obliged to shut down several hours per day. There was also very low water in 1854, 1858, 1864-65, 1868 and 1874-75 . . ."

"The branch of the Wandle at Croydon was dry in 1864 and also in 1874 . . ."

"In the period before registration of deaths took place it will be found that the most unhealthy periods are those when there was a great drought. The year 1741 is shown to have been the most unhealthy year on record at Croydon. The year preceding it was a dry year, and in 1741 there was a great deficiency of rainfall . . ."

"By reference to the accompanying particulars (the 89 pages of records) showing the state of the public health in Croydon, it will be observable that the unhealthy periods are those when there has been a prolonged drought, and on the first indication of the rise in the water the unhealthy period commences, and continues most of the time percolation is taking place . . . A very wet year that would bring out a Bourne flow at Croydon may be, and often is unhealthy, especially in former times when the increased underground flow tended to mix the waters of wells and cesspools which were in close proximity. It should be noted that a prolonged frost leads to a lowering of the underground water,

[1] *Proc. Croydon Nat. Hist. Soc.*, 1909, vol vi, p. cxxxvii. Pages referred to cxli–cliv.

as it locks up the surface water and prevents percolation, and has the same effect as a drought," as far as underground water is concerned.

" What will be observed with reference to all the records . . . is the fact that either at the time of or immediately following a period of great drought the health of Croydon has been invariably bad, the death-rate always rising . . ."

" The area in which the Croydon Waterworks were established was a very foul area, due to the accumulation of the filth of centuries, and one of the first things done to improve the sanitary condition of this low-lying area of the old town was to remove a mill that existed near the old church, and to construct a culvert to intercept the Bourne water, and the effect of these works was such that all the ditches forming fences between properties became dry . . . Local wells were also dried up. We therefore see that there was an artificial lowering of the water in this area which would bring about the same conditions in the ground as an extended drought, and on the first percolation taking place through the artificially prepared bed fever broke out and continued for years, until the strata had become comparatively purified. Then followed periods of excessive low water, and the escape of sewage from imperfectly constructed sewers into the ground, producing in every one of the epidemics the same conditions . . ."

He thinks, however, that " the health of a district will not be affected by these climatic conditions unless there are sources of pollution to affect the sources of water supply, and therefore the introduction of new sources of water supply that are not liable to pollution to the same extent as the original source of supply is a distinct gain to Croydon."

He notices the facts of incidence of fever in the various epidemics in the town, calling attention to the fact that in the one of 1875 the high level district suffered most and that its water came direct from the rising main from the wells, whereas the low level district had its supply from a reservoir, in which the waters could mix. In April, 1881, he " had tests made by putting lithia into the subsoil water outside the Croydon waterworks wells (Surrey Street), and this lithia was found to pass into the waterworks wells, and into the water supply, when it was also found that the lithia was distributed in greater intensity in the high level district of water supply than in the low level district, thus following the incidence of the outbreak of fever."

Speaking of that part of the Wandle Basin which drains towards Croydon Mr. Latham says:—" A most important factor for consideration . . . is the fact that the whole [?great part] of this Croydon drainage area is densely populated, and that at the present time there cannot be less than 2,500 people living on each square mile, on the average . . . which is an enormous population on an area from which " a water-supply has to be taken. It seems to me however that the average population to the square mile is hardly to the point, for certainly large part of the district is still of a rural character. He thinks " that most of the fever and diarrhœa in Croydon has been contracted from the polluted area in which the present old waterworks are located."

He showed that pumping at the waterworks affected the water-level in an experimental well close by (*see also* above, p. 79), and adds that "at a subsequent period the pumping at the waterworks has been shown to affect the sewers, wells, and water in cellars of houses located a considerable distance from the pumping station." Of course since then the insanitary state of the neighbourhood of the old waterworks has been remedied, considerable protection has been given to the old wells and new waterworks have been made outside the town, and these things have "had a very happy influence in modifying the cause of disease in Croydon."

When visiting, in 1909, the beautiful burying ground near Compton, famous in connection with the late Mr. Watts, R.A., I was struck with the strange idea of placing the well at the northerly foot of the slope, though certainly that is the right site merely from the view of getting water, as the rain falling on the ground above, southward, and sinking into the sand would naturally flow down (with the dip of the beds and the slope of the ground) toward the well. The ground above being a cemetery, and there being now graves close to the well, comment is needless.

My friend Mr. Burgess, who was with me, kindly took a sample of the water, and his analysis is given on p. 294. It is a comfort to find that the water is not so bad as it might be; but we may have here an example of the danger of trusting to chemical analysis alone, without knowledge of the site. That knowledge here is perhaps enough for condemnation of the water without an analysis: there may be no pollution yet; but there is certainly a risk of it.

SUPPLIES FROM SPRINGS.

Though springs are plentiful they are but little used for public supply in Surrey; nor indeed are they commonly used for private supply, and the reason for this may be that so much of the county is within reach of some public supply, whether from the Thames or from wells.

The interesting supplies to some estates in Croydon, once taken from springs from the Tertiary beds and still used to some extent, are noticed on pp. 46-48. A much older instance is that of Waverley Abbey, Farnham, which was supplied from Lower Greensand springs, *see* pp. 39, 40.

The only public supplies wholly got from springs seem to be the small ones of the Cranley and Hurtwood Companies, which apparently overlap.

There are some other supplies in part taken from springs, as by Dorking (*see* p. 149), Farnham, the Frimley and Farnborough Company (Bagshot Sand), Godalming (*see* p. 168), the Limpsfield and Oxted Company, at first wholly from springs (*see* p. 39), and the Woking and District Company, which gets some water from gravel-springs at Chertsey and some from the Thames.

According to the Waterworks Directories, 1909 and 1911, the yield of the Frimley springs in 1908 was 105,035,000 gallons, and in 1910, 103,517,000; and the hardness of the water was 3½°.

Cranley or Cranleigh.

A note of MR. TOPLEY'S says that the water comes from a Lower Greensand spring. The supply, started in 1886, is in the hands of a Company. The population supplied numbers 2,400. The hardness of the water is 3·5°. Water Works Directory, 1911.

According to DR. SEATON'S Report to the County Council, 1905, the site is at Nore, in the parish of Bramley, and a small part of Wonersh is also supplied.

Hurtwood.

The following particulars of this Water Company are taken from the Water Works Directory, 1911. The Works were made in 1904. The supply is from impounding reservoirs on Hurtwood Common. [On the Ordnance Map Sheet 285, new ser., there are two Hurt Woods, but no Common of that name. On the old map Sheet 8 the Common seems to cover the area of both these and rather more.] Presumably, therefore, the water is from Lower Greensand springs : it is rather hard.

The district of supply is Cranleigh (part), Ewhurst and Shere, the population supplied being 1,750

According to DR. SEATON, however (Report of 1905), the supply is from a well at Gomshall.

SUPPLIES FROM WELLS AND BORINGS.

Of the wells described in the following pages it will be seen that the great majority are for what may be called private supplies; not only to houses and institutions, for domestic use; but also very largely to manufactories of various sorts, for trade-purposes. This last is, of course, notably the case in the metropolitan area and in its populous borders.

It is very difficult to make even a rough approximation to the amount of water thus pumped for private supplies; but in the case of the metropolitan part of Kent this has been done with some approach to accuracy by Mr. C. Beadle,[1] as referred to in the Memoir on the Water Supply of that county, and it is much to be wished that this work could be extended into Surrey. Meanwhile one must be content with the statement that probably these private supplies take as much as, or possibly more than, the establishments for public purposes. Therefore any depletion of water that may occur should not be wholly put to the account of public undertakings, as is not uncommonly done, but should be shared by those private undertakings, most of which do not take water for a public purpose, though some, which supply public institutions, may rank in a middle class.

The part of Surrey supplied by the Metropolitan Water Board depends mainly on Thames water; but some addition is got from wells. Outside that area the position is reversed, and nearly the whole supply is got from wells and borings, but little coming from river or springs.

Many of the borings are of considerable depth. A great number range between 300 and 500 feet, and the following is a list of those that go deeper.

From 500 feet and more, but not reaching 600, there are 11, at Battersea, Coulsdon, Croydon, Dulwich, Great Bookham, Merton, Penge, Putney, Wandsworth, and two at Wimbledon.

From 600 feet, but short of 700, there are six, at Bagshot, Chertsey (two), Cobham, Esher, and Kingston.

From 700 feet, but short of 800, there are two, at Chobham and Egham.

From 800, but short of 900 feet, there are six, at Caterham, Chertsey, East Horsley, Epsom, Thorpe, and Woking.

One at Reigate reaches to over 900 feet, and then we pass to four very deep borings, one at Dunsfold reaching to 1,200 feet; one at Streatham to over 1,200; one at Richmond to over 1,400 and one at Chertsey to over 1,500.

Having therefore in the last the deepest boring for water in the Home Counties, and three others a long way over 1,000 feet in depth, Surrey is in the front rank as regards works for deep-seated water.

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[1] *Journ. R. Soc. Arts*, 1908, vol. lvi, no. 2895.

Wells notable Geologically.

Very many of the sections given in following pages are important as showing the depth to the Chalk and the character of the beds above the Chalk. Others give information as to the different divisions of the Lower Greensand. The following is a list of those of special interest:—

Bagshot.—Great thickness of the Bagshot Beds.

Caterham.—Deep pipe of the Blackheath Beds. Boring carried through the Chalk, the Upper Greensand and the Gault (very thick) to the Lower Greensand.

Chertsey.—No. 3. The boring at Ottershaw Park is the deepest in Surrey, being exceeded only in the S.E. of England by trial-borings for other purposes than water-supply in Kent and Surrey. It seems to show a fault. Reaches from Bagshot Beds to Lower Greensand.

Chobham.—Shows a considerable thickness of the Bagshot Beds (three divisions) and great depth to the Chalk.

Cobham.—Considerable thickness of Tertiary Beds, from Bagshot Sand, above the Chalk.

Coulsdon.—No. 4. The Purley boring is carried through the Chalk and Upper Greensand into the Gault.

Dunsfold.—Proves a very great thickness of Weald Clay, the most ever passed through.

East Horsley.—Carried right through the Chalk, from top to bottom.

Oxted.—Reaches from Folkestone Beds to Atherfield Clay.

Reigate.—No. 2. Shows a great thickness of Folkestone Beds.
No. 3. Through a great thickness of Weald Clay to Hastings Beds.

Richmond.—No. 4. A very deep boring, through Tertiary and Cretaceous Beds into Great Oolite and older rocks.

Streatham.—No. 3. A very deep boring, as at Richmond.

Tatsfield.—Reaches from Gault into Hythe Beds.

Woking.—The Brookwood Well passes through a great thickness of Tertiary Beds (Bracklesham and Bagshot Beds, London Clay and Reading Beds) to the Chalk.

Wells notable for Supply.

Addington and *Croydon.*—The wells of the Corporation Waterworks. Large supply from Upper Chalk.

Camberwell.—No. 7. Large supply from Honour Oak Well, sunk into the Chalk, with long galleries.

Chertsey.—The Ottershaw Park Boring gets water from the Lower Greensand at the greatest depth to that formation yet reached, except perhaps at Lowestoft.

Coulsdon.—Nos. 3, 4. Large supply at the Kenley and Purley Works E. Surrey Co.) from deep borings in Middle and Lower Chalk.

Dorking.—Supply from Springs and Wells. Lower Greensand.

Epsom.—No. 4. Good supply from the Chalk.

Godalming.—No. 6. Supply from Wells and Springs. Lower Greensand.

Guildford.—No. 4. Large supply from Upper and Middle Chalk.

Horley.—No. 1. A supply from a stone-bed in the Weald Clay.

Kingston.—Borings into Chalk through a great thickness of Tertiary beds. Water overflowed.

Leatherhead.—No. 3. Large supply from Upper Chalk.

Streatham.—No. 3. Large supply, from deep boring through the Chalk.

Sutton.—Large supply from Upper Chalk.

Tatsfield.—Good supply from Lower Greensand.

Tooting.—Many overflowing wells.

Woodmansterne.—No. 1. Large supply of Sutton Co. from Upper and Middle Chalk.

New Wells.

The following is a list of those wells of which accounts are now published for the first time, or of which details have not been published before. In many other cases additional information has been given. Besides these there are many others in the London part of the county of which abstracts are given, the reader being referred for details to the Geological Survey Memoir, 'Records of London Wells,' 1912.

Albury, No. 1 ; Battersea, No. 7 ; Bermondsey, No. 19 ; Brixton, Nos. 1 and 2 ? ; Burstow ; Camberwell, Nos. 1, 3, 15 ; Caterham, No. 1 ; Chelsham (gaugings) ; Clapham, No. 3 ; Cranley, No. 1 ; Croydon, Nos. 9, 10, 12 (Stroud Green and Waddon Pumping Stations) 13, 14, 15 ; Dulwich, No. 5 ; Epsom, No. 2 ; Farnham, No. 8 ; Godalming, Nos. 5, 6 ; Guildford, No. 1 ; Headley, No. 2 ; Kennington, Nos. 1, 2 ; Lambeth, No. 10 ; Lingfield, both ; Merton, No. 5 ; Mitcham, Nos. 5, 14 ; Normandy, both ; Peckham, Nos. 6, 7 ; Putney, Nos. 2, 3 ; Reigate, Nos. 1, 2 ; Southwark, No. 3 ; Stockwell, No. 3 ; Sutton, Nos. 3, 4 ; Thursley, Nos. 1, 2 ; Tooting, No. 1 ; Wandsworth, No. 9 ; Woking, Nos. 1, 2, 3, 5 ; Wonersh, No. 2 ; Woodmansterne, No. 1.

Also the following, in Addenda, Epsom, Tooting, Witley.

DETAILS OF WELLS AND BORINGS FOR WATER.

An alphabetic arrangement, by the names of towns or villages in which the wells occur, is adopted, except in the case of London, in which the names of the boroughs are generally taken. Sometimes, however, this rule may be broken in favour of a well-known name that it is convenient to use, but cross-references to many such places, hamlets, &c., are given. It is sometimes difficult to be precise, but a full index may cover a multitude of sins in this matter, and it must not be assumed that a well is not noticed because it does not appear under the heading that a reader may expect: the index should be referred to. It is not unusual to have information localised according to the nearest place or railway-station, or under the name of a hamlet instead of under that of the village it belongs to. The Parish Council is the lowest unit of local government, and it is well, as a rule, not to go beneath its bounds. In towns, however, division into parishes is not recognised, being of no importance in connection with water-supply.

A valuable essay by SIR A. R. BINNIE on "Chalk Wells in and Around London"[1] has enabled me to give more precise information as to ground-levels than was given in my Memoir on the Geology of London (1889), and to add information as to water-levels at the end of 1891, sometimes with the change of level (nearly always a decrease) over a period of years.

In many cases some details have been added from that useful book the Water Works Directory, 1911, and from the MS. of the forthcoming Memoir on London Wells.

Abinger.

Ordnance Maps 285, 286, new ser. Geological Map 8.

LUCAS notes 6 wells in this parish, in Lower Greensand. *Proc. Inst. Civ. Eng.* 1880, vol. lxi, pt. iii.

Addington.

Ordnance Map, new ser. 270. Geological Map, new ser. London District, Sheet 4.

1. CROYDON WATERWORKS. On the eastern side of the road, three-quarters of a mile south of the church. 1888.

Communicated by MR. T. WALKER, then Borough Engineer. Also from paper by E. LOVETT (*Trans. Croydon Micr. Nat. Hist. Club*, 1889, vol. iii. pp. 152–154).

318¾ feet above Ordnance Datum.

Shaft, of 10 feet diameter, 200 feet deep, 3 feet filled up with concrete, lined with brickwork for 51½ feet; with a short boring.

Galleries, in various directions at the depths of 116 to 122 and 132½ to 142½ feet. [In these, when I was in them, there were parts almost dry, sometimes for a long way, between springs]. Lowest 153 feet down and 62 yards long. The longest, at 142 feet, runs for 291 yards in a south-easterly direction, with a branch, ten yards from the well, of 156 yards, to the north-east, and from this two other branches, in a south-easterly direction.

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[1] Appendices, R. Comm. Metrop. Water Supply, 1893. Pages referred to 158–165, 167, 169.

Addington—*continued.*

At 101 feet pumps had to be started, to keep the well free for work.

Water-level about 68 or 69 feet down (at first). But in 1888, after pumping had been stopped for a year, the levels were 92 feet down on April 4th and 87·4 feet on April 25th. I understand that the water-level has varied from 270 to 160 feet above Ordnance Datum (= over 48 to over 158 feet down).

On 10th April, 1887, after the galleries had been made, the yield was 2,491,000 gallons [a day]. Supply in 1893 at the rate of 777,000 gallons a day.

		Thickness. Ft.	In.	Depth. Ft.	In.
Earth [soil, &c.]		5	6	5	6
Flinty [Upper] Chalk.	Chalk, with 7 layers of flints	28	6	34	0
	Hard brownish chalk-rock	1	0	35	0
	Chalk, with 5 layers of flints	20	5	55	5
	Open bed, with flint (water first found)	3	0	58	5
	Open chalk...	5	6	63	11
	Close bed and flints	2	4	66	3
	Close chalk...	6	5	72	8
	Watery open flint-bed	2	3	74	11
	Chalk, mostly close, partly open, partly with flints, with some layers of flint; one at the bottom, a foot thick, beneath which no more flint was found ...	77	1	152	0
Flintless [Upper] Chalk.	Close bed, and then "plum-pudding chalk," with 3 inches of bind [marl ?] at the base ...	5	0	157	0
	Close bed ...	12	0	169	0
	Curly chalk [? irregular curved jointing] with 2 layers of bind [marl ?]	31	0	200	0

It is possible that Middle Chalk may have been reached.

For an analysis of the water *see* p. 291.

2. Lucas notes 2 Chalk wells in this village. *Proc. Inst. C. E.*, 1877, vol. xlvii, pp. 106, 107.

Albury.

Ordnance Map 285 new ser. Geological Map 8.

1. Waterworks (? private), at western end of pond on the Tillingbourne, about 750 yards westward of the church.

Boring 37 feet in sand, Hythe Beds ?

2. Lucas notes 3 Chalk wells in this parish. *Proc. Inst, Civ. Eng.*, 1877, vol. xlvii, p. 98.

3. Also 12 wells in Lower Greensand. *Ibid* 1880, vol. lxi, pt. iii.

Anerley *see* Penge.

Ash.

Ordnance Map, 285 new ser. Geological Map 8.

1. South Eastern Railway Station.

Rev. A. Irving, *Proc. Geol. Assoc.*, vol. ix, no. 6, p. 415.

		Thickness. Feet.	Depth. Feet.
[Bagshot Sand].	Yellow and buff sand, with occasional iron-stone	48	48
[? Passage-beds].	Dark grey laminated clay...	7 to 8	55½
	Dirty greenish sand	5 to 6	61
Blue London Clay		15	76

Ash—*continued.*

2. London and South Western Railway Station. 1866.

Communicated by Prof. T. R. Jones.

? Bored throughout. About 290 feet above Ordnance Datum.

Blue [London] and mottled [Reading] clays, with a thin bed of sand and pebbles 100 feet down in the London Clay. Very little sand on the Chalk, which was touched at ...	370
[Upper] Chalk. Water sudden ...	230
Total	600

3. Ash Grange. About half way between the two railway-stations.

Capt. H. G. Lyons. *Quart. Journ. Geol. Soc.* 1887, vol. xliii p. 437.

Deepened to about 300 feet in 1864. Supply considerably reduced by the South Western Railway well. Water probably got from the base of the London Clay or from the Reading Beds.

Ashstead.

Ordnance Map 286 new ser. Geological Map 8.

Lucas notes a well here, site not given, water 134 feet above O. D. Nov. 1874, 138 June 1875. *Proc. Inst. Civ. Eng.* 1877, vol. xlvii, pp. 102, 103.

Bagshot.

Ordnance Map 269, new ser. Geological Map 8.

Albert Orphan Asylum. 1866?

Communicated by Messrs. Easton & Amos.

(The words in brackets are from a MS. account in the papers of Sir J. Prestwich).

Sunk 123 feet, the rest bored.

		Thickness. Feet.	Depth. Feet.
Gravel ...		9	9
[Bagshot Beds, 445 feet ?]	Light-green sand ...	114	123
	" " ...	112	235
	Yellow sandy loam and stones ...	2½	237½
	Dark dead sand ...	10	247½
	Dark sand and pebbles ...	2½	250
	Dark sand and clay (or sandy clay) ...	9	259
	Green sand ...	19	278
	Light-coloured sand and clay (or sandy clay) ...	13½	291½
	Green sand ...	16½	308
	Light-coloured sandy clay...	18	326
	Light-coloured dead sand ...	5	331
	Live sand (lost the water) ...	2½	333½
	Dead brown sand ...	8½	342
	Light-coloured dead sand (with clay in top 7 feet) ...	18	360
	Light-coloured sand rock ...	19	379
	Da·k sand (or sandy clay) ...	12	391
	Dead sand and clay* ...	63	454
Blue [London] clay ...		192	646

* [This may belong in part to the London Clay.]

Balham Hill.

Ordnance Map 270, new ser. Geological Map, London District, Sheet 3.

75 feet above Ordnance Datum.

PRESTWICH, *Quart. Journ. Geol. Soc.*, vol. x, p. 141, and DR. J. MITCHELL'S MSS., vol. 4, p. 205.

Dug 90 feet, the rest bored.

Water rose to within 60 feet of the surface.

		Thickness. Feet.	Depth. Feet.
Mould	...	1	1
[Drift], 14 feet	Yellow clay [Brick-earth ?]	4	5
	Sand ...	4	9
	Gravel	6	15
London Clay, 239 feet.	Brown clay ...	6	21
	Blue clay, with cement-stones	233	254
Woolwich and Reading Beds, 53 feet.	Oyster-shell rock	5	259
	Brown clay ...	13	272
	White clay ...	4	276
	Yellow clay ...	3	279
	Red clay ...	2	281
	Light-blue clay	5	286
	Black clay ...	3	289
	Brown clay ...	13	302
	Pebbles ...	5	307
Thanet Sand	...	40	347

Banstead.

Ordnance Map 270, 286, new ser. Geological Map 8.

1. ASYLUM.

One account I have makes the well 300 feet deep ; another 380.

500 feet of galleries.

From Report for 1892 :

Depth of water in well, average 32 feet.

Yield 106,526 gallons a day. 60,000 gallons softened to $3\frac{1}{4}°$.

2. LUCAS notes 7 Chalk wells in this parish. *Proc. Inst. Civ. Eng.* 1877, vol. xlvii, pp. 104, 105.

Barnes.

Ordnance Map 270, new ser. Geological Map, London District, Sheet 3.

1. From Sheet 1 of the "Sections of Borings in the Metropolitan District," 1849, by J. PHILLIPS.

About a foot above Trinity High Water-mark.

Made ground [? gravel]	18	198 feet to Chalk.
Blue clay	180	

[This must be wrong, and the depth to the Chalk greater.]

2. WEST MIDDLESEX WATERWORKS. (Now Metrop. Water Board). 1887.

About 18 feet above Ordnance Datum.

Made and communicated by MESSRS. DOCWRA.

Hole dug 10 feet, the rest bored.

		Thickness. Feet.	Depth. Feet.
Ballast [River Gravel] ...		25	25
[London Clay, 168 ft.]	Blue clay, with claystones [septaria], a foot thick, at 71, 102, and 134, 6 inches thick at the bottom ...	$151\frac{1}{2}$	$176\frac{1}{2}$
	Hard, grey sand ...	$14\frac{1}{2}$	191
	Stone [? basement-bed] ...	2	193

Barnes—*continued.*

2. West Middlesex Waterworks—*continued.*

		Thickness. Feet.	Depth. Feet.
[Reading Beds, 62 ft.]	Coloured [mottled] clays	35½	228½
	Hard rock	5	233½
	Clay and sand	21½	255
[? Thanet Sand.]	Sand...	7½	262½
	Flints	½	263
[Upper Chalk, 142¼ ft.]	Chalk, with layers of flint at 273–4 and at 278–8½	22½	285½
	Chalk and small layers of flints	64¾	50¼
	Hard chalk...	55	405¼

Battersea.

Ordnance Map 270, new ser. Geological Map, London District, sheet 3.

1. Latchmere Road Baths. No. 2 Boring. 1901.

15 feet above Ordnance Datum.

Made and communicated by Messrs. A. C. Potter & Co.

40 feet of tubes, of 13 inches internal diameter, fixed into the London Clay, to shut out surface-water, and 260 feet of tubes of 10 inches internal diameter, 9 feet into the chalk. Water-level 80 feet down. Yield 5,000 gallons an hour.

		Thickness. Feet.	Depth. Feet.
Pit, in Made Ground		—	9
[River] gravel		15	24
[London Clay, 132 feet ?]	Clay, with 6 inches of claystone at the base	39½	63½
	Loamy clay	30	93½
	Sandy clay	15½	109
	Blue clay, with claystone 129 to 129½ feet down	39	148
	Sandy clay...	3	151
	Basement-bed [?]. Conglomerate and shells	5	156
[Woolwich and Reading Beds, 57 feet.]	Clay and shells	4½	160½
	Mottled clays, brown, green, red, yellow and grey (7 beds)	24	184½
	Grey sandy mottled clay	5½	190
	Grey clay	2	192
	Oyster-shells	3	195
	Grey (1 foot) and brown mottled clays	18	213
[Thanet Sand, 38½ feet.]	Compact sand	6	219
	Running sand	21	240
	Loamy sand	11	251
	Flints	½	251½
[Upper (and ? Middle) Chalk, 265½ feet.]	Hard chalk and flints	98	349½
	Soft chalk and flints, the top 32½ feet, water-bearing	143½	493
	Soft chalk, streaked with grey	9	502
	Hard chalk...	15	517

See also the last entry under No. 9, p. 113.

Battersea—*continued.*

2. London and Provincial Steam Laundry Co., Battersea Park Road. 1880.

Communicated by Mr. E. Turner and by Messrs. Tilley.

Over 16 feet above Ordnance Datum. Shaft 13 feet, the rest a 7-inch bore. Water rose to 43 feet from the surface. Yield 26 to 30 gallons a minute. Good supply in 1891. Water 85 feet down, and yield 1,800 gallons an hour in 1908.

		Thickness. Ft.	In.	Depth. Ft.	In.
Alluvium.	Black loam, redder and sandier at the bottom	4	0	4	0
[River Drift, over 31 feet.]	Fine, red sand	2	0	6	0
	Sand and gravel	29	2	35	2
[London Clay, nearly 108½ ft.]	London clay, sandy in places in the bottom part	106	10	142	0
	Pebble-bed [basement-bed]	1	6	143	6
[Woolwich and Reading Beds, 56½ feet.]	Hard, sparry stone	1	1	144	7
	Blue clay	1	3	145	10
	Bluish, sandy clay	5	2	151	0
	Blue and bluish-green clay, with red stripes...	7	0	158	0
	Red clay...	3	0	161	0
	Blue-green clay and brown bands ...	2	0	163	0
	Greenish-brown uniform clay... ...	2	0	165	0
	Mottled clay	3	0	168	0
	Yellowish orange-coloured clay, with white-brown patches, variable ...	4	0	172	0
	Brown clay	5	0	177	0
	Brown clay, changing to red	2	0	179	0
	Red clay...	1	0	180	0
	Pinkish clay	1	0	181	0
	Mottled grey and brown clay... ...	7	0	188	0
	Brown clay	2	0	190	0
	Grey, brown, mottled brown and red clay, with grey and green patches and pebbles	10	0	200	0
Thanet Sands, yellowish, buff and grey ... ... nearly		51	0	251	0
[Upper] Chalk with flints ... ... about		150	0	401	0

3. Messrs. Beaufoys' "Pays Bas" Works, near Lavender Hill (Wandsworth Road). Two wells.

No. 1. About 5½ feet below Trinity High Water Mark.

Bored, about 1830. Closed. Has not been used for many years.

Communicated by Messrs. Beaufoy.

		Thickness. Feet.	Depth. Feet.
[Alluvium] with land-spring 1½ feet down		5	5
[River Drift] Sand and gravel		9	14
Blue [London] Clay		133	147
[Woolwich and Reading Beds, 56½ feet.]	Coloured [mottled] clay	2	149
	Shell-rock	4½	153½
	Black clay	2	155½
	Brown clay	1½	157
	Mottled clay	7½	164½
	Greenish sand	3	167½
	White sand	4¼	171¾
	Blue clay	1¼	173
	Yellow clay	¾	173¾
	Yellowish clay and carbonate of lime	2¼	176
	Coloured [mottled] clays	19½	195½
	Black sand	¼	195¾
	White sand and stone	1½	197¼
	Coloured [mottled] sand and stone...	2¾	200
	Coloured [mottled] sand	3½	203½

Battersea—*continued.*

3. MESSRS. BEAUFOYS' "PAYS BAS" WORKS—*continued.*

		Thickness. Feet.	Depth. Feet.
[Thanet Sand, 26 feet.]	Greyish sand	½	204
	Dirty grey sand	2½	206½
	Dirty white sand	11½	218
	White sand	11½	229½

MESSRS. BEAUFOYS' No. 2. About 4¾ feet above Trinity High Water Mark. Bored about 1835.

From a large collection of specimens in the possession of MESSRS. BEAUFOY, with some further particulars from a communication from MESSRS. BEAUFOY.

Water overflowed originally. In 1870–73 the water-level was within 29 feet of the surface before pumping (J. LUCAS).

		Thickness. Feet.	Depth. Feet.
[Alluvial beds]	Brownish, sandy clay	2	2
	Bluish clay...	2	4
	Grey clay, with calcareous matter, and at the bottom pieces of plants and sand	nearly 3	7
[River] Gravel (with water)		about 6	13
[London Clay, 136 feet.]	Clay with septaria and pyrites	„ 103	116
	Clay, more or less sandy	„ 29	145
	[Basement-bed.] Sandy clay, with green grains and flint-pebbles; Sandy clay ... ...; Sandy clay, with green grains	nearly 4	149
[Woolwich and Reading Beds, 55 feet.]	Black and brown clay, with shells ...	over 4	153
	Mottled and variously coloured clays ...	about 10	163
	Soft, calcareous earth	? 2½	165½
	Mottled and grey clay, with a little lignite at the bottom	1½	167
	Grey clay, with a few bits of shells (? 4 inches) ... ...; Fine, brown, compact sand, partly clayey, with pyrites; the lower part with a few bits of shells; at the bottom sandy clay (? 3 inches) ...	nearly 5½	172½
	Yellowish and grey clay, with a few calcareous grains, which soon increase in quantity downward, until at last the clay is quite white with calcareous earth	„ 2½	175
	Mottled clays, puce, crimson, red, &c., with a little blackish sand at the bottom	about 19	194
	Brown and mottled clayey sand, with flint-pebbles ... ...; Mottled green and red clayey sand, with flint-pebbles ... ...; Green sand, with flint-pebbles ...; Green and grey sand, partly iron-stained; pebble at the bottom ...; Dark grey sand, with broken shells ...	„ 10	204
[Thanet Sand, 40 feet.]	Speckled sand	12	216
	White sand	8½	224½
	Speckled sand	½	225
	Close sand	9	234
	Loamy sand	10	244

The written account differs in the details of the Basement-bed and of the Woolwich and Reading Beds, and gives the details of the Thanet Sand.

Battersea—*continued.*

4. MESSRS. ORLANDO JONES & CO.'S STARCH WORKS. York Road (? in Wandsworth).

Sunk and communicated by MESSRS. S. F. BAKER & SONS. Additional notes from J. LUCAS, *Journ. Soc. Arts*, vol. xxv, pp. 600, 610.

About 15 feet above Ordnance Datum. Shaft 143 feet, the rest bored.

Water 46 feet below the surface, January 1877, not having been drawn upon for some time. Well abandoned.

		Thickness. Feet.	Depth. Feet.
Made ground and sand		13	13
[River] Gravel		19	32
Blue [London] Clay		127	159
[Reading Beds, 55 feet.]	Red clay	10	169
	Sand with much water	10	179
	Plastic clay	27	206
	Pebbles	8	214
[Thanet Sand in part] Grey and green sand		35	249
[Upper] Chalk		102	351

SECOND WELL. 1894. Diameter of bore 10 inches.

Made and communicated by MESSRS. LE GRAND and SUTCLIFF.

Water-level 76¾ feet down. Yield 5,000 gallons an hour. Water since fallen to 98 feet down in 1911.

		Thickness. Ft. In.	Depth. Ft. In.
Pit (the rest bored)		— —	9 0
[River Drift.]	Sand and gravel (mostly sand)	18 0	27 0
	Coarse gravel	4 0	31 0
[London Clay, 123¼ feet.]	Blue clay and septaria	71 0	102 0
	Clay, sandy, and septaria	51 0	153 0
	Black [flint] pebbles	1 3	154 3
[Woolwich and Reading Beds, 69¾ feet.]	Shells, conglomerate	1 8	155 11
	Clay	2 1	158 0
	Mottled clay	11 0	169 0
	Grey sand, with an inch of mundic (pyrites) at the base	13 0	182 0
	Mottled clay	8 0	190 0
	Red clay	15 6	205 6
	Pebbles and clay	18 6	224 0
[Thanet Sand, 26¼ feet.]	Grey running sand	6 0	230 0
	Dark grey sand, with 3 inches of flints at the base	20 3	250 3
[Upper Chalk.]	Chalk and flints	86 9	337 0
	Flints and sticky chalk	13 0	350 0

5. THE PURE WATER CO. Queen's Road. 1897.

Made and communicated by MESSRS. ISLER.

Lined with 240 feet of tubes, 8½ inches in diameter, from 10 feet down.

Water-level 43 feet down. Supply 4,000 gallons an hour.

		Thickness. Feet.	Depth. Feet.
Well		—	12
[River Gravel]	Ballast	14	26
[London Clay, 142 feet.]	Blue clay, with claystone at 46 to 48 feet	30	56
	Blue clay and stones	61	117
	Clay and stone	51	168
[Reading Beds, 38 feet.]	Mottled clay and stone	3	171
	Green stone	3	174
	Blue clay and stone	4	178
	Mottled clay and stone, with 6 inches of stone at base	18½	196½
	Pebbles	3½	200
	Green sand and stone	6	206
Grey [Thanet] Sand		35	241
[Upper] Chalk and flints		159	400

Battersea—*continued.*

6. Spiers & Pond's Steam Laundry. ? Battersea Park Road. 1905.

About 15 feet above Ordnance Datum.

New Artesian Well made by Williams & Co. Communicated by Mr. A. Harston.

A boring of 8½ inches diameter in the Chalk.

Water rose to within 85 feet of the surface. Yield 6,000 gallons an hour. Hardness of the water 7°.

		Thickness. Feet.	Depth. Feet.
[River Drift.]	Gravel	15	15
	" and fine sand	10	25
	Sand and gravel	3	28
	Gravel	1	29
Gravel and blue clay		4	33
Blue [London] clay and clay-stones...		119	152
[Reading Beds and Thanet Sand.]	Clay-stones and mottled clay ...	16	168
	Mottled clay	24	192
	" " and pebbles and sand	10	202
	Sand and pebbles	10	212
	Dead sand	10	222
	Sand and pebbles	3	225
	Hard sand and pebbles	5	230
	Hard sand	4	234
	Dead Sand	8	242
	Green flint and chalk	1	243
[Upper] Chalk and flints		157	400

7. Nine Elms Brewery.

Well 24 feet deep, almost wholly through fine running sand, with here and there a few large flints.

8. Messrs. Thorne's Brewery, 27 Nine Elms Lane. 1892.

Made and communicated by Messrs. Isler & Co.

Water-level 54 feet down. Yield 3,500 gallons an hour.

		Thickness. Feet.	Depth. Feet.
Dug well (the rest bored, 8½ inches diameter) ...		—	12
[Deep hollow of River Drift?]	Ballast	10	22
	Sand and stones	13	35
	Blowing sand	5	40
	Sand and stones	19	59
	Ballast	35½	94½
[Woolwich and Reading Beds, 78½ feet?]	Sand, clay, and shells	15½	110
	Mottled clay	27	137
	Mottled clay and sand	13	150
	Clay, stones, and shells	4	154
	Reading Beds [? clay]	6	160
	Mottled clay and pebbles ...	6	166
	Congealed ballast [pebbles] ...	7	173
[Thanet Sand.]	Green and grey sand	35	208
	Green-coated flints and grey sand	4	212
[Upper] Chalk and flints		139	351

A shorter version appeared in 'Engineering,' vol. liii. p. 776 (24th June, 1892).

There is doubt as to the above classification. One would expect London Clay, and would be inclined to put this to the depth of 150 feet. It is hard, too, to believe in so great a thickness of River Drift as 94 feet.

Battersea—*continued.*

9. For details of the following *see* Geol. Survey Memoir, "London Wells," 1912.

(*a.*) Lombard Street Electric Light and Power Works. 1902.

About Ordnance Datum.

Water-level 85 feet down (1902); about 137 in 1911. Yield 10,000 gallons an hour (1902), 7,000 in 1911.

To Chalk about 254 } 450 feet.
In „ „ 196 }

(*b.*) Nine Elms. Borough Baths. Two 10-inch bores. 1904.

14 feet above Ordnance Datum.

Water-level 89 feet down. Yield together 27,000 gallons an hour in 1904, 6,000 each in 1911.

To Chalk 227 } 450 feet.
In „ 223 }

(*c.*) Nine Elms. Gas Light and Coke Co. 1906.

12¼ feet above Ordnance Datum.

Water-level 68¼ feet down. Yield 12,000 gallons an hour.

To Chalk 220⅓ } 402 feet.
In „ 181⅔ }

Second well, 1910. Water-level 80 feet down in 1911. Falls to 92 with one pump going, to 112 with two pumps. Yield from the two wells 20,000 gallons an hour.

(*d.*) Latchmere Cottage Estate. Artisans' Dwellings. 1903.

Two borings 15 feet above Ordnance Datum.

Water-level 80 feet down. Yield 5,000 gallons an hour, 1903.

To Chalk 248 } 450 feet.
In „ 202 }

MR. T. W. HAYWOOD says (1911) that these two borings and the two at the Latchmere Road Baths each yield 4,000 gallons an hour, even when all are being pumped from at once, and that the water level is then 140 feet down.

Beddington.

Ordnance Map 270, new ser. Geological Map, London District, Sheet 4.

1. RUSSELL HILL SCHOOL.

About 324 feet above Ordnance Datum.

Communicated by MESSRS. A. WILLIAMS & Co., who made the boring (1895).

Shaft 208 feet, with beds of flints in the Chalk nearly all the way down. Depth of water 14 feet.

Boring 150 feet in hard dry chalk, with no flints and no water.

In summer the supply is pumped out easily in about an hour.

2. In the village there are a great number of wells, of no great depth. In December 1897 I had notes of more than 30, one, at Queenswood being 76 feet deep and used only during severe frosts. Several were not used for domestic purposes. The well at the Female Orphan Asylum is noticed and an analysis of its water is given on p. 292.

3. LUCAS notes five deeper Chalk-wells in the parish. *Proc. Inst. Civ. Eng.*, 1877, vol. xlvii, p. 106.

4. In 1908 what seems to have been a very old well was found at the south-eastern corner of the brickworks, Sandy Hill. It was 62 feet deep, 3¾ feet in diameter, at first, and lined with courses of chalk. The base of the Thanet Sand was reached at 48 feet, and then the diameter increased to 4½ feet. In the Chalk the well opened out into a chamber, filled with earth and bones, with some pottery and glass. *Proc. Croydon Nat. Hist. Soc.* for 1908, vol. vi, p. cclix. Fuller and more correct account in *Proc.* for 1910, pp. xix, xx, by G. W. MOORE.

Bermondsey.

Ordnance Map 270 new ser. Geological Map. London District, Sheet 4

1. BLUE ANCHOR ROAD. Donkin & Co., Engineer's Works. 1838.

Communicated by MR. B. DONKIN.

About 7 feet above Ordnance Datum.
Shaft 9½ feet, the rest bored.
Water rose to about 16 feet below the surface of the ground (1864). The water-level is sunk to nearly 39 feet by pumping.
Yield 30 gallons a minute.

		Thickness. Feet.	Depth. Feet.
[River] Gravel	...	23	23
[Woolwich and Reading Beds 30 feet.]	Blue clay ...	1	24
	Coloured [mottled] clay ...	6	30
	Pebbles ...	2	32
	Coloured [mottled] clay ...	2	34
	Green sand...	3	37
	Rock ...	½	37½
	Green sand and pebbles ...	9½	47
	Green sand...	6	53
[Thanet Sand, 38½ feet.]	Quick sand ...	37	90
	Flints ...	1½	91½
[Upper] Chalk, 140½ feet.	Chalk ...	23	114½
	Sand ...	½	115
	Chalk and flints ...	117	232

MR. BRAITHWAITE gives the figures 110 and 155 for the depth to and in Chalk (*Proc. Inst. Civ. Eng.*, vol. ix, diagram opp. p. 168).

2. CRIMSCOTT STREET. Mr. Cooper's (Leather Dresser). 1863.

Bored and communicated by MESSRS. S. F. BAKER & SONS.

About 10 feet above Ordnance Datum. Yield plentiful.

To clay ...	25	140
Bad water at ...	39	
Blue clay and shells to ...	54	
To Chalk ... about	120	
[Upper] Chalk ... "	20	

According to MR. J. LUCAS (*Journ. Soc. Arts*, vol. xxv., p. 609), water rose to 30 feet below the ground, and in 1873 stood at 39 feet before pumping. In Nov. and Dec. 1891 the water-level was 45 feet below Ordnance Datum, a loss of 25 feet in 23 years.

In 1911 the water-level was about 100 feet down and the yield 1,800 gallons an hour. (G. BARROW.)

3. CRIMSCOTT STREET. Messrs. Lazenby's. 1877.

11 feet above Ordnance Datum.

Bored and communicated by MESSRS. LE GRAND and SUTCLIFF.

Water-level 47 feet down. Yield 1,000 gallons an hour, when made.

		Thickness. Feet.	Depth. Feet.
[River Drift.]	Sand and gravel ...	29	29
Blue [London] clay	...	6½	35½
[Woolwich and Reading Beds 45½ feet.]	Sand ...	1	36½
	Rock ...	2	38½
	Sand and shells ...	6½	45
	Coloured [mottled] clay ...	9	54
	Sand ...	3	57
	Oyster-shells ...	2½	59½
	Sand and shells ...	9½	69
	Coloured [mottled] clay ...	4	73
	Green sand and pebbles ...	8	81
	Black pebbles ...	1	82

Bermondsey—*continued.*

3. Crimscott Street—*continued.*

		Thickness. Feet.	Depth. Feet.
[Thanet Sand, 52 feet.]	Hard sand	9	91
	Grey sand	43	134
[Upper] Chalk and flints		66	200

I am in some doubt as to the top three beds classed as Woolwich and Reading; whether they may belong to the basement-bed of the London Clay, or whether they may be a local development of the Oldhaven Beds.

4. Drummond Road. Messrs. Peek, Frean & Co.'s Biscuit Works. 1878.
8 feet above Ordnance Datum.

Communicated by Messrs. Peek, Frean & Co., and by Messrs. S. F. Baker & Sons.

Supply originally abundant; but insufficient in 1891. Highest water-level 20 feet from the surface. In December 1891 the water-level before pumping was 14½ feet below Ordnance Datum, and after pumping 91½. A loss of 2½ feet in 13 years. (Binnie.) Water-level the same in 1911 and the yield less than 1,000 gallons an hour. (G. Barrow.)

Shaft and cylinders to the Chalk; the rest bored, 12 inches diameter, 60 feet into the Chalk. Water of 23° of hardness.

		Thickness. Feet.	Depth. Feet.
Made ground, loam, &c.		12	12
[River] Gravel or ballast, surface-water		18¾	30¾
[Woolwich and Reading Beds, 30¼ ft.]	Shelly clay	¾	31½
	Close bed of broken shells ...	8	39½
	Very hard clay	½	40
	Pebble-bed, red	1	41
	Mottled clay	1	42
	Very hard conglomerate, with traces of iron-pyrites ...	2	44
	Hard, green sand	4	48
	Large pebbles	½	48½
	Hard, green sand	1¾	50¼
	Hard, green sand, with pebbles	1¾	52
	Hard, green, streaky sand ...	6½	58½
	Green sand and pebbles ...	2½	61
[Thanet Beds, 46 ft.]	Grey sand	6	67
	Hard sand	38	105
	Flints ... ... about	2	107
[Upper] Chalk, with beds of flints from 6 to 18 inches apart		215	322
? Deepened later		158	480

5. Grange Road. Messrs. Oastler & Palmer's (Tanners). 1859.
Bored (14 inches diameter) and communicated by Messrs. S. F. Baker & Sons.
8·7 feet above Ordnance Datum.

	Thickness. Feet.	Depth. Feet.
Made ground and gravel	32	32
Not accounted for	4	36
White stone	½	36½
Sand, with very bad water	4½	41
Stone	2	43
Blue clay, no thickness given, and nothing said of the beds below. To Chalk-flints	—	127
[Upper] Chalk (according to Sir A. R. Binnie)	133	260

According to Mr. J. Lucas (*Journ. Soc. Arts*, vol. xxv, p. 609) this well is carried down to a depth of 232 feet; in February 1877 the water-level before pumping was 50 feet down; and 6,000 gallons an hour were pumped.

In Nov., Dec. 1891 water-level 51·3 feet below Ordnance Datum, a loss of 10 feet in 14 years.

Bermondsey—*continued.*

6. Horney Lane. Messrs. Barrow Bros. 1887 ?

Made and communicated by Messrs. Isler.

10 feet above Ordnance Datum. Shaft 8 feet, the rest bored.
Water-level 58½ feet down. Minimum yield 3,000 gallons an hour.

		Thickness. Feet.	Depth. Feet.
Made ground		8	8
[River] Gravel		20	28
[London Clay.]	Blue clay	26	54
	[Basement-bed] Pebbles	1	55
	[Basement-bed] Very hard rock	$2\frac{1}{3}$	$57\frac{1}{3}$
[Woolwich and Reading Beds, $56\frac{2}{3}$ feet.]	Green sand	$4\frac{2}{3}$	62
	Green sand and mottled clay	4	66
	Grey sand	18	84
	Mottled clay	3	87
	Clay and shells	2	89
	Clay, sand and shells	$1\frac{1}{2}$	$90\frac{1}{2}$
	Sandy mottled clay	$2\frac{1}{2}$	93
	Conglomerate bed of pebbles	7	100
	Green sand and pebbles	14	114
[Thanet sand, 41 feet.]	Green [? damp] sand	30	144
	Grey sand	$10\frac{1}{2}$	$154\frac{1}{2}$
	Green-coated flints	$\frac{1}{2}$	155
[Upper Chalk]	Hard block-chalk and flints	95	250

7. Long Lane. Mr. Codrey's (Fellmonger).

Sunk and communicated by Messrs S. F. Baker & Sons.

About 12 feet above Ordnance Datum.
Shaft 100 feet ; 6,000 gallons an hour pumped (J. Lucas, *Journ. Soc. Arts*, vol. xxv, p. 609).

To clay	29	149 feet to Chalk.
To pebbles	60	
Sand and water	$1\frac{1}{2}$	
Plastic clay		
Yellow [? sand]		

8. Long Lane. Messrs. Hepburn's. 1860.

About 12 feet above Ordnance Datum.

Made and communicated by Messrs. S. F. Baker & Sons.

Shaft 80½ feet ; the rest bored.
Water-level in 1877, before pumping, 58 feet below the surface ; reduced 20 feet by pumping. Yield over 4,000 gallons an hour (J. Lucas, *Journ. Soc. Arts*, vol. xxv, p. 609). Failed and abandoned in 1883.

To Chalk	184	$288\frac{1}{2}$ feet.
[Upper] Chalk	$104\frac{1}{2}$	

9. Jute Factory. 1873.

Made and communicated by Messrs. Tilley.

		Thickness. Feet.	Depth Feet.
Through made ground into gravel.	Surface to dome	—	6
	Depth of well, 6 feet	—	12
Gravel [River Drift]		6	18
[? Woolwich Beds]	Blue Clay	1	19
	Marl. Sand	3	22
	Shells	1	23
	Pebbles	7	30
[? Thanet] Sand and water		$39\frac{1}{2}$	$69\frac{1}{2}$

Bermondsey—*continued.*

10. MARKET STREET. Mr. Matthews (Leather-dresser). 1820.

Made and communicated by MESSRS. S. F. BAKER & SONS.

About 19 feet above Ordnance Datum. To Chalk, 160 feet.

MESSRS. BAKER think that there must be some mistake in this depth, as it is close to the well of 1876. MR. LUCAS gives it as 170 feet, and in Chalk 60 feet (*Journ. Soc. Arts*, vol. xxv, p. 609).

According to SIR A. R. BINNIE, Appendices R. Comm. Metrop. Water, 1893, p. 165, the water-level was once 44 feet below Ordnance Datum, and in Nov. Dec. 1891 was 49. A loss of 5 feet. The section given is

To Chalk	190	244 feet.
In [Upper] Chalk ...	54	

SECOND WELL. 1876. Not used in 1891.

Made and communicated by MESSRS. BAKER.

Water-level 56 feet down.

		Thickness. Feet.	Depth. Feet.
Peat and made ground ...		12	12
[Valley Drift.]	Sand ...	6	18
	Gravel ...	9	27
[London Clay.]	Blue clay ...	61	88
	Pebbles [basement-bed] ...	2	90
[Reading Beds.]	Coloured [mottled] clay ...	42	132
	Pebbles ...	7	139
Green and grey [Thanet] Sand ...		42	181
To Chalk.			

11. NEW WESTON STREET. (? Manning Street.) Messrs. Margetson's (Leather Dressers). (Now Messrs. Faudell's.) 1853.

Sunk and communicatad by MESSRS. S. F. BAKER & SONS.

About 12 feet above Ordnance Datum.

Water rose to 38 feet below ground, and in 1871 stood at 74 feet, before pumping (J. LUCAS, *Journ. Soc. Arts*, vol. xxv, p. 609). Loss 36 feet in 18 years. Failed in 1879 and was abandoned.

	Thickness. Feet.	Depth. Feet.
Made ground and gravel	15	15
Sand	15	30
Blue and plastic clay ...	82	112
Pebbles, sand and clay ...	58	170
[Upper] Chalk	9	179

12. PARK STREET. Messrs. Bowron's.

Boring made and communicated by MESSRS. ISLER & CO.

Lined with tubes to 195 feet.

Water-level 70 feet down. Supply 2,500 gallons an hour.

		Thickness. Ft. In.	Depth. Ft. In.
Dug well (the rest bored, $7\frac{1}{4}$ inches diameter) ...		— —	7 6
[? Alluvium and River Drift.]	Blue clay ...	8 6	16 0
	Gravel ...	13 0	29 0
[London Clay, $67\frac{1}{2}$ feet.]	Clay ...	37 6	66 6
	Sandy clay ...	9 0	75 6
	Clay ...	17 10	93 4
	Green sand [? Basement-bed]	3 2	96 6

Bermondsey—*continued.*

12. PARK STREET—*continued.*

		Thickness. Ft. In.	Depth. Ft. In.
[Woolwich and Reading Beds, 33 feet.]	Clay	5 0	101 6
	Mottled clay	8 0	109 6
	Clay	3 6	113 0
	Sandy clay	6 6	119 6
	Clay	4 6	124 0
	Mottled clay	5 6	129 6
[? Woolwich and Thanet] Green sand		29 6	159 0
[Thanet] Sand		28 6	187 6
[Upper] Chalk		163 0	350 6

13. ROVEL ROAD. Messrs. Lipton's.

Made and communicated by MESSRS. LE GRAND and SUTCLIFF. 1896.

10 feet above Ordnance Datum.

Bore 8½ inches diameter.

Water-level 21 feet down. Yield 3,000 gallons an hour.

		Thickness. Feet.	Depth. Feet.
Pit (the rest bored)		—	8
[River Drift]	Ballast [gravel]	13	21
	Gravel and clay	3	24
[Woolwich and Reading Beds, 45 feet.]	Mottled clay	3	27
	Sand	3	30
	Shells, sand, and strong clay	9	39
	Mottled clay and grey stone	5	44
	" " red "	1	45
	Pebbles and sandy clay	3	48
	Conglomerate; pebbles and sandy clay	3	51
	Very hard sand and pebbles	18	69
Thanet Sand		35½	104½
[Upper] Chalk and flints		270½	375

14. STAPLE STREET. Messrs. Pink & Sons'. 1886.

Made and communicated by MESSRS. C. ISLER & CO.

12·15 feet above Ordnance Datum.

Shaft 12 feet; the rest bored.

Water-level 73 feet down. 8 feet lower in Nov., Dec., 1891. Yield (minimum) 3,000 gallons an hour. Later information (1891) says they pump about 18 gallons a minute and are never short of water.

		Thickness. Ft. In.	Depth. Ft. In.
Made ground		3 0	3 0
Clay (? brick-earth)		6 6	9 6
[River] Gravel or ballast		17 0	26 6
[London Clay, 38½ feet.]	Blue clay	37 6	64 0
	Basement-bed: Black pebbles	0 8	64 8
	Basement-bed: Clay, with black pebbles	0 6	65 2
[Woolwich and Reading Beds, 48 feet.]	Sandy clay and shells	4 6	69 8
	Mottled clay	11 0	80 8
	Sand	12 6	93 2
	Yellow mottled clay	11 0	104 2
	Mixed pebbles	1 9	105 11
	Mottled clay and stones	2 3	108 2
	Green mottled clay and stones	5 0	113 2
	Mixed sand and shells	3 0	116 2
[Thanet Sand, about 38¾ ft.]	Green sand	11 0	127 2
	Sand and pebbles	8 10	136 0
	Live sand	19 0	155 0
[Upper] Chalk and flints		95 3	250 3

For an analysis of the water see p. 292.

Bermondsey—*continued.*

14. STAPLE STREET—*continued.*

SECOND WELL. 1898?

Made and communicated by MESSRS. ISLER.

Lined with 160 feet of tube, of 12 inches diameter, from 7½ feet down.
Water-level 78 feet down in the boring. Supply 8,000 gallons an hour.

		Thickness. Feet.	Depth. Feet.
Well (? old), the rest bored		—	8
[River Gravel]	Ballast	19	27
[London Clay, 45 feet.]	Blue clay	17	44
	Sandy clay	22	66
	Dead sand and pebbles [? basement bed]	6	72
[Woolwich and Reading Beds, 64 feet.]	Mottled clay	18	90
	Mixed clay	2	92
	Mixed clay and shells	7	99
	Mottled clay and stones	5	104
	Green sand and pebbles	2	106
	Clay and pebbles	4	110
	Green sand and pebbles	5	115
	Mixed sand and pebbles	8	123
	Dead sand and pebbles	13	136
Dead [Thanet] sand		24	160
[Upper Chalk.]	Grey chalk and flints	10	170
	Chalk and flints	130	300

15. SWAN STREET (Pope's Walk). Messrs. Learmouth & Roberts (Leather Dressers), now Hewits. 1839.

Abandoned and built over by the Trustees of the Guinness Fund.

Sunk and communicated by MESSRS. S. F. BAKER & SONS.

About 9 feet above Ordnance Datum.

	Thickness. Feet.	Depth. Feet.
Made ground and gravel	19	19
*Blue [? London] Clay	8	27
*Pebble and sand [? Oldhaven Beds] (bad water)	11	38
*Blue clay [? Woolwich Beds]	19	57
Plastic clay and sand [Woolwich and Thanet Beds] To Chalk.	45	102

* [Possibly all Woolwich Beds.]

An old published account of a well here (in D. ALLPORT'S *Collections Illustrative of the Geology, &c., of Camberwell*, 1841, p. 8) differs from the above, but very likely refers to an older well than that sunk by Messrs. Baker. It is as follows :—

	Thickness. Feet.	Depth. Feet
Greenish and other coloured sands and clay	40	40
Shelly sandstone	1	41
Marbled [mottled] clay / Layer of shelly sandstone	64	105
Greenish quicksand with large oyster-shells (to Chalk)	3½	108½

According to MR. J. LUCAS (*Journ. Soc. Arts*, vol. xxv. p. 609) a well here has a shaft of 45 feet, is 127 feet to Chalk, and 58 feet in Chalk ; whilst another has a shaft of 60 feet.

16. WHITE'S GROUNDS. Day Noakes and Co.'s Brewery.

From R. W. MYLNE'S "Sections of the London Strata."

About 12 feet above Ordnance Datum ? less.

The water-level was (no date) 53·3 feet below Ordnance Datum. In Nov., Dec., 1891, it was 69·8. A loss of 16½ feet. The level is lowered only about 6 inches by 15 hours pumping.

To Chalk ...	198	325 feet.
[Upper] Chalk ...	127	

MESSRS. DAY and Co. told me that the well is 400 feet deep.

Bermondsey—*continued.*

17. WILLOW WALK. Beach's Tan-yard. 1851.

Bored and communicated by MESSRS. BAKER.

About 8½ feet above Ordnance Datum.

Water rose to a height of 3 to 4 feet from the surface. In November and December 1891, the water-level was 41¾ feet below Ordnance Datum before and 61¼ after pumping, a loss of 47 feet in 40 years.

To Chalk, 111 feet.

18. WILLOW WALK. Messrs. Oastler and Palmer. 1862.

Made and communicated by MESSRS. BAKER.

About 9 feet above Ordnance Datum.

Bored throughout. Supply about 100 gallons a minute.

To Chalk ...	127	333 feet.
[Upper] Chalk ...	206	

According to MR. LUCAS (*Journ. Soc. Arts.*, vol. xxv. p. 609), this bore is 126 feet to, and 14 in, Chalk; the water-level before pumping was 40 feet down (1877), and 5,700 gallons an hour were pumped.

A later well at the same place.

Communicated by MESSRS. EASTON and ANDERSON.

Shaft and cylinders throughout.

		Thickness. Feet.	Depth. Feet.
[River] Gravel, with water ...		21	21
[London Clay or Reading Beds.]	Clay ...	12	33
	Sand ...	3	36
[Reading Beds.]	Mottled clay ...	16	52
	Conglomerate ...	2	54
	Hard, green sand ...	6	60
	Hard stones (? flint pebbles) ...	2	62
[Thanet] Sand ...		46	108
[Upper] Chalk ...		66	174

SIR A. R. BINNIE notes a sunk well here as 7·4 feet above Ordnance Datum, 70 feet to and 130 in Chalk, with the water-level 32·6 below Ordnance Datum.

19. MESSRS. C. BROWN & CO., Flour Mills, Shad Thames.

About 15 feet above Ordnance Datum.

Made and communicated by MESSRS. ISLER & CO.

168 feet of tubes 8½ inches in diameter.

Water-level 94 feet down.

Yield about 7,000 gallons per hour.

		Thickness. Feet.	Depth. Feet.
Made Ground ...		7	7
[River Drift (? and Alluvium) 29 feet.]	Clay ...	7	14
	Loamy sand ...	4	18
	Ballast ...	18	36
[London Clay, 40 feet.]	Blue clay ...	34	70
	Clay and pebbles ...	6	76
[Reading Beds, 56 feet.]	Mottled clay ...	12	88
	Grey sand ...	6	94
	Blue clay ...	4	98
	Mottled clay ...	6	104
	Conglomerate stones ...	8	112
	Green sand ...	12	124
	" and pebbles	8	132
[Thanet Sand, 35¾ feet.]	Grey sand ...	35	167
	Green-coated flints ...	¾	167¾
[Upper] Chalk and flints ...		172¼	340

(Depth given as 350 feet.)

Bermondsey—*continued.*

20. MESSRS. PUGHS.

Communicated by MESSRS. BAKER, and from R. W. MYLNE'S "Sections of the London Strata."

To Chalk (Pebble-beds at 60 feet)	115	202 feet.
[Upper] Chalk	87 ?	

21. BERMONDSEY STREET.

From Sheet 3 of the "Sections of Borings in the Metropolitan District (1849), by J. PHILLIPS.

3¼ feet below Trinity high-water mark.

		Thickness. Feet.	Depth. Feet.
[Alluvium.]	Bog, peat, trees, &c.	9	9
	River-clay	3	12
[River Drift ?] Quicksand		20	32
Blue [London] Clay		60	92
Gravel [? and sand. Lower London Tertiaries] ...		110	202

22. In SIR J. PRESTWICH'S MSS. is a note of a well near the church, 95 feet deep, with water 25 feet down, in which the water rose and fell about 3 feet with the tide.

23. PAGE'S WALK, Mr. Hewitt's. 1839 (deepened later ?) premises closed.

SIR A. R. BINNIE'S Appendices to the Report of the R. Comm. Metrop. Water Supply, 1893, p. 159.

8·1 feet above Ordnance Datum.

Water-level, in Nov., Dec., 1891, 51·9 feet below Ordnance Datum.

To Chalk ...	102	120 feet.
In [Upper] Chalk	18	

By some mischance it is added "Whitaker, p. 191, gives several different accounts of wells here, but only one exists." I cannot, however, find any reference to this site in my "Geology of London," vol. ii, which must be the work referred to. The many other wells in Bermondsey noticed in that Memoir are now reproduced.

24. MR. W. GRAVATT says "A pipe sunk by Mr. Turner 95 feet deep, near Bermondsey new church :—when they reached 80 feet, the rod sunk down 15 feet at once ; after pumping out several tons of green mud, the water rose to within 25 feet of the top ; it rises and falls about three feet with the tide ; the water is quite clear and tasteless. At a place not 500 yards from this, they sunk a pipe 190 feet with very little success, the water being out of reach of a pump, and appearing bad." *Trans. Inst. Civ. Eng.* 1836, vol. i, p. 154.

25. HORSLEYDOWN. Anchor Brewery (Courage & Co.), Shad Thames. 1859.

Communicated by MESSRS. EASTON & AMOS.

About 15 feet above Ordnance Datum.

Sunk 100 feet, the rest bored (2 borings, of 14 inches and 18 inches diameter).

Water-level 50 feet below the surface.

Supply insufficient and considerably less than formerly (1891). In 1904 yield 2,500 gallons an hour, 5,700 after air-lift was installed. 3,240 gallons an hour in 1911.

		Thickness. Feet.	Depth. Feet.
Gravel, sand and mud		32	32
Blue [London] Clay ... ... about		51	83
[Woolwich and Thanet Beds, 75 feet.]	Coloured [mottled] clay ,,	17	100
	Hard rock	15	115
	Sand	14⅓	129⅓
	Green [? sand and] pebbles ...	14⅓	143⅔
	Spring sand	14⅓	158
[Upper] Chalk and flints		104	262

An account of this well in "A Treatise on Waterworks," by S. HUGHES, new Ed., 1875, pp. 195, 196, makes the blue clay 50 feet and the mottled clay 15, reducing the depth to the Chalk to 155, but adding 91 feet of Chalk, and so making the total 350.

Bermondsey—*continued.*

26. MANOR ROAD, Messrs. Rolls. 1875?

MR. G. HAWKSLEY (well-sinker) told me, in 1876, that a well 25½ feet in sand and gravel yielded a great quantity of water with a temperature of 70° F. It was suggested that the high temperature might be due to the nearness of a chimney-shaft and boiler.

27. For further particulars of the following BERMONDSEY WELLS, *see Geological Survey Memoir*, "London Wells," 1912.

(*a.*) Neckinger. Borough Electricity Works. 1902.

10 feet above Ordnance Datum. A 9 inch boring.
Water-level 64 feet down in 1911. Yield 7,000 gallons an hour.

$$\begin{matrix} \text{To chalk} & 150 \\ \text{In} \quad ,, & 200 \end{matrix} \Big\} \text{350 feet.}$$

(*b.*) Jacob Street, Messrs. Spiller and Baker. 1908.

16 feet above Ordnance Datum. A 10 inch boring.
Water-level 98 feet down. Yield 3,000 gallons an hour.

Betchworth.

Ordnance Map 286 new ser. Geological Map 8.

LUCAS notes four wells in Lower Greensand in this parish. *Proc. Inst. Civ. Eng.*, 1880, vol. lxi, pt. iii, p. 223.

DR. A. STRAHAN tells me that the hamlet of Brockham is supplied from a well on the Green.

Blechingley.

Ordnance Map 286 new ser. Geological Map 8.

1. HIGHFIELD. Well and Bore-holes. The section is at Bore-hole No. 1.

E. SPON. "Water Supply. The Present Practice of Sinking and Boring Wells," Ed. 2, p. 213 (1885).

Water from 45 to 59 feet down, in various parts of the grounds. Yield over 300 gallons an hour.

		Thickness. Ft. in.	Depth. Ft. in.
Soil	...	1 0	1 0
Clay	...	5 0	6 0
[Sandgate Beds, 65 feet.]	Hard and soft sandstone ...	15 4	21 4
	Brown clay ...	5 4	26 8
	Sandstone and sand ...	14 3	40 11
	Fullers' earth, mixed with sand	2 8	43 7
	Clay and traces of Fullers' earth	5 8	49 3
	Dry and white clay ...	1 0	50 3
	Fullers' earth ...	0 2	50 5
	Blue and grey hard sandstone	5 3	55 8
	Fullers' earth ...	3 2	58 10
	Clay and sand ...	2 10	61 8
	Fullers' earth ...	4 6	66 2
	Sandstone ...	2 10	69 0
	Fullers' earth ...	2 0	71 0

There is some doubt as to whether the upper three beds classed with the Sandgate Beds may not belong to the Folkestone Beds, the thickness given to the former division being in excess of any previous record in the neighbourhood.

2. LUCAS notes seven wells in Lower Greensand in the parish. *Proc. Inst. Civ. Eng.*, 1880, vol. lxi, pt. iii, pp. 224, 225.

Brixton.

Ordnance Map 270, new ser. Geological Map, London District, Sheet 4.

1. London, Gloucester and North Hants Dairies.

Made and communicated by Messrs. Isler & Co.

190 ft. of tubes 5 inches in diameter from 3½ ft down.
Water-level 81 ft. down.

		Thickness. Feet.	Depth. Feet.
Blue [London] Clay	...	96	96
[? Blackheath and Reading Beds.]	Gravel-rock with sand and shells	12	108
	Sand ...	12	120
	Mottled clay ...	15	135
	Clay and gravel-rock ...	11	146
Green [Thanet] Sand	...	34	180
[Upper] Chalk and flints	...	170	350

2. Gaol (? site).

MSS. of Sir. J. Prestwich.

To mottled clay, top 30 feet yellow [London Clay]	196 feet.
,, sands and clays on Chalk ...	207 ,,
Total depth ...	220 ,,

3. Acre Lane. Belvidere Lodge Laundry. 1908.

For further details, see *Geol. Survey Memoir*, "London Wells," 1912.
75 feet above Ordnance Datum.
Water-level 133 feet down. Yield 4,200 gallons an hour.

To Chalk 246 } 400 feet.
In ,, 154 }

Brookwood, *see* Woking.

Buckland.

Ordnance Map 286, new ser. Geological Map 8.

Lucas notes 3 wells in Lower Greensand. *Proc. Inst. Civ. Eng.*, 1880, vol. lxi, pt. iii.

Burstow.

Ordnance Map 302, new ser. Geological Map 8.

Rede Hall (Red Hall Farm of the older map). 1894.

Made and communicated by Messrs. Duke and Ockenden.

Shaft 47 feet, the rest bored.

Water came in quickly in the well, from 40 to 47 feet down, but was cloudy and stunk.

Weald Clay, with two layers of rock in the well. Veins with a little water 70 and 80 feet down. Rock at the bottom, 144 feet.

Camberwell.

Ordnance Map 270, new ser. Geological Map, London District, Sheet 4.

1. Ashford's Laundry, Albany Road. 1908.

About 10 feet above Ordnance Datum.

Made and communicated by Messrs. Isler & Co.

80 ft. of tubes, 5 inches in diameter.
60 ,, ,, 6 ,, ,,
Water-level 50 feet down. Supply 1,200 gallons an hour.

		Thickness. Feet.	Depth. Feet.
Made ground	...	2	2
[? River Drift]	Brown clay ...	3	5
	Ballast [gravel] ...	20	25
[? Woolwich Beds]	Green sand ...	15	40
[Thanet Sand]	Grey ,, ...	34	74
	Grey sand and pebbles	1	75
[Upper] Chalk	...	175	250

Camberwell—*continued.*

2. BAGSHOT STREET, Albany Road, Messrs. White's. 1894.

Made and communicated by MESSRS. ISLER & Co.

A boring of 13½ inches diameter.

Water-level 23 feet down. Good supply, 12,000 gallons an hour. Pumping at this rate lowers the water-level to 40 feet down.

		Thickness. Feet.	Depth. Feet.
Dug well (the rest bored, 13½ inches diameter)		—	10
[River Drift, 10½ feet.]	Gravel	8½	18½
	Gravel and sand	2	20½
[Woolwich Beds, 13½ feet.]	Dead green sand	2½	23
	Green sand and pebbles ...	6	29
	Pebbles and grey sand ...	5	34
Dark grey [Thanet] sand		37	71
[Upper] Chalk and flints		289	360

3. HAYES LAUNDRY, Coldharbour Lane. 1906.

About 45 feet above Ordnance Datum.

Made and communicated by MESSRS. ISLER & Co.

Dug well 6 feet, the rest bored.

165 ft. of tubes 10 inches in diameter 1 foot above surface.

Supply about 7,000 gallons per hour; but as much as 13,000 an hour has been pumped continuously for 4 days, without appreciably altering the water-level, which is 115 feet below Ordnance Datum.

		Thickness. Feet.	Depth. Feet.
Made Ground	... ...	3	3
[River Drift, 10 feet.]	Loamy sand	8	11
	Gravel	2	13
[London Clay, 66 feet.]	Yellow clay	5	18
	Blue "	53	71
	Clay and pebbles	8	79
[Reading Beds, 41 feet.]	Mottled clay	19	98
	" " and pebbles ...	3	101
	Red mottled clay	8	109
	Mottled sand and pebbles	11	120
[Thanet Sand, 39½ feet.]	Green sand	8	128
	Very hard grey sand ...	30½	158½
	Green-coated flints ...	1	159½
[Upper] Chalk	... ...	240½	400

4. CUNARD STREET, Albany Road. Messrs. R. White and Sons' Mineral Water Manufactory. 1885.

8·1 feet above Ordnance Datum.

Made and communicated by MESSRS. LE GRAND and SUTCLIFF.

Water-level, 25½ feet down. In 1890 5·9 feet above Ordnance Datum, a rise 11½ feet. Supply abundant.

		Thickness. Feet.	Depth. Feet.
Dug well (the rest bored)		—	13
	Made ground and gravel ...	5½	18½
	Green, sandy clay and stones ...	4	22½
[Thanet Sand]	Live, grey sand	42½	65
	Flints	1	66
[Upper Chalk 269 feet.]	Chalk and flints	235¼	301¼
	Coloured, sticky chalk and flints	18	319¼
	White, sticky chalk and flints ...	14¾	334

Camberwell—*continued.*

5. Cunard Street, Albany Road, Messrs. White's. 1895.

Made and communicated by Messrs. Isler & Co.

Lined with 90 feet of tubes, 13½ inches diameter.

Water level, 27 feet down. Good supply, 12,000 gallons an hour. Pumping at that rate lowers the water-level to 40 feet down.

		Thickness. Feet.	Depth. Feet
Dug well (the rest bored, 13½ inches diameter)		—	11½
[River Drift, 9½ feet.]	Ballast [gravel]	7	18½
	Ballast and clay	2½	21
[Woolwich Beds, 10 feet.]	Sand and pebbles	4	25
	Green sand and pebbles ...	6	31
Grey [Thanet] sand		35	66
[Upper] Chalk and flints		296	362

6. Grove Lane.

Allport's "Collections Illustrative of the Geology, &c. of Camberwell and the Neighbourhood," (1841), p. 8.

Gravel, clay and sand	60	91 feet.
Dark, cindery, friable, earthy matter (decomposed pyrites)	31	
Peacock coal [lignite ?] half a foot		
Clay, to water, at 91 feet		

7. Honour Oak Pumping Station of the Southwark and Vauxhall Water Co., now the Metropolitan Water Board. E. of Priory Farm, S.E. of Peckham Rye Common. 1903 ?

Over 107½ feet above Ordnance Datum.

Communicated by Mr. J. W. Restler.

Shaft and cylinders into the Chalk. Galleries driven at a depth of 236 feet, for a length of 3,123 feet.

Rest-level of the water 4 feet above Ordnance Datum. Yield about 1½ million gallons a day.

		Thickness. Feet.	Depth. Feet.
Soil ...	... ...	1	1
[London Clay, 57 feet.]	Yellow clay	4	5
	Coarse yellow clay ...	19	24
	Blue clay	34	58
[Woolwich and Reading Beds, 42½ feet.]	Fine grey sand	7½	65½
	Clay and shells	11 ? +	76½
	Mottled clay	7 ? —	83½
	Sandy clay and pebbles	6½	90
	Sand and concretions ...	10½ ?—	100½ ?—
[Thanet Sand, 41 feet.]	Green sand	39	139½
	Flints, dark coated ...	2 ?+	141½ ?+ (?should be 151½)
[Upper] Chalk	... ...	148½	300

8. Neate Street (eastern end, northern side). White's Mineral Water Works (formerly Oil-cloth Works). 1886.

8·1 feet above Ordnance Datum.

Made and communicated by Messrs. Le Grand and Sutcliff.

Water-level 17½ feet down. In 1890 30 feet down, a loss of 12½ feet in 5 years.

		Thickness. Feet.	Depth. Feet.
Dug well [? gravel, &c.], the rest bored ...		—	12
[River Drift]	Gravel and sand	11	23
[? Thanet Sand.]	Grey, sand and clay ...	4	27
	Live, grey sand	36	63
[Upper] Chalk and flints		187	250

Camberwell—*continued.*

9. Neate Street, Messrs. White's (? Artis, Capel & Co.).

Made and communicated by Messrs. Isler & Co.

Water-level 18 feet down. Yield 6,000 gallons an hour.

	Thickness. Feet.	Depth. Feet.
Dug well (the rest bored, 10 inches diameter)	—	12
[Woolwich and Thanet Beds] Sand, &c. ...	68	80
[Upper] Chalk and flints	219½	299½

10. Another well in same street. Messrs. White's. Same authority. 1895.

Water-level 20½ feet down. Supply 12,000 gallons an hour. Pumping at this rate lowers the water-level to 40 feet down.

	Thickness. Feet.	Depth. Feet.
Dug well (the rest bored, 13½ inches diameter)	—	13½
[River] gravel	9½	23
[Woolwich Beds, 4½ feet.] Loamy green sand	½	23½
[Woolwich Beds, 4½ feet.] Dead green sand	4	27½
Grey [Thanet] sand	36½	64
[Upper] Chalk and flints	302	366

11. North Surrey Brewery, Messrs. Pugh & Co. 1895.

Made and communicated by Messrs. Isler & Co.

Lined with 40 feet of 7½ inch tube from 25 feet down, and with 83 feet of 5 inch tube from 15 feet down.

Water-level 25 feet down. Supply about 2,000 gallons an hour.

	Thickness. Feet.	Depth. Feet.
Dug well (the rest bored)	—	30
[Woolwich Beds] Green sand and pebbles	9	39
Green [Thanet] sand	41	80
[Upper] Chalk and flints	101	181

Second Well. 1905.

Boring of 7½ inches diameter.

Water-level 41 feet down (G. Barrow),

12. Near Church Street.

R. W. Mylne's "Sections of the London Strata."

To Chalk, 105 feet.

13. Camberwell Grove. Mr. Wynne's.

J. Simpson, *MS. in Library Inst. Civ. Eng.* In 1891 Sir A. R. Binnie could not find this well.

Water rose to 90 feet below the ground.

To Chalk ...	208	508½ feet.
In „ ...	300½	

Camberwell—*continued.*

14. NUNHEAD. Trial-boring, for the Southwark and Vauxhall Water Co. In the ground behind the houses of the N.E. side of Peckham Rye Common and those of the N.W. side of Ryehill Park. 1897. (Now Metropolitan Water Board.)

Communicated by Mr. J. W. RESTLER, the Co.'s Engineer (and from specimens).

110 feet above Ordnance Datum.

		Thickness. Ft.	In.	Depth. Ft.	In.
Soil	...	1	6	1	6
[London Clay.]	Yellow (brown) clay, clay-stones (septaria) 8 inches thick at base	11	8	13	2
	Yellow (brown, rather sandy) clay	1	10	15	0
	Yellow (brown) clay, with clay-stones 6 inches thick at base ...	8	6	23	6
	Yellow (brown and partly grey) clay, with clay-stones (septaria) a foot thick at base	2	3	25	9
	Yellow (brownish-grey) clay (with selenite in upper part)... ...	5	5	31	0
	Blue (grey and brownish) clay ...	40	6	71	6
	[Basement bed.] Blue clay (grey sandy, with green grains) and stones (flint pebbles)	3	6	75	0
	[Basement bed.] Blue sandy clay (grey clayey sand, hard)	2	6	77	6
[Woolwich and Reading Beds, 51¾ feet.]	Blue (grey) clay and shells (*?Cyrena*)	1	4	78	10
	Blue clay (grey, some bits of *Ostrea*, ?carried down)	0	8	79	6
	Light-coloured mottled (pale grey and brown) clay	0	9	80	3
	Dark blue (light-grey) clay ...	5	9	86	0
	Grey sand (buff, compact, fine, ? part clayey)	10	6	96	6
	Clayey sand and shells (grey sandy clay, broken shells)	8	0	104	6
	Mottled clays (puce, grey purple and brown, small calcareous concretions in lower part) ...	6	0	110	6
	Sandy clay (grey and brownish) and pebbles (of flint)	5	9	116	3
	Green sand (deep green, clayey) and small (flint) pebbles ...	4	6	120	9
	Green sand (clayey) with concretion (white calcareous matter, and a few very small flint pebbles)	8	6	129	3
[Thanet Sand, 38 feet.]	Grey sand (fine, buff)	37	3	166	6
	Dark green-coated flints	0	9	167	3
[Upper] Chalk and flints	...	152	9	320	0

15. OLD KENT ROAD. Camberwell Baths. 1903.

Communicated by MR. W. M. BINNY.

About 7 feet above Ordnance Datum.

Boring of 12 inches diameter, 400 feet deep, lined with tubes of 11½ inches diameter into the Chalk.

Standing water-level about 15 feet down.

Tested by continuous pumping for 14 days and yielded water at the rate of 15,379 gallons an hour.

To best of recollection nearly all coarse gravel and sand, with a layer of grey sand and flint just above the Chalk, which was reached at about 50 feet. (? 34.)

Camberwell—*continued.*

16. OLD KENT ROAD. Malt Street, near Canal Bridge. Britannia Brewery. 1877.

8 feet above Ordnance Datum.

Tube-well. Sunk and communicated by MR. G. HAWKSLEY.

Water rose to within 11 feet of the surface; temperature 52°; yield 800 gallons an hour.

	Thickness. Feet.	Depth. Feet.
Soil ...	6	6
Yellow gravel [River Drift] ...	12	18
[Thanet Sand.] Light-coloured, fine, compact sand, without water ...	16½	34½
[Thanet Sand.] Dark sand ...	4½	39
[Upper Chalk] and flints, ending in hard, continuous flint ...	22¾	61¾

17. OLD KENT ROAD No. 561. Welsh Ale Brewery.

Communicated by MR. C. LIDDELL.

About 10 feet above Ordnance Datum.

Water-level, before pumping, in April 1877, 9 feet down. (LUCAS, *Journ. Soc. Arts.*, vol. xxv. p. 608.)

Gravel and sand [the latter partly Thanet] ...	about 30	200 feet.
[Upper Chalk] Loose chalk ...	„ 70	
[Upper Chalk] Soft chalk, with water ...	„ 100	

(? nearly 100 feet deeper.)

18. WALWORTH. Victory Place, Rodney Road. White & Co.'s Mineral Water Works. 1884?

12 feet above Ordnance Datum.

A boring of 6 inches diameter made and communicated by MESSRS. LE GRAND and SUTCLIFF.

Water-level 51 feet down. Yield 2,000 gallons an hour.

		Thickness. Ft.	In.	Depth. Ft.	In.
Soil and sandy gravel [River Drift] ...		18	6	18	6
Blue [London] Clay ...		25	0	43	6
[Woolwich and Reading Beds, 64¾ feet.]	Grey sand ...	5	0	48	6
	Grey stone ...	0	5	48	11
	Blue, sandy clay and shells ... Light-grey clay (? shells) ...	1	4	50	3
	Brown and grey clay ...	1	0	51	3
	Brown clay ...	7	0	58	3
	Brownish-red and grey clay ...	3	0	61	3
	Brown and grey clay ...	12	0	73	3
	Blue clay and shells ...	3	0	76	3
	Yellow and grey clay, with gravel [pebbles] ...	6	0	82	3
	Mottled clay ...	5	0	87	3
	Grey sand ...	2	0	89	3
	Mottled clay, with black pebbles	6	0	95	3
	Grey, sandy clay, with white pebbles ...	7	0	102	3
	Dark green, sandy clay ...	6	0	108	3
[Thanet sand, 38¾ feet.]	Hard, dead, grey sand ...	20	0	128	3
	Live, grey sand ...	18	0	146	3
	Flints ...	0	9	147	0
[Upper] Chalk and flints ...		64	0	211	0

I have some doubt as to the division between the London Clay and the Woolwich and Reading Beds, which may perhaps be a little lower than as given above.

Camberwell—*continued.*

19. Borough Baths. Church Street, Camberwell Green. 1904.

18 feet above Ordnance Datum.

Water-level 38 feet down : falls 30 or 40 feet after pumping for some time. Yield 12,000 gallons an hour.

To Chalk ... 147 } 432 feet.
In ,, ... 285 }

For details see forthcoming Geological Survey Memoir. "London Wells," 1912.

Carshalton.

Ordnance Map 270, new ser. Geological Map, London District, Sheet 3.

Ansell's Paper Mill. [? Papermill Lane.] 1909.

Made and communicated by Messrs. Le Grand and Sutcliff.

Water rose to 17 inches above the ground (October).

		Thickness. Feet.	Depth. Feet.
Soil ...		8½	8½
[Reading Beds, 50½ feet.]	Blue clay ...	10	18½
	Sandy clay ...	5½	24
	Mottled clay ...	25	49
	Green sandy clay and pebbles	10	59
Grey [Thanet] sand ...		38	97
[Upper] Chalk and flints ...		203	300

2. The Grange, formerly Mr. Smee's. The house is on the eastern side of the road over 200 yards from Wallington Bridge and about 1,230 yards N.E. of the parish church. Three borings.

Mr. Smee gave me the following notes in a letter dated August, 1896. The boring which reached the Chalk at 16 feet varied considerably in yield, but did not stop. The boring which reached the Chalk at 30 feet had been intermittent for some time, running for a few hours and then stopping. At first the water rose to 2 feet above the ground, and then took to pulsating. The boring which reached the Chalk at 50 feet was running full bore.

One of the borings is a little north of the mill-pond and close to the eastern edge of the grounds. Another is between the two streams, north-eastward of the house, at their junction.

3. London and Brighton Railway Company's Well. Near the northern side of the line, nearly two-thirds of a mile south-westward of the church. 1906.

From evidence given before a Parliamentary Committee.

About 200 feet above Ordnance Datum.

A boring of 2 feet diameter to 350 feet, in Chalk with flints, the flints decreasing downward. Water met with at various levels.

Water-level about 70 feet down, but rather deeper later.

First regular pumping on June 25, 1906. Over two million gallons in three days.

The contractors put down a boring (? 5 inches diameter and 100 feet deep) 21 feet to the west, and the level of water in this was said not to have been affected by the pumping. *See*, however, pp. 80, 81, where the effect on the Carshalton springs is noticed.

4. Lucas notes 5 Chalk wells in the parish, *Proc. Inst. Civ. Eng.*, 1877, vol. xlvii, pp. 106, 107.

Caterham.

Ordnance Map 286, new ser. Geological Map 8.

1. METROPOLITAN DISTRICT ASYLUM. In the central block, west of the Chapel. From the Foreman of Works (? 1894).

Figures refer to height above mean sea-level (Ordnance Datum).

Floor of engine-room, 607·53 feet. Bottom of western heading, 156·2. Bottom of eastern heading, 156. Bottom of well, 145·2. The well, therefore, is over 462 feet deep, in Chalk, except for the top 34 feet, which pass through soil and clayey beds.

According to MR. TOPLEY's notes, from 9,000 to 10,000 gallons an hour have been pumped. The pumping at this and the Waterworks well did not affect each other.

A communication from the Metropolitan Asylums Board, in 1911, makes the well 500 feet deep ; the water-level at start, 172 feet [? above Ordnance Datum], four hours later, 116 feet ; and the average depth of water in winter, 98 feet, in summer, 160 feet. On going down the well, in 1895, I saw but little water oozing in, a good way down the shaft. I was told that the chief supply came from a fissure in the western heading (bricked up at the entrance, the water being let out through a valve). The eastern heading showed only small springs, at joint-planes, three of which were well marked.

Analyses of the water are given on pp. 292, 293.

2. WATERWORKS. On the eastern side of the road, over 1,000 yards south-westward of the church. 1861.

FIRST WELL. Communicated by MR S. C. HOMERSHAM.

709 feet above Trinity High-water mark.

Shaft, 489 feet, the rest bored.

Normal water-level from 295 to 400 feet above Ordnance Datum.

		Thickness. Feet.	Depth. Feet.
Oldhaven pebble-beds down to 89 feet, when the Chalk was touched at one part ; the gravel not ending, however, for 140 feet from the surface of the ground. A little Clay-with-flints below the gravel in part		89	89
[Middle and Lower Chalk.]	Alternations of hard and soft chalk	241	330
	Very hard chalk. 19 feet down a thin layer of soft clay	27	357
	Hard chalk, nearly all dark. 19 feet down a very hard bed 8 feet thick. From 71 to 76 feet down many fossils	81	438
[Upper Greensand.]	Hard dark gritty bed, like Godstone Stone (the firestone of the Upper Greensand) ...	20	458
	Dark sandy bed	8	466
	Hard dark sandy bed. The foreman of the Godstone quarries said that this was the greensand above the Godstone Stone ...	11	477

It is hard to say whether the last three beds belong to the Upper Greensand, or whether only the last does. It is clear that all the chalk belongs to the Middle and Lower divisions, as no flints were found ; and it would seem that the gravel fills a very deep pipe.

This well was deepened in 1871, and carried further into beds classed as—

	Feet.	Feet.
Upper Greensand	$34\frac{1}{2}$	$511\frac{1}{2}$
Gault	343	$854\frac{1}{2}$
Loose sand (Lower Greensand)	30	$884\frac{1}{2}$

Caterham—*continued.*

2. Waterworks—*continued.*

Second Well. From a tracing communicated by Mr. E. Easton.

About 707 feet above Ordnance Datum.

About 20 feet from engine-house, and 30 feet from the older well, which is in the engine-house.

Shaft a little less than 480 feet; connected to the older well by adits at about 275, 360, and 440 feet (top of each).

Boring about 50 feet, into Gault, and another to Lower Greensand as follows.

Highest normal water-level from Chalk about 306 feet down: lowest, 410 feet down (Mr. Topley notes, ? later, mean 350 feet, lowest 500); normal water-level from Lower Greensand, 395 feet down.

	Thickness. Feet.	Depth. Feet.
Gravel [Blackheath Beds] ...	149	149
Chalk	307	456
Upper Greensand	55	511
Gault clay	343	854
Rock (with phosphatic nodules)	½	854½
Lower Greensand	19½	874

Third Well, 213 (or 220 ?) feet deep, with a boring, made in 1878, gave the following section (J. Barrow, *Proc. S. Wales Inst. Eng.*, vol. xi., no. 7, p. 324, pl. 52). within 90 feet of the other wells :—

	Feet.	Feet.
Gravel and flints [Blackheath Beds]	67	67
Chalk and Chalk Marl	400	467
Upper Greensand	53	520
Gault Clay	331	851
Lower Greensand	11	862

The yield of these works was at most a quarter of a million gallons a day. They have been absorbed by the East Surrey Co. and abandoned.

For an analysis of the water, *see* pp. 293, 294.

Cheam.

Ordnance Map 270, new ser. Geological Map 8.

Lucas notes three Chalk-wells here. *Proc. Inst. C.E.*, 1877, vol. xlvii, pp. 102, 103 ?

Chelsham.

Ordnance Map 286, new ser. Geological Map 6.

1. Chelsham and Woldingham Water Co. In the valley on the western side of the road northward of Warren Barn. 1884.

About 500 feet above Ordnance Datum.

Made and communicated by Mr. J. Taylor, then of Reigate.

Shaft, 6 feet diameter to 170 feet, and then of 10 feet.

Water found at 160 feet, and the work stopped by water at 163 feet, pending the fixing of temporary pumps. On leaving off in February, at 184½ feet, water rose 54 feet in some days. In the autumn the water sank, and at last disappeared: the well was then deepened. In the spring of 1885 the water stood 82 feet up.

		Thickness. Feet.	Depth. Feet.
[Valley Deposit]	Light soil and flints	8	8
	,, ,, merging into rubbly chalk	10	18
[? Middle and Lower Chalk.]	Rubbly chalk	31	49
	Hard chalk	9	58
	Very hard chalk	26	84
	Rotten clayey chalk	1	85
	Grey chalk	139	224

Chelsham—*continued.*

1. Chelsham and Woldingham Water Co.—*continued.*

Mr. Taylor gave me a record of gaugings of this well from May, 1885, to February, 1888, from which the following has been compiled. The figures are depths of water in the well, and not depths from the surface to the water.

1885. May 23. 79 ft. 2 in.
1886. 34 trials. From 86 ft. 6 in. on June 25 to 36 ft. 7 in. on October 28, and to 30 ft. 6 in. on October 12, after four hours' pumping.
1887. 107 trials. From 143 feet 9 in. on February 1 to 32 ft. on November 18.
1888. 13 trials. From 56 ft. 6 in. on January 3 to 53 ft. 8 in. on February 3.

The following show the effect of pumping :—

1886.	November 12.	Before pumping, 45 ft. 7 in.	After pumping, 36 ft.
	„ 25.	„ „ 60 ft. 4 in.	„ „ 49 ft. 5 in.
	December 29.	„ „ 76 ft. 9 in.	„ „ 67 ft.
1887.	March 23.	„ „ 97 ft. 4 in.	„ „ 89 ft.
	June 16.	„ „ 60 ft. 2 in.	„ „ 53 ft.
	„ 24.	„ „ 59 ft. 2 in.	„ „ 49 ft. 10 in.
	July 4.	„ „ 57 ft. 8 in.	„ „ 42 ft. 6 in.
	„ 7.	„ „ 57 ft.	„ „ 42 ft. 6 in.
	„ 12.	„ „ 56 ft. 5 in.	„ „ 39 ft. 11 in.
	„ 19.	„ „ 54 ft. 11 in.	„ „ 42 ft.
	„ 25.	„ „ 53 ft. 3 in.	„ „ 41 ft. 7 in.
	August 15.	„ „ 50 ft. 5 in.	„ „ 37 ft. 8 in.
	September 21.	„ „ 43 ft. 11 in.	„ „ 30 ft. 6 in.
	„ 27.	„ „ 42 ft. 8 in.	„ „ 34 ft. 3 in.
	October 4.	„ „ 41 ft. 1 in.	„ „ 29 ft. 6 in.
	„ 10.	„ „ 39 ft. 6 in.	„ „ 29 ft.

According to Dr. Seaton, in his Report to the County Council, 1905, there are headings ; the area of supply is the parish of Woldingham and part of the parish of Chelsham ; and the population was about 500 in 1901.

2. Henley Wood.

From the MS. of the Report of the Henley Wood Exploration Committee of the *Croydon Nat. Hist. Soc.* 1912. By N. F. Robarts.

An old well in the southern part of the wood was cleared out in 1911. It may possibly date from the 13th or 14th century. The diameter is 4 feet 1 inch to 53 feet down ; then 3 feet 11 inches to 68 ; 3 feet 9 inches to 106 ; 3 feet 7 inches to 115 ; 3 feet 4½ inches to 132 ; and 3 feet 4 inches to 143½ feet. There is flint steining to 6¾ feet down.

Chalk with flints to 45 feet, where there is a band of flint.

Flints ceased at 83 feet, and blocky chalk then reached to 96 feet.

Thence to the bottom the workmen reported chalk with flints. Mr. Robarts thinks that the flints were scarce. The men reported that the last few feet seemed to have held water.

This is an interesting case of a very old well (on high ground), the bottom of which is above the present level of underground water in the neighbourhood. It lends some support to the view that underground water once rose to a higher level than now.

3. Lucas notes the wells at Hallelu and Bughill Farms, *Proc. Inst. Civ. Eng.*, 1877, vol. xlvii., pp. 106, 107, as 408 and 375 feet above Ordnance Datum and 117 and 124 feet deep. The water-levels vary, even to dryness in the latter.

Chertsey.

Ordnance Map 269, new ser. Geological Map. London District, Sheet 3.

1. BREWERY. 1872. About 100 yards from the western side of Guildford Street, about midway between the church and the railway-station.

Communicated by MR. E. SWAIN.

Water overflows at the rate of about 600 gallons an hour.

Shaft 40 feet (1867); the rest bored.

		Thickness. Feet.	Depth. Feet.
Surface-mould and loamy clay... ... ... about		5	5
Gravel and sand ...		35	40
Dark sand		4	44
Blue [London] Clay, with many beds of clay-stone [septaria]		386	430
[Reading Beds, 93 feet.]	Mottled clay	50	480
	Greenish sand, with water	6	486
	Brown clay	25	511
	Hard green sand ...	12	523
[Upper] Chalk and flints		151	674

Mr. T. TILLEY told me that he found the Chalk at 517 feet in a well at Chertsey. This refers to the above, which was made by MESSRS. TILLEY.

Second well. 1888.

Bored and communicated by MESSRS. ISLER.

Water overflowed at the rate of 430 gallons an hour.

		Thickness. Feet.	Depth. Feet.
Made ground		5	5
[River Gravel.] Ballast		28	33
[Bagshot] Sand ...		17½	50½
[London Clay, 361½ feet.]	Sand and blue clay [? passage-beds] ...	23½	74
	Blue clay; with claystone at 155–156, claystone and pebbles at 179–180, claystone and pyrites at 195–197 and 240–242, and claystone at 384–385 ...	338	412
[Reading Beds, 104 feet.]	Green sand...	15	427
	Mottled clay	30	457
	Brown loamy sand	18	475
	Sand and water ...	15	490
	Brown clay	15	505
	Green sand...	11	516
[Upper] Chalk ...		304	820

According to MR. E. A. MARTIN the boring has been continued 180 feet deeper in the Chalk, giving a total depth of 1,000 feet. *Science Gossip*, 1898, n. ser. vol. v., p. 119.

There is some doubt as to the division between the London Clay and the Reading Beds in these two wells, the thickness given to the latter being probably too great.

2. SANDGATE. South-west of the town.

PRESTWICH, MS. note and *Proc. Roy. Inst. Brit. Architects*, ? 1850.

No water.

White [Bagshot] Sand ...	50	620 feet.
London Clay	530	
[Reading Beds] Mottled clay	40	

Chertsey—*continued.*

3. OTTERSHAW PARK. About 3 miles S.E. of the centre of the town. 1911.

C. REID. Summary of Progress of the Geological Survey for 1910, pp. 25, 26. With additions from MR. REID.

Boring made by MESSRS. DUKE and OCKENDEN. From whom has come the later information that the total depth is 1,586 feet, the water rising to 78 feet above the surface at the rate of 5,500 gallons an hour. The overflow (at the surface) was 132,000 gallons a day.

Lined with tubes decreasing from 12 inches diameter to 3 inches, below 1,530 feet.

	Thickness. Feet.	Depth. Feet.
Bracklesham Beds	89	89
Lower Bagshot Beds	124	213
London Clay	336	549
Reading Beds	100	649
Upper Chalk	40	689
Eocene clays and sands mixed with chalk and plants ...	211	900
Middle and Lower Chalk. Characteristic Melbourn Rock between 927 and 936 feet	315	1,215
Upper Greensand. Fine-grained silty and more or less glauconitic sandstones (hearth-stones and fire-stones) ...	45	1,260
Upper Gault [? sandy at top] with phosphatic nodules at the base	108	1,368
Lower Gault. Darker and more clayey than the above ...	188	1,556
Lower Greensand, from which water overflowed, at 1,573 feet, and rose to 73 above the surface at 1,583.		

"The boring seems to have followed the line of a nearly vertical fissure which slightly diverted the tool, for at 900 feet the system of boring, and the crown and chilled shot, cutting a solid core, was substituted for the percussion-tool. The boring immediately re-entered solid chalk, but had apparently passed through the Chalk-rock whilst in the fissure."

4. THE WOKING AND DISTRICT WATER CO. gets some water from gravel-wells.

Chiddingfold.

Ordnance Map 301, new ser. Geological Map 8.

1. REDWOOD. For Mr. S. Barrow. 1901.

Made and communicated by MESSRS. DUKE & OCKENDEN.

		Thickness Feet.	Depth. Feet.
Dug well [? old]		—	92
[Weald Clay.]	Blue clay	21	113
	Sand-rock	7	120
	Blue and brown clay ...	23	143
	Blue clay and clay-rock	33	176
	Blue and brown clay ...	8	184
	Blue clay and clay-rock	33	217
	Blue and brown clay ...	19	236
	Red clay	14	250

2. MR. H. B. WOODWARD tells me (1912) that limited supplies of water are got in shallow wells, from sandy beds within 30 feet of the surface.

Chipstead.

Ordnance Map 286, new ser. Geological Map 8.

LUCAS notes eight Chalk-walls in this parish. *Proc. Inst. C. E.*, 1877, vol. xlvii., pp. 104, 105.

Chilworth *see* Wonersh.

Chobham Place.

Ordnance Map 269, new ser. Geological Map 8.

PRESTWICH, *Quart. Journ. Geol. Soc.*, vol. iii., pp. 381, 384, and MS. note, left by him.

Water rose to 100 feet from the ground.

		Thickness. Feet.	Depth. Feet.
Upper Bagshot Sand		about 100	100
Middle Bagshot Beds, more clayey, with green sand		" 40	140
Lower Bagshot Sand		" 100 (? or more)	240
London Clay		" 400	640
[Reading Beds, given as 50 feet.]	Grey clay	" 5	645
	Mottled clay	" 40	685
	Brown sand	" 2	687
	Pebbles...	" 1	688
[Upper] Chalk		" 150 about	740

In *Proc. Roy. Inst. Brit. Architects* for 1850, PRESTWICH gives the depth to the Chalk as 649 feet.

Clapham.

Ordnance Map 270, new ser. Geological Map. London District, Sheet 3.

1. CLAPHAM COMMON.

DR. MANTELL in Brayley's *History of Surrey*, vol. i., p. 133 (1843).

Blue [London] Clay, 200 feet.

Sand, with many shells and water [basement-bed ?].

2. CLAPHAM ROAD. No. 139. Messrs. Causton's Printing Works. 1898 ?

Made and communicated by MESSRS. ISLER. Section printed in various newspapers.

Lined with 190 feet of tube, 15 inches in diameter, from 20 feet down.

Water-level 54 feet below surface in bore. Supply 12,000 to 18,000 gallons an hour.

		Thickness. Feet.	Depth. Feet.
Soil (made ground)		8	8
[River] Gravel		20	28
[London Clay, 81½ feet.]	Blue clay	77	105
	[Basement-bed] Black [flint] pebbles	1½	106½
	[Basement-bed] Green sand	3	109½
[Woolwich and Reading Beds, 47½ feet.]	Bed of shells	1½	111
	Dead grey sand	10	121
	Mottled clay	6½	127½
	Loamy sand	5½	133
	Hard mottled clay	14½	147½
	Congealed [cemented] pebbles ...	3	150½
	Green sand and pebbles	6½	157
[Thanet Sand, 38 feet.]	Green sand	5	162
	Hard grey sand	9	171
	Dark green sand	11	182
	Dark grey sand	13	195
[Upper Chalk.]	Flints with chalk	225	420
	Hard grey chalk	5	425

Clapham—*continued.*

3. Clapham Road. No. 14. For the City & South London Railway.

Made and communicated by Messrs. Isler.

Dug well, 5 feet, the rest bored.
218 feet of tubes $11\frac{1}{2}$ inches in diameter from 6 feet above the surface.
30 „ „ 18 „ „ from the surface.
Yield, tested with an Air Lift Pump, 10,500 gallons per hour.
Standing water-level 78 feet down.

		Thickness. Feet.	Depth. Feet.
Made ground ...		5	5
[River Gravel] Ballast		18	23
Blue [London] Clay ...		97	120
[Reading Beds.]	Grey loamy sand ...	22	142
	Mottled clay ...	15	157
	Clay and pebbles ...	5	162
[Thanet Sand, 49 feet.]	Green sand ...	30	192
	Grey sand ...	18	210
	Green-coated flints	1	211
[Upper Chalk.]	Chalk and flints ...	175	385 ?
	Grey chalk ...	16	400 ?

This place may be in Lambeth.

Cobham.

Ordnance Map 286, new ser. Geological Map 8.

Hatchford. Lord F. Egerton's. About $1\frac{1}{2}$ miles S.W. of the village, on a hill higher than the top of the house. 1843.

Sunk and communicated by Mr. C. Page, of Uxbridge.

Shaft 45 feet ; the rest bored.
At a depth of 625 feet the water rose to within 25 feet from the surface.

		Thickness. Feet.	Depth. Feet.
[Bagshot] sand, the lower part with water		80	80
Blue London Clay ...		362	442
Coloured grey clay [? partly London Clay]		100	542
[Reading Beds.]	Plastic clay ...	14	556
	Black and green sand...	4	560
	White marl and shells	2	562
	Pebbles and green sand	8	570
[? Thanet (or Reading) Beds.]	Green sand ...	8	578
	Grey clay, with sand ...	5	583
	Black flint-rock ...	1	584
[Upper] Chalk, with flints at intervals ...		66	650

Compton.

Ordnance Map 285, new ser. Geological Map 8.

1. Heath Nurseries. 1900.

Made and communicated by Messrs. Duke & Ockenden.

Water-level 48 feet down.

	Thickness. Feet.	Depth. Feet.
Dug well [? old]	—	50
Sand	6	56
Bargate stone ...	2	58
Sand and clay...	50	108

2. According to Lucas, *Proc. Inst. Civ. Eng.*, 1877, vol. xlvii, p. 97, the water-level in a Chalk-well at Down Place was 283 feet above Ordnance Datum in

Compton—*continued.*

November 1876; possibly two other wells, given as in St. Nicholas parish, are in Compton.

3. He also notes four wells in Lower Greensand. *Proc. Inst. Civ. Eng.*, 1880, vol. lxi, pt. iii, p. 219. Besides three in the parish of St. Nicholas.

Coulsdon.

Ordnance Map 286, new ser. Geological Map 8, and London District, Sheet 4.

1. Asylum (? Cane Hill) Smitham Bottom. 1878.

Sunk and communicated by Messrs. Docwra.

Shaft throughout.
Water found at 97½ feet.

		Thickness. Feet.	Depth. Feet.
Loose ballast...		6	6
Chalk	Loose chalk	30	36
	Chalk	5	41
	Hard grey chalk and flints	13	54
	Hard chalk, with two layers of flints	43½	97½
	Chalk and flints	1	98½

2. Reedham Asylum.

Letter from Mr. J. C. Carter (Master) to Mr. Topley.

Well 230 feet deep. Headings south, north, and west (10 feet high, 6 wide); the first 20 feet long, the other two 40. Their floors are about 12 feet above the bottom of the well, and the northern one dips down considerably.

The water (April, 1894) 20 feet up in the well, so that the headings are nearly full. The lowest level, according to Mr. Topley, gave about 6 feet of water in the well.

3. Kenley. East Surrey Waterworks. In the bottom of the valley.

Information from Mr. A. E. Cornewall-Walker.

Four borings, 250, 350, 308 and 353 feet deep, lined with cast iron cylinders 100 feet down. The first made about 1873 and enlarged in 1883; the second made in 1884; the third made in 1891; the fourth made in 1895. Average level of the borings 263 feet above Ordnance Datum.

Rest-level of water, at end of August 1911, 48 feet down. Pumping at the rate of 1,000 gallons a minute lowers the water-level about 20 feet. This quantity of water can be got from borings 3 or 4, but 1 and 2 are of smaller diameter and have not been tested so far.

Except for 10 feet at the top [soil and gravel] the borings are wholly in Chalk.

Presumably this is mainly through Middle Chalk, there can be but little Upper; but probably the Lower Chalk is reached. This is a case of a large supply being got from the lower part of the Chalk. W.W.

For an analysis of the water *see* pp. 294, 295.

4. Purley. East Surrey Waterworks. Between the Brighton and Caterham Roads, westward of the railway station.

About 215 feet above Ordnance Datum.

Made and communicated by Mr. R. Batchelor (with notes from specimens in the Company's office at the works, in brackets).

Borehole No. 4 (the deepest), with shaft of 11½ feet.

		Thickness. Feet.	Depth. Feet.
Soil and Gravel [Valley Drift]		5¼	5¼
[Upper, Middle, and Lower Chalk.]	Chalk and flints ...	451¾	457
[Lower Chalk, ? at base Upper Greensand.]	Chalk Marl, base firm	10	467
	Clay (dark chalk marl at 476 feet; light-coloured greenish sand, with glauconite-grains, ? chalky, at 478)	12	479

Coulsdon—*continued.*

4. Purley—*continued.*

		Thickness. Feet.	Depth. Feet.
[Upper Greensand, 35 feet ?]	Green sand, fine (like the last, but finer, at 480 feet. Pale green sand at 482, 484, rather greener, 486, 488, and 490)	12	491
	Rock	1	492
	Dark greensand rock (light-grey fine sand at every 2 feet, from 492 to 510, getting clayey going downward, and at 512 a sandy clay)	22	514
[Gault.]	Clay (sandy clay, every 2 feet, from 514 to 521½) ...	8	522

A large supply of water has been got at these works.

Mr. Batchelor tells me that he put down four large borings here.

5. Lucas notes six Chalk wells in this parish. *Proc. Inst. Civ. Eng.*, 1877, vol. xlvii, pp. 104, 105.

Cranley or Cranleigh.

Ordnance Map 301, new ser. Geological Map 8.

1. Baynards. London and Brighton Railway. About 100 yards westward of the station, by side of road. 1900.

Made and communicated by Messrs. Duke and Ockenden.

Lined to 317 feet down.
Clay and rock, 350 feet.

2. Bog. (Field 676 of 25 in. Map xxxix-ii. ed. 2, 1896.)

Boring of 3 inches diameter, from 19½ feet downward.

Communicated by Mr. Stephen Rowland, of Yew Tree House. 1901.

	Ft. In.	Ft. In.
Bog, cleaned out to the depth of...	19 6	61 4
Shaly clay	4 0	
Red clay, with a slight admixture of blue clay here and there	37 10	

When the bottom of the bog was reached a good flow of water was obtained from several fissures in the shale, and, with a view of increasing the supply, the bore-hole was made, but with no result.

3. Wethersal Grange.

Bored and communicated by Messrs. Duke and Ockenden.

[Weald Clay.]	Old well, the rest bored	43	98 feet.
	Hard clay, no water ...	55	

4. The following are from Mr. Topley's notes, taken long ago.

Two wells (? borings) near Windmill, 120 feet deep. Water overflows.

Smithwood Common. Boring in progress, 215 feet deep, ? sand just being approached.

Boring at Brewery, close to church, 100 feet deep, no water yet.

5. Waterworks.

According to the Water Works Directory, 1911, the works were established in 1886, the hardness of the water is 3·5°, and the population supplied is 2,400. I could get no further particulars.

Croydon.

Ordnance Map 270, new ser. Geological Map, London and District, Sheet 4.

1. EMPRESS LAUNDRY. Dartnell Road. 1902.

Made and communicated by MESSRS. DUKE & OCKENDEN.

The only indications of water were at 287 to 296 feet down. Later the water rose to a considerable height above the ground.

		Thickness. Feet.	Depth. Feet.
Made ground		4	4
Gravel		4	8
[London Clay.]	Clay	54	62
	Rock	6	68
	Clay	8	76
	Sand	13	89
	Sand and clay	3	92
	Clay	16	108
	Rock	2	110
	Clay	3	113
[? London Clay and Reading Beds.] Green sand and clay		121	134
[Thanet] Sand		43	177
[Upper] Chalk		133	310

For an analysis of the water *see* p 295.

2. GASWORKS, Waddon. 1868.

Communicated by MR B. LATHAM.

126 feet above Ordnance Datum.

Shaft about 40 feet; the rest bored.

A failure as regards water-supply from the Chalk. Bore-hole filled up, and water got from the Tertiary sands.

		Thickness. Feet.	Depth. Feet.
Black clay		16	16
Yellow clay		6	22
[Reading Beds, 68 feet.]	Black sand [Oldhaven Beds?]	20	42
	Mottled clay	38	80
	Oyster-bed [? clayey green sand]	10	90
[Thanet Sand, 18¾ feet.]	Mouse-coloured and black sand and pebbles	12	102
	Green sand	6	108
	Green flints	¾	108¾
[Upper] Chalk and black flints		138	246¾

The mottled clay is given as 33 feet thick in *Proc. Croydon Micr. Nat. Hist. Club*, 1884, p. cli., and mouse-coloured is given as mauve-coloured.

SECOND WELL, about 300 yards southward of the other. 1890.

Made and communicated by MESSRS. LE GRAND and SUTCLIFF.

Water rising to 5 feet below the ground. Supply ample.

		Thickness. Feet.	Depth. Feet.
Pit (gravel)		—	7
[Woolwich and Reading Beds.]	Stony clay	3	10
	Hard clay	7	17
	Plastic clay	4	21
	Sand and pebbles	9	30
[? Woolwich and Thanet Beds.]	Blowing sand	11½	41½
	Black sand	19	60½
	Sandy silt	13½	74
[Upper] Chalk and flints, with a vein of sand at the depth of 102–102½		210	284

In the older well the depth to the Chalk is 108¾ feet, or more than 34 in excess of the above, showing a southerly rise of about 1 in 26.

Croydon—*continued.*

2. Gasworks, Waddon—*continued.*

Third Well. 1898.

Made and communicated by Messrs. Le Grand and Sutcliff.

Water-level 4½ feet down (June).

		Thickness. Feet.	Depth. Feet.
Soil	...	2	2
[River] Gravel	...	4½	6½
[Reading Beds, 31½ feet.]	Mottled clay	13½	20
	Sandy clay	4	24
	" " and pebbles	14	38
[Thanet Sand, 36 feet.]	Grey sand	2	40
	Dark "	30	70
	Loamy sand	3	73
	Green flints	1	74
[Upper Chalk, 330½ feet.]	Chalk and flints, sticky	179	253
	" " hard	151½	404½

3. Gloucester Road. No. 43. American Steam Laundry. 1896.

About 175 feet above Ordnance Datum.

Made and communicated by Messrs. Isler.

Lined with 175 feet of tubes, 6 inches in diameter, from 5 feet down. Water-level 66 feet down. Supply about 1000 gallons an hour.

		Thickness. Feet.	Depth. Feet.
[River Gravel.]	Ballast, with water	19	19
[London Clay, 50 feet.]	Blue clay ...	47	66
	Clay and pebbles (? with water)	3	69
[? Oldhaven Beds.]	Hard grey sand (? with water)	13	82
[Woolwich and Reading Beds, 51 feet.]	Blue clay ...	11	93
	Mottled clay	20	113
	Green sand and pebbles...	5	118
	Green sand, with water ...	15	133
[Thanet Sand, 42 feet.]	Grey " " "	27	160
	Green " " "	9	169
	Loamy sand	6	175
[Upper] Chalk and flints	...	75	250

4. Mitcham Road. Ice Co. By the western end of the Barracks. 1899.

About 138 feet above Ordnance Datum.

Made and communicated by Messrs. Le Grand and Sutcliff.

Diameter of bore 4 inches. Water-level 12 feet down (June). Yield 1240 gallons an hour.

		Thickness. Feet.	Depth. Feet.
Soil ...	...	1½	1½
[River Drift.]	Gravel	17½	19
	Brown sand ...	4	23
[Woolwich and Reading Beds, 40½ feet.]	Blue clay and shells...	8½	31½
	Black clayey soil	3½	35
	Blue clay	4	39
	Mottled clay ...	15½	54½
	Grey loamy sand	1	55½
	Green sandy clay	8	63½
Grey [Thanet] sand	...	45½	109
[Upper Chalk]	Chalk and flints	12	121
	" " harder	129	250

Croydon—*continued.*

5. Morland Road, about half-way along, next to No. 58. Messrs. White's Mineral Water Manufactory. 1896.

Made and communicated by Messrs. Isler.

Lined with 190 feet of tube, of 8½ inches diameter, from 2 feet down. Water-level 32 feet down. Supply 4200 gallons an hour.

		Thickness. Feet.	Depth. Feet.
	Well (made ground), the rest bored ...	9	9
[London Clay.]	Clay	17	26
	Blue clay	17	43
[Blackheath Beds, 37½ feet.]	Dark gravel [pebbles] ...	18	61
	Rock	1½	62½
	Ballast [pebbles] ...	18	80½
[Woolwich and Reading Beds, 42½ feet.]	Blue clay	4	84½
	Mottled clay	23½	108
	Green sand and pebbles	15	123
[Thanet Sand, 41 feet.]	Rock	3	126
	Sandstone [firm sand]	23	149
	Dark loamy sand ...	15	164
[Upper Chalk.]	Chalk	8	172
	Chalk and flints ...	51	223
	Chalk	127	350

6. Norwood. The Jolly Sailor [64, High Street, South Norwood].

From Sir J. Prestwich's MSS.

Depth 140 feet. Water found in the pebble-bed [below London Clay].
London Clay, 70 feet.
Bed of clayey limestone with shells [? Woolwich Beds] at 80 feet.

7. Pitlake. Surrey Ironworks (Messrs. Measures). 1902.

(Within 100 yards of the Ice Co.'s well, *see* above.)

Bored and communicated by Messrs. Duke & Ockenden.

		Thickness. Feet.	Depth. Feet.
[River Drift.]	Sand and gravel... ...	15	15
[Woolwich and Reading Beds, 40 feet.]	Blue clay	22	37
	Yellow clay	11	48
	Green sand and clay ...	7	55
[Thanet Sand, 50 feet.]	Green and white sand	3	58
	White and black sand	12½	70½
	Black sand	27	97½
	Sand and clay	7½	105
[Upper Chalk.]	Marl	16	121
	Chalk and Flints ...	179	300

For an analysis of the water *see* p. 296.

8. Thornton Heath. Trial-boring for the Lambeth Water Company, next the Reservoir. 1891. Now Metrop. Water Board.

218·2 feet above Ordnance Datum.

Made and communicated by Messrs. Docwra; with some particulars from a Report by Mr. Etheridge, communicated by Mr. S. H. Loutitt, Secretary to the Company.

Water-level 119 feet down.

		Thickness. Feet.	Depth. Feet.
[London Clay.]	Yellow clay [? also gravel and sand, according to Mr. Etheridge]	16½	16½
	Stones [pebble-bed, according to Mr. Etheridge]	¾	17¼
	Coloured clay	11¾	29
	Blue clay	30	59
	[Basement-bed] Sand	2	61
	[Basement-bed] Grey stone, with shells	1¾	62¾

Croydon—*continued.*

8. THORNTON HEATH—*continued.*

		Thickness. Feet.	Depth Feet.
[Oldhaven Beds.]	Fine sand ...	12	74¾
	Clay, with stones and shells [thin pebble-bed, according to Mr. Etheridge] ...	¼	75
[Woolwich and Reading Beds, 42½ feet.]	Black clay [dark grey, Etheridge]; shells and stone mixed ...	14	89
	Mottled clay ...	15½	104½
	Green sand and pebbles ...	6	110½
	Green sand...	6	116½
	Pebbles, very hard ...	1	117½
[Thanet Sand, 47½ feet.]	Very hard sand ...	12½	130
	Sand, not so hard ...	15	145
	Sand ...	15	160
	Black sand, like clay ...	4	164
	Flints ...	1	165
[Upper] Chalk, with flints [hard bed at 271–295, according to Mr. Etheridge] ...		305	470

At 177 feet the yield was 250 gallons an hour.
" 207 " " " 550 " " " or 13,200 a day. (3-inch pump).
" " " " " 1070 " " " or 25,680 a day.
" 288 " " " 2520 " " " or 60,480 a day (6-inch pipe), after boring to 420 feet

WELL AND HEADINGS. 1901.

Shaft, made and communicated by MESSRS. DOCWRA.

		Thickness. Feet.	Depth Feet.
[London Clay.]	Yellow clay ...	57¾	57¾
	Dark sand, with pebbles	¼	58
[Oldhaven Beds 16 feet.]	Light-coloured sand ...	5	63
	Dark sand ...	11	74
[Woolwich and Reading Beds, 31 feet.]	Blue stone ...	1	75
	Shells and sand ...	4	79
	Dark clay ...	2	81
	Shells and sand ...	5	86
	Blue clay ...	½	86½
	Mottled clay ...	15¾	102¼
	Light-coloured sand ...	½	102¾
	Sand and pebbles ...	2¼	105
[? Woolwich & Thanet.]	Green sand ...	19	124
	Thanet sand ...	38	162
[Upper] Chalk ...		78	240

This differs in details from the account of the trial-boring. The London Clay is made a little thinner, the Oldhaven Beds a little thicker, and the depth to the Chalk 3 feet less.

9. SHIRLEY BREWERY

Information from MR. L. W. LAMOTTE (1891).

Shaft 200 feet, of 5 feet diameter to 125, then tapering to 4 feet. Deepened later, 25 feet. Bored to 500 feet?

Galleries, 10 feet by 7 feet high, at 200 feet and lower.

Plenty of water for all requirements [from the Chalk].

Later information, from MR. T. WALKER, Borough Engineer (October, 1898), makes the ground-level 336 feet above Ordnance Datum, the water-level 167·7 feet above O.D., and the depth of the well 237 feet.

He also notes some shallow wells in Tertiary beds, at the Infants' Schools (50 feet), at Surprise Tavern, at cottages in Shirley Road, and at Shirley Lodge Farm.

Croydon—*continued.*

10. Wickham Road. St. Olave's Union Cottage Schools. About 600 yards S.W. of Ham Farm. 1903.

About 210 feet above Ordnance Datum.

Water-level about 60 feet down. Yield 4,000 to 5,000 gallons an hour (1903).

To Chalk 140 }
In ,, 160 } 300 feet.

For details *see* Geol. Survey Memoir "London Wells," 1912.

11. Workhouse, Queen's Road. 1883.

162 feet above Ordnance Datum.

Mr. H. M. Klaassen. *Proc. Croydon Micr. Nat. Hist. Club*, 1884, pp. cli, cliii; and information from Mr. J. Berney.

Shaft 63 feet; the rest bored (6 inches diameter). Water-level 70 feet down.

		Thickness. Feet.	Depth. Feet.
Mould		2	2
[River] Gravel		9	11
[London Clay, 55½ feet.]	Mouse-coloured clay	3	14
	Clay, with septaria a foot thick, 6 feet down	29	43
	Sandy clay	1	44
	Clay	4	48
	Sandy clay	3	51
	Clay	6	57
	Sandy clay	3	60
	Clay	2	62
	Sandy clay and septaria	1	63
	Sand } [? Oldhaven Beds]	2	65
	Sand and pebbles } [? Oldhaven Beds]	1½	66½
[Woolwich and Reading Beds, 56 feet.]	Blue clay	25	91½
	Mottled clay	16	107½
	Dark sand	1	108½
	Green sand and pebbles	14	122½
[Thanet Beds, 54 feet.]	Light-coloured sand	43	165½
	Loamy sand, with water	10	175½
	Flints	1	176½
[Upper] Chalk and flints; no water		281½	458

One would take the blue clay 66½ feet down to be London Clay but for the bed above. Perhaps it is only the shell-beds in great thickness. Mr. Klaassen told me that in 1866 a well was dug and abandoned, 100 feet to the west, in which, instead of the blue clay and the two beds above it, the following were found:—

Dark sandstone	2	} 29 feet.
Light-coloured sand	5	
Stone	1	
Pale sand	1	
Black sand	4	
Sandstone	5	
Sandy clay	3	
Shelly bed	2	
Black, sandy clay and sand	6	

He infers that, if both sections are right, the fault shown in the Park Hill railway-section (1883) extends northward.

A letter from Mr. J. Berney, gives the following particulars:—Originally water was found at the bottom of the well (63 feet) and rose to 30 feet from the ground. At first it came in pretty rapidly, but soon lost its power, and was easily pumped out, by a 4 horse-power engine, in 1½ hours. When the boring passed through the 10 feet of loamy sand [Thanet], the water in the well (to the level of the top of the bore-pipe) passed down the pipe and continued to do so as fast as water rose in the well.

Croydon—*continued.*

12. Waterworks.

There are three pumping stations in the borough (besides one at Addington *see* p. 104). These will be noticed in order of age. The area supplied from these includes the village of Addington, the Croydon Mental Hospital, and all but the northern part of the borough.

Surrey Street Works opened in 1851.

According to Sir R. Rawlinson (Report on the Waterworks at Croydon, 1882) there are 4 wells, 2 sunk in 1851, 1 in 1865, and 1 in 1877, with a total yield of 2,460,000 gallons a day. Mr. H. M. Klaassen told me that the last of these passed through 10 feet of gravel and 204½ of Chalk with flints.

Mr. G. F. Carter has communicated the following particulars (1911) :—

The four wells are connected by pipes for syphoning the water. The wells are lined watertight to the following depths: No. 1 to 56 feet, No. 2 to 75 feet, No. 3 to 60 feet, No. 4 to 75 feet. The wells were made at the following dates :—1851, 1864, 1867, 1875 (differs from above).

Taking the ground-level at 150 feet above Ordnance Datum, the rest-level of water is about 14 feet below ground, and when pumping is going on at the rate of about 2½ millions of gallons a day the water is lowered to a depth of about 27 feet below ground. Pumping is continuous, night and day.

Dr. H. M. Richards, in his Annual Report for 1905, says : "All these wells pass through three or four feet of made ground and about 11 feet of valley gravel before entering the chalk. . . Each well is further bored to a depth varying from 150 to 264 feet."

The following are sections of two of the wells :—

A. Well No. 1. 1851.

Sunk and communicated by Messrs. T. Docwra & Son. Some particulars added from a MS. section in the Engineer's Office, Metropolitan Board of Works.

Yield 1,500,000 gallons a day.

		Thickness. Feet.	Depth. Feet.
Made ground		4	4
[Valley Drift, 11 feet.]	Rough, loamy gravel	4	8
	Sand	½	8½
	Finer, loamy gravel	3½	12
	Coarse gravel	3	15
[Upper Chalk, 62 feet.]	Hard chalk, with large flints	15	30
	Chalk	24	54
	Hard crust (the chief supply of water comes from this)	1½	55½
	Chalk	21½	77

B. Well No. 2. 1864. 56 feet from the older well.

Sunk and communicated by Messrs. T. Docwra & Son.

Water rose to a height of 11½ feet below the surface.

		Thickness. Feet.	Depth. Feet.
Made ground		5¼	5¼
Gravel, 9¾ feet.	Black gravel	1½	6¾
	Grey gravel	1	7¾
	Red gravel ...	¼	8
	Yellow gravel	7	15
[Upper Chalk, 137 feet.]	Chalk (with rough gravel 7 feet down on one side of the well)	23	38
	Chalk, layers of flints every 6 inches	10	48
	Flints and chalk	16	64
	Flints and rock chalk	29	93
	Hard chalk...	11½	104½
	Yellow chalk	2	106½
	Rock chalk...	4	110½

Croydon—*continued.*

12. WATERWORKS.—B. Well No. 2—*continued.*

		Thickness. Feet.	Depth. Feet.
[Upper Chalk, 137 feet]—*cont.*	Chalk and flints	13	123½
	Blue clay	½	124
	Chalk and flints	12	136
	Grey chalk	1	137
	Chalk and scattered flints	8	145
	Soft chalk	7	152

Analyses of the water from the Surrey Street Station are given on pp. 296, 297.

Stroud Green Works. 1905.

A little more than 500 yards northward of Shirley House.

Communicated by MR. G. F. CARTER, Borough Engineer.

192·6 feet above Ordnance Datum.

Shaft 391 feet. Bricked about 20 feet, cylinders to 154. Upper Headings 2,800 feet long, from 224–230 feet down; Lower Headings 1,380 feet long, 374–380 feet down. With a 12-inch boring.

		Thickness. Feet.	Depth. Feet.
[Surface-earth.]	Soil	1	1
	Loamy sand	4	5
[London Clay.]	Sand and clay	8	13
	London clay	12	25
	Strong clay	6	31
	Pebbles and blue clay	2	33
[? Oldhaven Beds, 19 feet.]	Blue sand	8	41
	Very hard yellow sand	11	52
[Woolwich and Reading Beds, 46 feet.]	Clay and shells	16	68
	Mottled clay...	14	82
	Green sand, clay and pebbles ...	3	85
	Green sand and clay	10	95
	Black sand and clay	3	98
[Thanet Sand.]	Thanet sand	40	138
	Flints	1	139
[? All Upper Chalk.]	Chalk	11½	150½
	Chalk and flints	124½	275
	Hard sandy chalk	15	290
	Chalk and flints	40	330
	Hard sandy chalk	8	338
	Chalk and flints	7	345
	Fine sandy chalk	5	350
	Brown sandy chalk (water) ...	10	360
	Sandy chalk...	5	365
	Grey sandy chalk	5	370
	Chalk and flints	41	411
	Dark sandy chalk	2	413
	Light-coloured sand	7	420
	Very hard chalk	22	442
	Fine light-coloured sandy chalk and hard grey chalk (water)... ...	3	445
	Light-coloured sandy chalk ...	8	453
	Hard grey chalk	1	454
	Light-coloured sandy chalk ...	1	455
	Brown sandy chalk...	10	465
	Grey chalk	26	491
	Light-coloured sandy chalk ...	5	496
	Grey chalk	41	537

During visits to the works I noticed that some of the surrounding ground was sandy and pebbly. This may be owing to wash from the neighbouring slopes

Croydon—*continued.*

12. Waterworks.—*Stroud Green Works*—continued.

of the Blackheath Beds. The section shows that the London Clay extends a little further than is shown on the Geological Survey Map, Sheet 6. In the earth thrown out there was evidence of the sand and pebble-beds of the Blackheath Series, though this seems to be in much less thickness than over the neighbouring outcrop. The shelly clays of the Woolwich Beds showed a great number of the usual fossils. The Thanet Sand was fine and compact, with a little clayey greensand and green-coated flints at the base.

A spring occurred in a bedding-plane in the Chalk 191½ feet down.

Daily capacity 650,000 gallons.

Waddon Works.

Completed 1910, opened 1911. By Coldharbour Lane.

From a Paper by Mr. G. F. Carter (Inst. Munic. Eng., 1911), and from a drawing.

Ground-level about 190 feet above Ordnance Datum.

Pit 6 feet; then well of 8 feet diameter, lined with cast-iron cylinders (2 feet up in the pit), 58 feet; then bored (6½ feet diameter) to 190 feet.

The amount of water to be taken is limited to 50 million gallons in 30 days. As much as 1,750,000 gallons has been pumped in a day.

		Thickness. Feet.	Depth. Feet.
Loose soil	...	about 4	4
[Upper Chalk.]	Loose chalk ...	„ 2	6
	Chalk ...	„ 24	30
	Chalk with flints ...	„ 123	153
	Flints (yielding water)	„ 3	156
	Chalk with flints ...	„ 11	167
	Flints ...	„ 2	169
	Grey chalk ...	„ 21	190

A trial-boring was put down some years before, and this continues the section downward as follows (information from Messrs. Isler):—

Grey chalk and flints to ...	—	208
Grey chalk ...	9	217
Flints ...	4	221
Chalk and flints ...	6	227
Grey chalk ...	47	274
Hard chalk ...	26	300

The water-level was 42 feet 8 inches down.

The following figures of pumping at Waddon have been communicated by Mr. G. F. Carter:—

Year.	Total (Gallons).	Number of Days on which Water was pumped.	Daily Average (Gallons).
1899, from July 21st ...	79,233,460	146	542,694
1900 ...	55,744,090	110	506,764
1901 ...	138,571,110	270	513,226
1902 ...	172,937,182	295	586,227
1903 ...	188,698,931	205	920,482
1904 ...	71,506,009	165	433,369
1905 ...	277,297,721	317	874,756
1906 ...	122,196,373	182	671,408
1907 ...	51,224,318	79	648,409
1899 to 1907 ...	1,157,409,194	1,840	629,026

This pumping must have been from the boring.

Croydon—*continued.*

12. Waterworks.—*Waddon Works*—continued.

Another set of figures gives the result of pumping on 13 successive days in 1908 and the effect on the water-level in the bore-holes. The total pumping came to 14,765,565 gallons.

Date.	Gallons pumped.	Water-level in Bore-holes, 6 a.m., feet above Ordnance Datum.
March 10	1,209,882	144·5
" 11	1,299,600	130·5
" 12	1,320,120	128·5
" 13	1,308,150	128·5
" 14	1,319,322	128·92
" 15	1,305,528	128·5
" 16	1,311,000	128·66
" 17	1,316,700	128·5
" 18	1,296,750	128·16
" 19	1,251,720	128·66
" 20	1,255,368	128·92
" 21	284,772	129·5
" 22	286,653	144·
" 23	No pumping	145·
Total... ...	14,765,565	

For an analysis of the water from this well, *see* p. 298.

See also Addington.

Mr. G. F. Carter has noted the heavy demands, on the Croydon supply as a whole, from August 28 to September 4, 1906. These varied from 4,630,647 gallons on August 29 to 5,251,023 on September 3, and the whole gave a daily average of 4,876,272 over the eight days.

In earlier years the maximum demand was as follows:—1902, July 8th, 4,268,362 gallons; 1903, July 10th, 4,353,074; 1904, July 19, 4,908,278; 1905, May 29th, 4,958,007.

In 1910, the maximum day's supply was 6,725,000 gallons, in September (Water Works Directory, 1911).

The average daily consumption has increased thus:—1902, 3,142,637 gallons; 1903, 3,309,016; 1904, 3,493,192; 1905, 3,614,667; 1906, 3,778,539.

In addition to the supply from wells, 400,000,000 gallons a year are taken from the Metropolitan Water Board for the northern part of the borough.

13. Upper Norwood.

Mr. E. A. Martin has found three wells existing here, and has given me the following information. Two are in yards off Westow Street. The other is in a garden a little down South Vale, and was still used for drinking-purposes (in 1896), having been inspected many times by the Sanitary Inspector. They are shallow wells, probably going only to the bottom of the gravel, which is more prevalent along the hill (Church Road and Beulah Hill) than is shown on the Geological Survey Map.

Croydon—*continued.*

14. EAST CROYDON RAILWAY STATION. A little north of the platform. About 1863 or 1864?

Information got by MR. W. TOPLEY from MR. P. NEATE.

Water stood from 15 to 20 feet down, never sinking lower. Plenty of water, but it was chalky.

Gravel, with water ...	20	24 feet.
Blue [London] Clay ...	2	
[? Blackheath Beds.] White sand with pebbles	1 to 2	

15. SANITARY STEAM LAUNDRY. Strathmore Road.

Boring, lined into the Chalk.

Communicated by MESSRS. BURLEIGH.

		Thickness. Feet.	Depth. Feet.
[Gravel]	Ballast ...	12	12
[? London Clay, 94 feet.]	London clay ...	58	70
	Black sand ...	4	74
	Sand and clay ...	9	83
	Blue clay ...	15	98
	Yellow clay ...	8	106
[Reading Beds, 44 feet.]	Red clay ...	8	114
	Sand and clay ...	3	117
	Green sand and gravel	17	134
	Black sand and stones	9	143
	Green sand and stones	7	150
[Thanet Sand, 20 feet.]	Running sand ...	6	156
	Green sand ...	14	170
[Upper Chalk, 137 feet.]	Chalk ...	28	198
	Chalk and flints ...	109	307

16. Of the 5 Chalk-wells noted by LUCAS as in the parish of Croydon (*Proc. Inst. Civ. Eng.*, 1877, vol. xlvii, pp. 106, 107), three seem to be outside it, two of them in Sanderstead.

Dorking.

Ordnance Map 286, new ser. Geological Map 8.

1. DENBIES. DR. J. MITCHELL'S MSS., p. 248.

About 600 feet above Ordnance Datum.

	Thickness. Feet.	Depth. Feet.
Gravel, abounding in small flints of the size of peas	26	26
Clay, like pipe-clay ...	1	27
Chalk, with and without flints ...	343	370

Has been deepened to 444 feet, with good supply. Water-level, 424 feet down. September, 1876. J. LUCAS, *Proc. Inst. Civ. Eng.*, 1877, vol. xlvii, p. 101?

2. LUCAS also notes Chalk-wells at Bradley Farm and Bradley Lane Cottages, in the same paper.

3. HOLMWOOD. Brickfield. 1899. Abandoned.

Made and communicated by MESSRS. DUKE & OCKENDEN.

[Weald Clay.]	Blue clay...	107	155 feet.
	Red clay ...	17	
	Blue clay...	31	

Dorking—*continued.*

4. Messrs. Young's Brewery.

Made and communicated by Messrs. Isler & Co.

Water-level 4 feet down. Supply 6000 gallons an hour.

		Thickness. Feet.	Depth. Feet.
Lower Greensand.	Pit	—	6
	Running sand	146	152
	Sandstone and running sand	3	155
	Red sand and sandstone ...	6	161
	Red sand	3	164
	Sand and sandstone	21	185

5. Shellwood Farm. For the Duke of Northumberland. 1897.

Made and communicated by Messrs. Duke & Ockenden.

Bored to 170 feet. Water-level 68 feet down.

6. Waterworks. 1869.

From Report by Dr. Williamson quoted in Dr. Seaton's Ann. Rept. to the County Council, for 1901, pp. 34, 35.

Town [? Tower] Hill Well. 1873. Lined to the depth of 100 feet with 18-inch brick-work, in cement.

The Redlands. Apparently springs, carried by two underdrains to sand-filters, to remove the iron.

The Rookery. Similar to the above.

Castle Gardens Well, near the Mole, 24 feet deep, lined with iron cylinders; then two bore-pipes of 65 feet.

"In the summer an auxiliary supply had to be taken from the springs from which the swimming bath is filled."

The Water Works Directory, 1911, notes also Station Road Well and the Westcott gathering-ground (? The Rookery) and gives the yearly supply as 103,000,000 gallons. The area supplied is Dorking (Urban and Rural), Capel and Ockley, and the population supplied is 14,423. The water is filtered.

According to *Water*, vol. 6, no. 66, June 15, 1904, p. 2, "eight artesian wells have been sunk through the gault clay into the lower greensand, the deepest . . . being 310 feet."

7. Lucas notes 19 wells in the Lower Greensand in the parish of Dorking. *Proc. Inst. Civ. Eng.* 1880, vol. lxi, pt. iii, pp. 222, 223.

Dulwich.

Ordnance Map 270, new ser. Geological Map, London District, Sheet 4.

1. East Dulwich Grove (Champion Hill), Southwark Union Infirmary. 1887?

79 feet above Ordnance Datum.

Made and communicated by Messrs. S. F. Baker & Sons.

Shaft 91 feet, the rest bored 8 inches diameter.
Yield 4000 gallons an hour.
Water-level about Ordnance Datum. Falls 23 feet on pumping (1911).

		Thickness. Feet.	Depth. Feet.
[Woolwich and Reading Beds.]	Sand	15	15
	Loam, with fragments of shells ...	1	16
	Loamy sand	1	17
	Coloured clay with shells	1	18
	Shaly clay	2	20
	Hard, shelly rock (cockle-bed) ...	4	24
	Coloured [mottled] clay	3	27
	Hard stone	2	29

Dulwich—*continued.*

1. East Dulwich Grove—*continued.*

		Thickness. Feet.	Depth. Feet.
[Woolwich and Reading Beds] —*cont.*	Strong, mottled clay	9½	38½
	Pebbles	2½	41
	Green sand, with water	9	50
	Sand and pebbles	2	52
	Hard sandstone	3	55
[Thanet Sand.]	Thanet Sand	36	91
	Flints	1	92
[Upper] Chalk	... ...	213	305

2. Champion Hill.

Mylne's *Sections of the London Strata.*

To Chalk 210 }
In ,, 298 } 508 feet.

3. Constance Road Workhouse, near East Dulwich Station.

Communicated by Mr. W. M. Binny.

65 feet above Ordnance Datum.

Boring of 12 inches diameter.

Standing water-level about 100 feet down.

Some water met with 40 feet down rose to within 30 feet of the surface. This was shut out by an iron lining tube, driven down to a depth of 190 feet.

On the first test a large quantity of the Thanet Sand, with water at the rate of 7,000 gallons an hour, made its way into the bore-hole. The sand was shut out by driving the lining tubes into the chalk; but the yield of water was thereby reduced considerably. The water was pumped for a week continuously and samples then taken were reported as suitable for domestic purposes.

		Thickness. Feet.	Depth. Feet.
Made Ground	... ...	3	3
[London Clay.]	Brown clay	12	15
	Blue clay	19½	34½
	Clay and shells	1½	36
	Sand and gravel [? pebbles]	3	39
[Woolwich Beds, 52½ feet.]	Clay	24	63
	Brown clay	10	73
	Flints [? pebbles]	3½	76½
	Sand	12½	89
	Flint [? pebbles]	2½	91½
[Thanet]. Fine grey sand, with water		44	135½
[Upper and ? Middle Chalk.]	Chalk with layers of flint ...	67½	203
	Hard chalk without flints ...	306	509

Total depth given as 504.
This boring has never been used.

4. Herne Hill, at the foot of.

Allport's *Collections Illustrative of the Geology, &c. of Camberwell*, p. 7.

[Soil, &c., 10 ft.]	Gravel	1½
	Black mould	8½
Blue [London] clay, with pyrites and selenite		43
To sand, yielding plenty of water ...		53 feet.

Dulwich—*continued.*

5. Herne Hill. Alliance Dairy Co., 14, Half Moon Lane, close to S. E. and C. Railway Station.

About 75 feet above Ordnance Datum.

Communicated (1910) by Mr. G. C. Tilley.

Water-level 106 feet down.

		Thickness. Feet.	Depth. Feet.
Soil		2	2
Clay and stones (dirty gravel)		4	6
Mottled clay		7	13
Black clay		4	17
Black sand (a little water)		8	25
[Woolwich and Reading Beds.]	Black clay and shells	2	27
	Oyster-shells	2	29
	Dirty sand and water	8	37
	Clay and shells	2	39
	Shells (congealed)	7	46
	Mottled clay	10	56
	Black pebbles	13	69
	Green sandy clay	1	70
	Conglomerate (close gravel)	18	88
[Thanet Sand.]	Dead sand	26	114
	Flints	1	115
[Upper] Chalk		87	202

6. Mineral Wells.

Phil. Trans., vol. xli, p. 835.

[London Clay.]	Clay, with vegetable substances	20	40 feet to water.
	" " pyrites and septaria	20	

Dunsfold.

Ordnance Map 301, new ser. Geological Map 8.

1. Blacknest. On the northern side of the road about 160 yards a little S. of W. from Wintershall Farm (? over 1100 yards southward of St. Mary's church.

About 130 feet above Ordnance Datum.

Boring made and communicated by Messrs. Duke and Ockenden.

Lined with 4 sets of tubes, all up to the surface: 12 inch down to 175 feet; 10 inch to 390; 8 inch to 868; and smaller to 1138?

Water cut between 1046 and 1070 feet; ? chiefly from a fissure between 1065 and 1070. For an analysis see p. 299. The water slowly rose to 18 feet above the ground, and overflowed at the rate of 50 gallons an hour. Test-pumping, with the suction 375 feet down showed an upflow of 700 gallons an hour at that depressed level.

(Notes of specimens, preserved at the Geological Survey Office, from 408 feet downward, by G. Barrow, are enclosed in this kind of bracket). The difference between the descriptions of the well-sinker and those of the specimens, is not surprising. The beds of the Wealden Series are to a great extent so near the passage from sand to clay, the sands being so generally very fine and compact, that different observers may readily differ in their description. Moreover specimens of such beds differ in themselves when fresh and when they have been at the surface for some time. Clearly Mr. Barrow was sometimes at a

Dunsfold—*continued.*

1. Blacknest—*continued.*

loss to give a precise definition, as has often been the case with myself in like cases; indeed I have commonly felt greatly troubled in attempting to describe specimens of the kind.

	Thickness. Feet.	Depth. Feet.
Well [old ?. In Weald Clay] ...	—	140
Clay (soft greenish grey, with fossils, 408–409. Pale greenish soft sandstone, with clay-pellets, 409–410. Nearly white soft sandstone, 410–415. Pale greenish soft sandstone, with clay-pellets, 415–416. Dark grey clay, 416–434½) ...	285	425
Sandstone ...	4	429
Clay, with a foot of rock at the bottom. (Fine compact rock, 6 inches, to 435. Pale grey shaly clay, 435–462) ...	21	450
Clay (sandy, grey, 462–464. Grey, hard, 464–517. Fresh-water shells, 517–518. Light-coloured clay, 518–525). 10 inches of rock at 525, thin layers at 548, 553 and 635. (Hard dark grey clays, 526–666. Pale grey sandy clay, 666–684. Less sandy, 684–721. 721–727 micaceous sandy silt) ...	275	725
Sandstone and clay (fine sand-rock, 727–731. Hard clay, 731–733. Grey hard clay, 733–740) ...	15	740
Clay (variously coloured, grey and chocolate-colour, 740–798. Mostly pale-grey and sandy, 798–842) ...	101	841
Soft sandstone ...	2	843
Hard clay (grey mostly, 842–861. Pale soft sand-rock, 861–864. Sandy or silty clay, 864–893. Piece of jet at 886. 893–895 grey. 895–899 fine soft sand-rock) ...	56	899
Clay and sand (irregular sandy clay) ...	2	901
Soft sandstone (sandy silt) ...	2	903
Clay (grey)...	1	904
Hard sandstone (sandy silt) ...	4	908
Clay (hard, dark grey) ...	3	911
Sandstone (fine, soft) ...	2	913
Clay (sandy, grey) ...	2	915
Sandstone (sandy silt, almost a soft sandstone) ...	3	918
Soft clay and sand (sandy silt) ...	2	920
Hard clay and sand (sandy silt) ...	5	925
Sandstone (very fine, soft sand-rock) ...	3	928
Clay and sand (grey hard clay) ...	2	930
Soft sandstone (greenish sandy clay) ...	5	935
Clay and sand (greenish grey clay) ...	3	938
Soft sandstone (sandy clay) ...	2	940
Hard (grey) clay and black particles ...	5	945
Hard clay and sand (grey clay) ...	2	947
Sandstone (sandy grey clay) ...	1	948
Hard clay (grey, some sandy) ...	4	952
Soft clay (pounded up) ...	2	954
Sandstone (pale fine sand-rock to 955. Soft sandy clay, pounded up, 955–957) ...	2	956
Soft clay and sand ...	1	957
Sandstone (pale) ...	1	958
Clay and sand (pale sandy silt) ...	2	960
Hard clay (grey) ...	2	962
Soft clay and sand (pale sandy clay, pounded up) ...	8	970
Clay and sand (sandy silt) ...	2	972
Soft clay and sand (same as the above) ...	2	974
Hard sandstone (sandy clay to 975, then harder and more compact) ...	2	976
Hard (grey) clay and rock ...	3	979
Soft clay and sand (sandy silt) ...	5	984
Hard (grey) clay and sand ...	3	987
Sandstone (grey clay) ...	1	988

Dunsfold—*continued.*

1. Blacknest—*continued.*

	Thickness. Feet.	Depth. Feet.
Soft clay and sand (pale grey sandy clay)	1	989
Hard clay and sand (as the above)	7	996
Sandstone (grey compacted clay to 1002. Fine white sandstone, 1002–1005)	9	1005
Hard clay and sand (sandstone with clay)	1	1006
Hard (grey) clay	3	1009
Hard (pale grey) clay and rock	1	1010
Hard clay (pale grey ; 4 inches of claystone at top)	5	1015
Hard clay and sand (silt)...	3	1018
Sandstone (very fine, soft)	3½	1021½
Hard clay and sand (pale silt)	1	1022½
Sandstone (silt and hardened clay-lumps, to 1025)	½	1023
Hard clay (hard grey shale 1025–1026)...	3	1026
Hard sandstone (hard grey clay, to 1027½)	1	1027
Soft clay and sand	½	1027½
Hard clay and sand, or sandstone (pale grey sandy clay) ...	3½ or 4½	1031 or 1032
Soft sandstone (very fine)	11 or 10	1042
Hard (grey) clay	2	1044
Soft sandstone, with hard bands (sand-rock interlaminated with grey shaly clay)	2	1046
Hard clay (silt, sandy, to 1070)	2	1048
Sandstone	18	1066
Soft sandstone, and hard clay ?	4	1070
Hard clay (grey shale)	7	1077
Hard clay with sand (sandy clay)	4	1081
Sandstone, hard (soft sand-rocks to 1086)	4	1085
Very soft sandstone	1	1086
Hard sandstone (sandy clay)	2	1088
Hard clay, little sand	10	1098
Soft clay (somewhat mottled)	20	1118
Hard clay (more mottled)	3	1121
Hard sandstone (green)	1	1122
Soft sandstone (pale green)	1	1123
Hard clay (grey to 1125. Mottled chocolate-colour 1125–1128. Compact, greenish-grey 1128–1130)	7	1130
Hard (pale and grey) clay with hard band	3	1133
Clay, hard and soft (pale soft sand-rock)	5	1138
Soft sandstone (pale greenish)	1	1139
Hard clay and sand, mixed (compact, sandy clay)	11	1150
Soft sandstone (almost white)	6	1156
Hard clay and sand, mixed. Stones	1	1157
Hard clay (sandy)...	8	1165
Soft sandstone	1	1166
Hard clay and sand, mixed (dark green-grey sandy clay) ...	5	1171
Soft sandstone (as the above)	1	1172
Soft clay and sand, mixed (pale sandy clay)	2	1174
Sandstone (very sandy clay)	2	1176
Hard (light-grey sandy) clay	2	1178
Soft clay (sandy)	1	1179
Sandstone (soft, pale, fine)	1	1180
Soft clay (sandy)	5	1185
Hard clay (greenish marl, lower half slightly mottled) ...	4	1189
Sandstone (mottled marl. Pale greenish very fine sand at the base)...	4	1193
No cores brought up from below this ; but the boring went deeper. Feeling as of clay again	8	1201

Many of the specimens are described as shaly, and several as containing plant-remains.

Dunsfold—*continued.*

1. Blacknest—*continued.*

Mr. Barrow gives the following notes. The specimens from 684 to 731 feet show a passage from sandy mud to very fine sandstone. This passage occurs again and again in the series. From 731 to 798 feet the beds consist of hardened clay, the bulk of which has a distinct chocolate-colour ; here and there however the clay is of the more usual dark grey. From 798 to 842 feet the beds are mostly banded and paler, due to the presence of parallel layers of sandy material, the amount of which in some specimens is enough to make the rock approach a very fine sandstone in composition. From 895 to 928 the beds are distinctly sandy, mostly fine sandy silts.

The classification of the beds is difficult, as is nearly always the case with deep borings in the Wealden Series ; but it is clear that the Weald Clay takes up three-quarters of the section. Mr. H. B. Woodward thought that the Tunbridge Wells Sand might have been reached at the depth of about 900 feet. This agrees with Mr. Topley's estimate of the thickness of the Weald Clay in this district, for he says of this formation :—" It appears to be thickest in the meridian of Leith Hill," some 8 or 9 miles eastward. " Here it is probably 900 or 1,000 feet."(1) The oncoming of the Lower Greensand being about 1¾ miles northward of the site and at a considerably higher level, we have to add somewhat to the 900 feet to get the full thickness of the formation here, as the highest beds must be absent. Although therefore there is here but a very slight dip, we must give the Weald Clay a thickness of over 1,000 feet.

If the Tunbridge Wells Sand is reached at about 900 feet where is its base ? There is little to guide us in answering the question, but it may be even as low as 1086 or 1088 feet, below which clay seems dominant ; on the other hand this base may be as high up as 958 feet, below which clay prevails down to about 1000 feet. It seems hopeless to attempt the further division of the Hastings Beds, and it must be remembered that their nearest point of outcrop is some 10 miles off. Difficulties in this matter, possibly due to faulting, have been noted in the description of sections at Edenbridge in Kent and Chailey in Sussex.[2]

2. Rickhurst Farm, S.E. of the village. 1909.

Boring made and communicated by Messrs. Duke and Ockenden.

Lined with 12 inch tubes to 50 feet, and with 10 inch tubes to 203. No water.

		Thickness. Feet.	Depth. Feet.
Weald Clay.	Blue clay ...	147	147
	Rock	9	156
	Red clay... ...	47	203
	Mixed clay ...	27	230
	Rock	7	237
	Brown clay ...	50	287
	Sand-rock ...	7	294
	Hard brown clay	6	300

Earlswood *see* Reigate.

East Clandon.

Ordnance Map 285, new. ser. Geological Map 8.

Lucas notes 10 chalk-wells in this parish. *Proc. Inst. Civ. Eng.* 1877, vol. xlvii, p. 98.

(1) The Geology of the Weald, 1875, p. 96.
(2) *See* Memoir on the Water Supply of Sussex, 1911, p. 243.

East Horsley.

Ordnance Map 285, new ser. Geological Map 8.

1. ROBARNS. FOR THE EARL OF LOVELACE. 1885.

Made and communicated by MESSRS. LE GRAND and SUTCLIFF.
Water-level 97¼ feet down.

Dug well (the rest bored)	19	229 feet.
Chalk and flints	210	

According to LUCAS there is an older well here about 101½ feet deep, the depth to water being 96¾ to 97¼ feet in September and November. 1876.

2. THE TOWERS, just outside the garden-wall, north of the house. 1886.

? About 300 feet above Ordnance Datum.

Made and communicated by MESSRS. LE GRAND and SUTCLIFF [and from specimens].

Water (in chalk) rose to 105 feet from surface. Fell on reaching Upper Greensand to 117 feet. Practically no supply until over 400 feet deep, when the water-level rose several feet. A further sudden rise in the water-level has twice taken place since, and each time accompanied by a practical increase in the yield, so that in March, 1886, over 1,000 gallons an hour could be got without lowering the head of water more than 25 feet (526 feet deep).

		Thickness. Feet.	Depth. Feet.
	Dug well [partly gravel]	—	13
[Thanet Sand (top three beds rather doubtful), ? 20 feet.]	Clay [light-brown sand]	8	21
	Sand and clay [sand, with green grains and bits of brown clay]	2	23
	Clay [brown sand, with clay]...	2	25
	Sand [fine, buff]	5	30
	Mottled clay [brownish and buff sand] ...	1	31
	Flints [green-coated]	2	33
[Upper, Middle and Lower Chalk, 817½ feet.]	White chalk and flints	236	269
	Putty chalk and flints	99	368
	Marly chalk	4½	372½
	Hard chalk and flints [ordinary white chalk]	41½	414
	Very hard chalk [hard cream-coloured chalk]	159	573
	Granular chalk [a sort of loose chalk grit]	20	593
	Marly chalk and hard bands [hard cream-coloured marly (?) chalk]	12	605
	Grey chalk [white]	51	656
	Marly chalk and hard bands [hard cream-coloured chalk]	20½	676½
	Hard grey chalk [greyish]	31	707½
	Chalk marl [compact, firm, grey]	143	850½
Upper Grensand (& Gault?).	Upper Greensand [compact greenish sand, calcareous ?]	17½	868
	Gault [friable sandstone of Upper Greensand; clay said to have been found also]	6	874

A later communication from MESSRS. LE GRAND says that a careful measurement makes the depth to the Upper Greensand 853 feet and to the Gault 870, increasing the thickness of the Chalk to 820 feet; but they do not say where the small error occurs.

3. LUCAS notes 7 other Chalk-wells in this parish. *Proc. Inst. Civ. Eng.*, 1877, vol. xlvii, p. 99.

East Surrey Waterworks.

The following general particulars are from the Waterworks Directory. 1911.

The population in the area of control was 46,000 in 1881, 60,500 in 1891, 73,000 in 1901, 90,000 in 1911, the estimated population supplied being 89,000 in the last year.

East Surrey Waterworks—*continued.*

The quantity of water drawn in a year was 788 million gallons ; the maximum day's consumption being 3,000,000 ?

According to Dr. Seaton's Report to the County Council in 1905 the area of supply is 170 square miles and includes the following 26 parishes :— Betchworth, Bletchingley, Buckland, Burstow, Caterham, Chaldon, Charlwood, Chipstead, Coulsdon (which includes Kenley and Purley), Crowhurst, Farley, Gatton, Godstone, Headley, Horley, Horne, Leigh, Lingfield, Merstham, Newdigate, Nutfield, Reigate, (including Red Hill), Sanderstead, Tandridge, Walton and Warlingham.

For analyses of the Water *see* pp. 294, 295.

See **Caterham, Coulsdon, Reigate** for wells.

Effingham.

Ordnance Map 286, new ser. Geological Map 8.

J. Lucas, *Proc. Inst. Civ. Eng.*, 1877, vol. xlvii., pp. 99, 100.

A well at Effingham Hill Lodge, 399 feet deep, and another at the Laundry Farm, 379 feet deep, are said to reach down to the Upper Greensand. But this seems doubtful.

The water-levels at these and 13 other wells in the parish are given.

Egham.

Ordnance Map 269, new ser. Geological Maps 7, 8.

1. Callow Hill, E. of Virginia Water. Mr. Pocock's. 1851.

Sunk and communicated by Mr. C. Page.

In [Bagshot] Sand at 84 feet.

2. Mr. Mills'.

Dr. J. Mitchell's MSS., vol. 3, p. 237.

Water at 131 feet, through blue clay.

3. Staines Waterworks. 1883.

Sunk and communicated by Mr. T. Tilley.

Shaft 260 feet ; the rest bored.

Sand-spring, at 306 feet, yielded 30 gallons a minute, at a depth of 16 feet (cloudy). Another, at 337 feet, yielded 4 gallons a minute at the surface (bright). When the water stood at 97 feet from the surface about 7 gallons a minute was found to be the yield from the Chalk (October, 1882). At 130 feet from the surface the yield of the sand-springs was 400 gallons a minute (April, 1883).

		Thickness. Feet.	Depth. Feet.
Ground made up		3	3
Sand and gravel [River Drift] ; bottom part coarse, with large flints and large clay-stones [septaria] on the clay		20	23
Blue [London] Clay ; with pebbles at 162, 172, and 251 feet from the surface, and slight soakage at 178 feet		235	258
[Reading Beds, 96 feet.]	Mottled clay	47	305
	Red sand (with water)	14	319
	Red sand-rock	1	320
	Red sand	1½	321½
	Mottled clay	16	337½
	Sandy clay (with water)	14	351½
	Sandy clay and chalk, mixed	2½	354
Chalk : specimens, from 700 feet, very hard and greyish. Mr. W. Hill has examined this microscopically, and says that it "is undoubtedly Chalk Rock" ... about		346	700

Elstead.

Ordnance Map 285, new ser. Geological Map 8.

LUCAS notes 5 wells in Lower Greensand. *Proc. Inst. Civ. Eng.*, 1880, vol. lxi., pt. iii, p. 218.

A note of a well at Elsted, in Sussex, was inserted in a paper on Surrey Wells, in 1905, under the mistaken idea that it was in this Surrey village.

Epsom.

Ordnance Maps 270, 286, new ser. Geological Map 8.

1. HORTON MANOR ESTATE (London County Council Asylum). 1898?

Central Station, a little W. of Horton Lane in field 110 of the Ordnance Map.

170 Feet above Ordnance Datum.

Made and communicated by MESSRS. ISLER and from later notes by MR. W. C. C. SMITH, Engineer to the Asylums Committee.

Lined with 29 feet of tube, of 11½ inches diameter, 5 feet down; and with 320 feet, of 7¾ inches diameter, 2 feet down.

Water-level 56 feet down (140 W. C. C. S.). Supply 1,200 gallons an hour (2,300 W.C.C.S.).

		Thickness. Feet.	Depth. Feet.
Well (the rest bored)		—	6
[London Clay.]	Brown clay	6	12
	Claystone ...	6	18
	Brown clay	122	140
	Brown clay and sandstone [septaria?]	9	149
	Brown clay	9	158
	Blue clay ...	10	168
	Sandy clay and stone	15½	183½
	Hard sandy clay ...	37	220½
[Reading Beds, 71 feet.]	Variegated clay ...	10½	231
	Variegated clay and sand	6	237
	Variegated clay ...	6	243
	London [? bluish-grey] clay	14	257
	Green sand	8	265
	Brown mottled clay	11½	276½
	Sand and clay	2½	279
	Clayey green sand	6	285
	Green sand and pebbles ...	6½	291½
[Thanet Sand, 16½ feet.]	Grey sand	1½	293
	Green sand	14	307
	Flint	1	308
[Upper] Chalk and flints		142	450

An account of another well or boring here, made and communicated by Messrs. BAKER, is as follows.

		Thickness. Feet.	Depth. Feet.
Mould		1	1
[London Clay.]	Brickearth	19	20
	Clay, a foot and then claystone, a foot ...	2	22
	Blue clay, with claystone at 53-53½, 71-72, 77-77½, 91-91⅓, 127⅔-128, 136-136½, 158½-160. At base 3 inches of claystone (with water), petrified wood and then 3 inches of pyrites ...	151	173
	Sandy clay	25	198
	Brown sand [? Basement-bed]	7	205

Epsom—*continued.*

1. Horton Manor Estate—*continued.*

		Thickness. Feet.	Depth. Feet.
[Reading Beds and Thanet Sand, 103 feet.]	Coloured [mottled] clay	10	215
	Green clay	12	227
	Grey sand with 2 inches of pebbles at top, and 4 inches at base ...	17	244
	Mottled clay [? some error] ...	62	306
	Brown sand	1	307
	Flints	1	308
[Upper] Chalk	... ...	194	502

Mr. W. C. C. Smith, the Asylums' Engineer of the L.C.C., tells us that the well here is 198½ feet deep (shaft and cylinders) with a boring to the depth of 500 feet (lined to 314), the depth to the Chalk being 309. The normal water-level is 70 feet down. His account of the trial-boring, 350 feet off, differs from both the above sections; but seems to refer to the first.

Boring made by Messrs Baker. In the Central Station Building a little westward of the above and also in field 110.

Communicated by Mr. Smith.

171 feet above Ordnance Datum.

A well 200 feet deep and of 10 feet diameter. Then a boring, with 12-inch steel tube, for 114 feet, and then an 11-inch boring in Chalk for 186 feet (? total 500).

Water-level 187 feet down. Yield 2000 gallons an hour.

2. Harvey's, late Chandler's, Brewery.

Information got by Mr. J. Lucas.
Three wells, one giving the section below.
Shaft 35 or 40 feet, then bored to 90 feet.
Water 3 feet from the surface (Feb., 1873); falls to 30 feet in dry seasons.

Gravel	15 or 16	feet.
Clay	35 or 40	
Sand.		
Chalk.		

A bed of oyster-shells was passed through, but its depth was not recorded.

3. Waterworks, established 1853.

Information got by Mr. J. Lucas from the Engineer. With some particulars from a Report by Mr. G. Hodson to the Local Board, 1894.

About 150 feet above Ordnance Datum.

Three wells:—1. In the engine-house: shaft 50 feet; then two bore-holes to 84 feet. 2. To the south-east: shaft 40 feet; then three bore-holes to 84 feet. 3. In the garden, further south-east: shaft 51 feet; the rest bored. (Section of this well given below). The three are connected by a pipe 45 feet below the surface. The shafts of 2 and 3 are given as 48 and 46 feet by Mr. Lucas in *Journ. Soc. Arts*, vol. xxv. p. 616.

Yield 14,000 gallons an hours; in summer, 12,000. The engineer says that the springs are equal to a supply of 25,000. A bore-hole close by, to the north-east, used to overflow before the pumping began.

The first boring was made in 1854, the second in 1864; both in No. 1 well (in the engine-house). In 1864 difficulties occurred, much grey sand was pumped up with the water and the yield lessened. In 1872 and 1874 it was found that, from defects in the brickwork of the wells, water from the gravel found its way in, and the outside of the wells had to be puddled, down into the clay. Since this was done the water has been uncontaminated and the supply has been of very good quality (1894).

Epsom—*continued.*

3. Waterworks—*continued.*

Garden Well.

		Thickness. Feet.	Depth. Feet.
Mould ...	... ...	2	2
Gravel ...	... ...	3	5
[Reading Beds, 27½ feet.]	Red clay	7½	12½
	Mottled clay	6	18½
	White fire-earth ...	2¾	21¼
	Green sand	10	31¼
	Oyster-shells	1¼	32½
[Thanet Beds, 29¾ feet.]	Slate-coloured sand ...	10	42½
	Grey sand	18	60½
	Course sand and flints	1¾	62¼
[Upper] Chalk	... ...	123¾	186

In the engine-house well a thin bed of grey clay comes in below the gravel, otherwise the same section is given by all the wells. As the dip is north-westward, the same horizons occur rather lower in 2 than in 3, and in 1 than 2. In 1 the depth to the Chalk is 66 feet, and in Chalk 14. The middle well (2) is 64 feet in Chalk.

Newer Well. 1889.

In the same yard as the older wells, but nearer the road (between the stables and East Street).

A boring of 18 inches diameter, made and communicated by Messrs. Tilley: with some particulars from a Report to the Local Board, by Mr. G. Hodson (1894).

When made this bore-hole was tested to 13,000 gallons an hour; but it is said that 20,000 gallons an hour are regularly pumped, and that once this quantity was got continuously for 42 hours, when the flow of water was still enough to gain on the pumps. The supply of the town is chiefly got from this boring.

		Thickness. Feet.	Depth. Feet.
Mould...	... ...	2½	2½
Gravel ...	... ...	3	5½
[Reading Beds, 19½ feet.]	Clay	7	12½
	Fire-clay ...	2	14½
	Green sand ...	9	23½
	Oyster-shells ...	1½	25
Thanet sand, 31 feet.]	Dark sand ...	29½	54½
	Sand and flints	1½	56
[Upper] Chalk	... ...	? 224	280

In these sections too great a thickness seems to be given to the Thanet Beds.

Mr. W. V. Graham, Consulting Engineer to the Urban Council, has given me the following additional information. *See also* p. 334.

In 1903 the Garden Well was deepened to 90 feet, or 18 feet into the Chalk, and a heading, 6 feet high, was driven either way from this, so as to connect the old borings, the total length being 250 feet.

In the well thus deepened new pumping plant was installed, and the effect of the work was to increase very largely the quantity of water obtainable. A two hours' test, made on November 16, 1903, showed a yield of 110,000 gallons an hour, the water-level being lowered to 19 feet from the surface (150 above Ordnance Datum). Though of very short duration this test shows a supply much in excess of the wants of the place.

According to the Water Works Directory 1911, the borings reach to the depth of 400 feet and there are adits from the wells, and the supply for the year was 195,313,224 gallons (that for the year ending March 1909 was 175,782,910). The average daily supply per head (excluding meter-supplies) was about 24 gallons, and the maximum day's supply 1,127,655 gallons, in June 1910. The population supplied is about 20,000.

4. Lucas notes 11 Chalk-wells in the parish of Epsom. *Proc. Inst. Civ. Eng* 1887, vol. xlvii, pp. 102, 103.

Esher.

Ordnance Map 270, new ser. Geological Map, London District, Sheet 3.

1. Claremont.

Prestwich, *Quart. Journ. Geol. Soc.* vol. x. p. 146.

		Thickness. Feet.	Depth. Feet.
Lower Bagshot Sand ...		50	50
Blue London Clay ...		450	500
Reading Beds, 60 feet.	Mottled clays ...	48	548
	Brown sand* ...	10	558
	Green sand and flints* to Chalk ...	2	560

* May not these two beds belong to the Thanet Sand ?

2. For H.R.H. Prince Leopold.

?Another version of the Claremont Well.
J. Simpson, *MS. in Library. Inst. Civ. Eng.*

To Chalk 475 }
In Chalk 170 } 645 feet.

3. Messrs. McMurray's Mills. On the right bank of the Mole N. of the railway.

About 44 feet above Ordnance Datum.

Sunk and communicated by Messrs. S. F. Baker & Sons.

Shaft more than 200 feet. In February 1877 the water stood 8½ feet down.
J. Lucas, *Journ. Soc. Arts*, vol. xxv., p. 603.

	Thickness. Feet.	Depth. Feet.
Gravel ...	28	28
Blue [London] clay ...	232	260
Plastic clay [Reading Beds]	85	345
[? Thanet] sand to Chalk ...	15	360

Ewell.

Ordnance Map 270, new ser. Geological Map, London District, Sheet 3.

1. Chesterfield House, next to the Queen Adelaide Inn.

About 125 feet above Ordnance Datum.

Communicated by Mr. E. Locke.

		Thickness. Feet.	Depth. Feet.
Soil and loam ...		2	2
[London Clay, 282½ feet.]	London Clay, with seams of sand, more frequent towards the base ...	281	283
	Pebble - bed (subangular flints) [basement-bed]...	1½	284½
[Reading Beds, 48 feet.]	Mottled red and blue, and yellow and brown clays ...	38	322½
	Dark green sand ...	9	331½
	Oyster-bed ...	1	332½
Purple [Thanet] sand ...		11	343½

2. Three "Tertiary wells" at Ewell are noted by Mr. J. Lucas, *Journ. Soc. Arts*, vol. xxv., p. 616; but no section is given. The depths range up to 172½ feet.

3. Three Chalk wells are also noted by him in *Proc Inst. Civ. Eng.* 1877, vol. xlvii, pp. 102, 103.

Farncombe *see* Godalming.

Farnham.

Ordnance Map 285, new ser. Geological Map 8.

1. Mr. W. Barling's Brewery. Southern side of East Street, about a third of a mile north-eastward of the church.

About 220 feet above Ordnance Datum.

Made and communicated by Messrs. Le Grand and Sutcliff.

Water-level 15 feet down.

		Thickness. Feet.	Depth. Feet.
Dug well, the rest bored		—	63
Pipes driven (no record of the beds)		—	92½
[Lower Greensand.]	Sand ...	9½	102
	Yellow sand ...	2	104
	Sand ...	26	130

2. Castle Brewery. 1901. (? Same place as No. 1.)

Made and communicated by Messrs. Duke & Ockenden.

Dug 62 feet, and then bored for 79 feet.
Water-level 45 feet down.

3. Farnham (near), Hale Farm.

H. L. Long, *Proc. Geol. Soc.*, vol. iii, p. 101.

		Thickness. Feet.	Depth. Feet.
Sand and gravel		6	6
Potter's [? London] clay		15 or 16	21½
[Reading Beds, 58 or 59 feet.]	Sand and gravel [pebbles ?]	20	41½
	Potter's clay	14 or 15	56
	Blue clay	22	78
	Green sand	2	80
[Upper Chalk, 96 feet.]	Hard chalk (a spring at the bottom)	20 or 30	105
	Chalk mud; Chalk with many flints	?66 or 76	176

4. Runfold. Whiteways Farm. For Mr. G. F. Roumieu. 1900.

This hamlet is marked, for the most part at least, as on the northern side of the railway, on the old map. But on the new map it is marked as chiefly on the southern side, along the main road. The site is between the main road and the railway, eastward of the hamlet, ? a little below the 300 feet contour-line.

Made and communicated by Messrs. Duke and Ockenden.

Dug well 20 feet (full of water), the rest bored. Lined to the depth of 262 feet, with sand-strainer at bottom 12.
Water-level in bore-hole 37 feet from the surface.

		Thickness. Ft.	Depth. Ft.
[Gault.]	Clay ? ...	20	20
	Black clay	16	36
	Hard black clay	10	46
	Black clay	26	72
	Black clay-rock	7	79
	Black clay and green sand	6	85
[Folkestone Beds, 200 feet.]	Sand ...	198	283
	Sand-rock	2	285
[? Sandgate Beds, 15 feet.]	Clay and rock	5	290
	Black clay and sand ...	5	295
	Green sand and clay	5	300
[Hythe Beds.]	Sand ...	30	330

Farnham—*continued.*

5. UNITED BREWERIES CO. 1896.

Made and communicated by MESSRS. DUKE & OCKENDEN.

Dug well (6 feet diameter) 16 feet. Bored to 132 feet.
Water-level in well 12 feet down, in bore-tube 10 feet down.

6. UPPER HALE SCHOOLS.

Information and specimens, from MESSRS. DUKE & OCKENDEN.

Shaft 50 feet, the rest bored. No supply.

Gravel and Bagshot Sand	64	114 feet.
London Clay	50	

7. WATERWORKS. West of Castle Street and about a quarter of a mile northward of the Church. Trial-boring. 1885.

? 245 or 250 feet above Ordnance Datum.

Made and communicated by MESSRS. LE GRAND and SUTCLIFF.

		Thickness. Feet.	Depth. Feet.
Made ground ...	...	2	2
[Drift, 16 feet.]	Loamy sand ...	11½	13½
	Light ballast and loamy clay ...	4½	18
[Gault, 152 feet.]	Grey clay ...	1	19
	Black gault ...	59	78
	Gault, with thin layers of green sand	2	80
	Gault, with stone in places ...	50	130
	Sandy gault, with 4 inches of stone at 160 feet ...	40	170
[Folkestone Beds, 187½ feet.]	Dead grey sand, with layers of green	10	180
	Live green sand, with stones ...	10	190
	Live green sand, darker ...	59	249
	Live green sand, cleaner and more lively ...	88	337
	Hard coloured dead sand, with small stones ...	20½	357½

1,621 houses are connected with the supply.

8. TILFORD. Abbot's Lodge. 1906?

196 feet above Ordnance Datum.

Boring of 3 inches diameter, made and communicated by MESSRS. LE GRAND and SUTCLIFF.

Water-level 11 feet down. Yield 1,000 gallons an hour.

		Thickness. Feet.	Depth. Feet.
Soil	...	3	3
[Folkestone Beds, 190 feet.]	Sand and stone ...	2	5
	Running sand (water at 10 ft. down)	85	90
	Dead sand ...	4	94
	Running sand ...	40½	134½
	Fine live sand and small pebbles	18½	153
	Coarse sand and pebbles ...	5	158
	Fine fairly dead sand ...	9	167
	Fine sand and seams of ironstone	10	177
	Live sand ...	4	181
	Loamy sand ...	2	183
	Live sand ...	3½	186½
	Dark sand ...	6½	193

Farnham—*continued.*

8. Tilford—*continued.*

		Thickness. Feet.	Depth. Feet.
[? Sandgate Beds.]	Sandy blue clay	$15\frac{1}{2}$	$208\frac{1}{2}$
[Hythe Beds.]	Thin layers of sandy clay and sandstone	$6\frac{1}{2}$	215
	Rock	1	216
	Loamy green sand	2	218
	Sand and rock in layers	12	230

9. Wrecclesham. Mr. G. F. Roumieu's, Willey Park. 1898.

Made and communicated by Messrs. Duke & Ockenden.

Dug well 30 feet, the rest bored. Water-level 154 feet down.

Clay	217	250 feet.
Clay and sand ...	15	
Sand	18	

10. Mr. F. Drew noted (Geology of the Weald, 1875, p. 142) that "A boring was made in this village (Wrecclesham) through 120 feet of sand, and then through some coarser earth, which may have been at the bottom of the Folkestone Beds."

11. Lucas notes 4 Chalk-wells in the parish of Farnham, one of which, at Dippenhall, west of the town, is 105 feet deep and reaches Upper Greensand. *Proc. Inst. Civ. Eng.*, 1877, vol xlvii, p. 97.

12. He also notes 20 wells in Lower Greensand. *Ibid.*, 1880, vol. lxi, pt. iii, pp. 217, 218.

Fetcham.

Ordnance Map 286, new ser. Geological Map 8.

Mr. Hankey's.

Dr. J. Mitchell's MSS., vol. ii, p. 263.

		Thickness. Feet.	Depth. Feet.
Gravel ...		8	8
Blue [London] clay ...		20	28
[Reading Beds.]	Sand (35 feet in MS. of Sir J. Prestwich)	38	66
	Sand, with oyster-shells (some $7\frac{1}{2}$ inches across) ...	7	73
Chalk ...		3	76

Forest Hill.

Ordnance Map 270, new ser. Geological Map, London District, Sheet 4.

1. Mr. Swansborough's.

Dr. J. Mitchell's MSS., vol. iv, p. 201.

Water rose 64 feet (Prestwich MS.).

Mould and yellow clay about	1
Black [London] clay	200
Then bored for	75
To gravelly sand and water...	276 feet.

Another well on the hill, dug through 300 feet of black clay to coarse sand and black pebbles.

2. Mr. J. Walter.

Allport's "Collections Illustrative of the Geology, &c. of Camberwell," p. 5. Ended in Chalk at 300 feet.

Frensham.

Ordnance Map 301, new ser. Geological Map 8.

1. HINDHEAD. Wey Valley Waterworks. 1899.

Made and communicated by MESSRS. DUKE & OCKENDEN.

Shaft 215 feet, the rest bored.
Water-level 203 feet down.

		Thickness. Feet.	Depth. Feet.
[HytheBeds.]	Sandstone, 23 feet at bottom light-yellow	238	238
	Hard blue rock	3	241
	Light-yellow sandstone	6	247
	Blue clay	1½	248½
	Light-yellow sandstone, with thin layers of blue clay	33½	282
	Rock (yellow sandstone)	1	283
	Yellow sandstone	12½	295½

According to the Waterworks Directory, 1909, there are 4 wells here, 250 feet deep. The number of consumers is 8,900. The area of control includes Dockenfield, Farnham (part) and Farnham Rural, Frensham, Puttenham, Seale, Shottermill, and Wanborough; besides many places in Hampshire and Sussex. The maximum day's consumption is 73,000 gallons, the normal being 65,000.

For analysis of the water, *see* p. 299.

2. LUCAS notes 13 wells in Lower Greensand in this parish. *Proc. Inst. Civ. Eng.* 1880, vol. lxi, pt. iii, p. 217.

Frimley.

Ordnance Map 285, new ser. Geological Map 8.

1. MYTCHETT PLACE. 1882?

Made and communicated by MESSRS. LE GRAND and SUTCLIFF.

250 feet above Ordnance Datum.

Water-level 66 feet down. According to a letter from MR. A. PAIN, this was unsuccessful in getting water.

		Thickness. Feet.	Depth. Feet.
[? Upper Bagshot & Bracklesham Beds ?]	Dug well, the rest bored	—	36
	Sand	26	62
	Clay and sand	18	80
[Lower Bagshot ?]	Sand	152	232
[London Clay ?]	Clay and pebbles	8	240
	Blue clay and sand	24	264
	Green sand [? colour from dampness]	23	287
	Marl and clay	8	295
	Clay	17	312

This is another version of the section given by the REV. A. IRVING, *Quart. Journ. Geol. Soc.*, vol. xli., p. 496 (1885).

The above classification of the beds seem more warrantable than that given before. DR. IRVING'S version is as follows :—

		Thickness. Feet.	Depth. Feet.
Upper Bagshot, 65 feet.	White sand	53	53
	Loamy sand...	12	65
Middle Bagshot, 28 feet.	Light green sand	2	67
	Dark green sand	26	93

Frimley—*continued.*

1. Mytchett Place—*continued.*

		Thickness. Feet.	Depth. Feet.
Lower Bagshot 102 feet.	Sharp light-green sand	87	180
	Light-green and sharp sand with shells, &c.	15	195
London Clay, 67 feet.	Blue clay, with smooth pebbles	33	228
	Green loamy sand	2	230
	Blue clay with pebbles	4	234
	Blue clay	11	245
	Dark green sand and clay	17	262
Reading Beds, 68 feet.	Dark green sand	23	285
	Brown sand, marl and clay	23	308
	Very fine sharp sand	22	330

In this classification of the beds, we have a most unexpected decrease in the thickness of the London Clay, which has been proved to be 300 feet and more in other wells at no very great distance. This great and sudden thinning-away of a formation not in the habit of doing that sort of thing, save in a very gradual fashion, lead me to doubt the classification, and to suggest (in 1886) that the reading might have to be altered, to the following extent :—

Upper Bagshot and Bracklesham Beds (Middle Bagshot)	? 245 or 262
Lower Bagshot	? 85 or 68

2. Ridgemount, Black Down Hill. 1896.

Communicated by Dr. A. Haviland.

Above the 350 contour-line [? is there such ?].
Water stood 7 feet [? from bottom].

	Thickness. Feet.	Depth. Feet.
Plateau gravel	6	6
Sand, varying only in colour	75	81
Clay, with sand sometimes	3	84
Sand	between 15 and 20	? 100
Bluish sand, having a sulphurous smell	5	? 105

On visiting the well a few days after the above report was taken, it was found that the thick colour of the water had disappeared, and the offensive smell had gone.

3. Frimley and Farnborough Water Co.

The well-supply of this Company is at Itchell, in the parish of Crondall, Hampshire (*see* Memoir on that County).

The following Surrey places are in the area of supply :—Ash, Camberley, Frimley, Normandy and Yorktown. Water Works Directory, 1909.

See also under Spring Supplies, p. 100.

Garratt.

Geological Map, new. ser., London District, sheet 3.

1. Copper-Mills, near Wandsworth, now Chamois Leather Factory.

Prestwich, *Quart Journ. Geol. Soc.*, vol. x. p. 139.

About 35 feet above Ordnance Datum.

Water rose 20 feet above the ground (R. W. Mylne, *Trans. Inst. Civ. Eng.*, vol. iii. p. 231).

Yielded 120 gallons a minute at the surface (J. Lucas, *Journ. Soc. Arts*, vol. xxv. p. 600).

			Thickness. Feet.	Depth. Feet.
[River] Gravel			9	9
London Clay, 71½ feet.	Grey clay		70	79
	Basement-bed	Hard clay ...	1	80
		Pebbles	½	80½

Garratt—*continued.*

1. Copper-Mills—*continued*

		Thickness. Feet.	Depth. Feet.
Woolwich and Reading Beds, 62½ or 54½ feet.	Grey clay	4	84½
	Yellowish-grey clay	2	86½
	Blue clay	2	88½
	Carbonaceous matter and clay	½	89
	Shells	1	90
	Grey clay	2	92
	Sandy [bed] and water	1	93
	Yellow clay	2	95
	Mottled grey and yellow clay	4	99
	Sandy [bed] and water	2	101
	Yellow mottled clay	3	104
	Grey clay	3	107
	Red clay	3	110
	Mottled clay...	1	111
	Yellow clay	6	117
	Mottled clays (2 beds)	12	129
	Dark blue clay	4	133
	Septaria ?	1	134
	Clay and gravel [pebbles ?]	1	135
	Green sand and water [possibly belongs to the Thanet Sand]	8	143

2. The Willows. Sheet 8.

Specimens shown me by Mr. Hallett.

32·16 feet above Ordnance Datum.

Well (sunk by Eastell) 235 feet deep. Water rose into a tank 15½ feet above the ground, the supply not varying (Nov. 1891).

London Clay.
Reading Beds { Variously coloured mottled clays. Pebbles. Green and red mottled clayey sand.
Fine, grey Thanet Sand.

According to Mr. J. Lucas, this bore is 256 feet deep, and reaches the Chalk.

3. The following are noted by J. Lucas, *Journ. Soc. Arts*, vol. xxv. p. 611. All overflowed.

	Height.	Depth.	
Garrett Farm	36	365	(? 360 to and 5 in Chalk).
Mr. Fenton's	30	360	to sand.
Althorp Lodge	34	240	„ „

Garratt is in the parish of Wandsworth; but some of these places may be in Tooting or Wimbledon. The first is just in Wimbledon, according to Mr. E. A. Turner, and not more than 200 yards from the well at Chambers Watercress Beds (p. 253). He tells me that the district is now known as Earlsfield.

Gatton.

Ordnance Map 296, new ser. Geological Map 8.

1. W. of Battlebridge Farm.

F. Drew, in the Geology of the Weald, 1875, p. 148.

Well through 80 feet of Gault; top 20 feet or so light-blue and brown clay the rest dark blue.

2. Lucas notes 3 wells in Lower Greensand. *Proc. Inst. Civ. Eng.* 1880 vol. lxi, pt. iii, p. 224.

Godalming.

Ordnance Map 285, new ser. Geological Map 8.

1. Munstead Heath (south-eastward from the town).

Mr. P. N. Graham's. 1896.

Made and commmunicated by Messrs. Le Grand & Sutcliff.

Water-level 155 feet 8 inches down (May).

		Thickness. Ft.	In.	Depth. Ft.	In.
	Pit (the rest bored) ...	—	—	6	0
[? Folkestone Beds].]	Red sand ...	5	0	11	0
	Yellow sand, with ironstone from 33¾ to 34 feet down ...	24	0	35	0
[? Hythe Beds, 162¼ feet.]	Buff stone, with ironstone from 51 ft. 6 in. to 51 ft. 8 in. down ...	24	6	59	6
	Grey limestone ...	6	1	65	7
	Buff sand ...	3	6	69	1
	Grey limestone ...	1	2	70	3
	Buff sand and layers of Bargate Stone ...	10	11	81	2
	Bargate Stone ...	1	9	82	11
	Buff sand and layers of Bargate Stone ...	24	7	107	6
	Sand and sandstone layers ...	7	6	115	0
	Light-buff sand ...	7	0	122	0
	Stiff buff sandy marl ...	23	6	145	6
	Greenish sand ...	4	6	150	0
	Grey calcareous sandstone ...	0	4	150	4
	Greenish buff sand ...	1	2	151	6
	Greenish buff sandy marl ...	39	6	191	0
	Buff clayey sand ...	6	3	197	3

2. Shackleford, W.N.W. of the town. 1899.

Made and communicated by Messrs. Duke & Ockenden.

[? Hythe Beds.]	Sandstone ...	29½	82 feet.
	Clay and sand	15½	
	Sandstone ...	97	

3. Messrs Pullman's, Leather Dressers.

Made and communicated by Messrs. Duke & Ockenden.

Good supply of water, rising to within 9 inches of the ground.

		Thickness. Feet.	Depth. Feet.
	Made up ground ...	12	12
[River Drift.]	Gravel, fine and coarse ...	8	20
[Hythe Beds.]	Yellow-brown sand ...	10	30
	Blue-grey sand ...	14	44
	Stiff blue clay ...	2	46
	Blue-grey sand ...	7	53
	Medium hard sandstone	7	60
	Bluish clayey sand ...	12	72

4. Not far S.W. of Catteshall Mill.

From information given by Mr. Sweetapple.

According to information got by Mr. C. E. Hawkins this was made before 1884, and was unsuccessful.

		Thickness. Feet.	Depth. Feet.
[Lower Greensand.)	Coarse sand ...	12	12
	Stones and sand ...	38	50
[Atherfield & Weald.]	Clay (the latter part sandstone)	490	540

Godalming—*continued.*

5. MR. H. MOON, of Godalming, notes that unsuccessful borings were made, many years ago, at Langham (? the one last noted), at the tannery in Mill Lane, and at a brewery in Bridge Street. MR. J. H. NORRIS thinks that these borings were unsuccessful chiefly because at the time they were made no devices for sand-screening were available. His experience shows that there is a sheet of water at a comparatively shallow level; thus, in making a basement at the Municipal Buildings in Bridge Street, he pumped about 3,000 gallons an hour from a depth of about 10 feet.

He says (1910] that most of the houses were formerly supplied from shallow wells, and a few of these still remain. There is a strong stream running down the Wey Valley through the gravel, but this water was not intercepted at any point in the deep sewer-trenches which were cut across the valley about a mile further down, and he thinks that this water finds its way into the bed of the river at some intermediate point.

6. THE CHARTERHOUSE, W. of Farncombe Baths.

From the Charterhouse Museum Records. Communicated by MR. J. H. NORRIS. Abandoned as unsuccessful.

		Thickness. Feet.	Depth. Feet.
[Hythe Beds.]	Well (old). The rest bored	—	33
	Brown live sand	6	39
	" dead sand	14	53
	" sand and small pebbles	2	55
	" " and clay ...	$7\frac{1}{3}$	$62\frac{1}{3}$
	Live sand	6	$68\frac{1}{3}$
	Dead sand	$\frac{2}{3}$	72

7. WATERWORKS.

Communicated by MR. J. H. NORRIS, Water Engineer, 1910 (some notes from his Report for the year ended March 31st, 1909, some from his notes to the Local Government Board, February, 1910).

The present sources of supply are as follows :—

	Yield. Gallons a day.	Rest-level or issue-level of water above Ordnance Datum.
Springs, Catteshall Lane	120,000	130 feet.
Borehole, Peperharrow Road (no details)	130,000	200 "
Syphons, Borough Road, collected at shallow level from sand	160,000	130 "
Collecting chamber, Peperharrow Road, about 25 feet deep... ...	30,000	160 "
New supply, behind Electric Light Station	180,000	130 "
New supply in withy-bed, Peperharrow Road, 2 chambers... ...	200,000	130 "

The last two are shallow waters, differing from the greensand waters, from gravel, beneath soil and about 5 feet of peat.

The area within which the corporation may supply water is about 36 square miles, and, besides Godalming (Urban and Rural) includes Bramley, and parts of Compton, Elstead, Hambledon, Peperharrow, Shalford and Witley. The estimated population supplied is 14,000. Annual supply 190,000,000 gallons. Maximum day's consumption 650,000 gallons. (*Waterworks Directory*, 1911.)

A further supply is being got in the Ockford valley and at Tuesley, of which details are given further on.

Godalming—*continued.*

7. WATERWORKS—*continued.*

Charterhouse Road Works.

From Charterhouse Museum Records. Communicated by MR. J. H. NORRIS
Surface-level 157 feet above Ordnance Datum.

		Thickness. Feet.	Depth. Feet.
[Hythe Beds.]	Well (old), the rest bored	—	55
	Live sand	6	61
	Concrete	5	66
	Live sand	6½	72½
	Very hard sand	6	78½
	" " " and rock ...	2	80½
	Blue clay and sand ...	6	86½
	Grey hard sand	8	94½
	Dead sand	5½	100
	" " with clay ...	18	118
	Brown clay...	4	122
	Blue clay	8½	130½
	Hard rock	4	134½
	Sand	4½	139
	Dead green sand and shells	5	144
	Dead green sand	9½	153½
Atherfield Clay.	Blue clay	19½	173
	" " and hard rock ...	7½	180½
	Blue clay	11½	192

The first source developed by the old Water Company. Not now used. It was closed owing to the difficulty of excluding running sand. The boring is said to have been unsuccessful.

According to a letter from MR. J. CHURCH, at these works, a large fissure was cut in rock, which runs under Frith Hill, and a large supply was got from this source. When more than 10,000 gallons of water were pumped in an hour sand got into the water.

Tuesley Site. By the western end of pond E. of Tuesley Farm and nearly 1¼ miles S. of Godalming church.

182 feet above Ordnance Datum.

Shaft about 30 feet, the rest bored.

		Thickness. Feet.	Depth. Feet.
Soil		8	8
[Alluvium] Clay and silt		1	9
[Hythe Beds.]	Bargate stone	1	10
	Compact sand with a little water	20	30
	Sand with water	3	33
Blue (Atherfield) Clay ?		27	60

If the above reading be correct the Atherfield Clay is nearer the surface than would have been expected.

Ockford Works. Near Wood Farm and about a mile nearly south-westward of Godalming church. 1909 ?

149 feet above Ordnance Datum.

Sump 20 feet, the rest bored. Lined with 10-inch tubes, plugged at top from 3 feet above the surface to 62 feet down ; and with 8-inch (internal diameter) sandscreen tube from about 58 feet down to the bottom.

There are 3 borings (to one of which the section below refers) and 4 shallow excavations about 20 feet deep and about 150 feet above Ordnance Datum.

The original level of the water about 12 feet down. It was kept down by surface-strata, the removal of which released the water, and it has since overflowed from all holes and borings.

Godalming—*continued.*

7. WATERWORKS—*Ockford Works*—continued.

Continuous pumping, day and night, from November 2 to 16, 1909, at the 4 shallow excavations reduced the water-level therein to 3 feet from the bottom, and the yield was at the rate of 173,000 gallons a day.

Continuous pumping, day and night, from January 17 to February 1, 1910, from the 3 borings, reduced the water-level to 100 feet above Ordnance Datum in two borings and to 80 feet in the other. The yield was as follows:— A. 3,192 gallons an hour. B 6,276. C. 2,184 or a total of 11,652=279,000 gallons in 24 hours; but there was a stoppage of some hours in the pumping on January 19, 20, owing to an accident.

The total yield here is therefore given as about 450,000 gallons a day.

The time taken for water to return to its original rest-level after pumping ceased was on an average an hour in the borings and 12 hours in the excavations.

		Thickness. Feet.	Depth. Feet
Surface-soil and peat		10	10
Ironstone-gravel		7	17
[Hythe Beds.]	Fine sand	13	30
	Blue clay and sand	1	31
	Fine sand	3	34
	Clay and sand	2	36
	Sand with thin layers of clay	12	48
	Sandstone-pebbles and fine sand	11	59
	Conglomerate sand	½	59½
	Fine sand	13½	73
	Blue clay	¾	73¾
	Fine sand	23¼	97
	Clay and sand (according to another account)	2½	99½

The other account differs slightly and makes the total depth 100 feet.

Analyses of the waters of the Godalming works are given on pp. 299, 300.

8. J. LUCAS notes 19 wells in Lower Greensand in the parish of Godalming. *Proc. Inst. Civ. Eng.* 1880, vol. lxi, pt. iii, pp. 219, 220.

Godstone.

Ordnance Map 286, new ser. Geological Map 6.

1. BRANSFIELD HOUSE, just northward of the Church. 1898 ?

Made and communicated by MESSRS. LE GRAND and SUTCLIFF.

Water-level 35 feet down.

		Thickness. Feet.	Depth. Feet.
[Folkestone Beds.]	Sandy clay	3	3
	Sand	6	9
	Running sand	19	28
	Stone	1	29
	Stone and sand	5	34
	Blowing sand	11	45
	Dead sand	27	72
	Green sand	2	44
	Blue sand	22	96
[Sandgate Beds, 38 feet.]	Dark sandy clay	8	104
	Hard stony marl	5	109
	Sandy clay and stone	12½	121½
	Hythe marl	12½	134
[Hythe Beds, 38 feet.]	Very hard stone	4	138
	Stone and sand	3	141
	Sandy clay	3	144
	Stone and clay	2½	146½
	Sand and sandy clay	13½	160
	Stone and sand	4	164
	Sandy clay	8	172

Godstone—*continued.*

2. COTTAGES in Hart Lane. 1888.

Bored and communicated by MESSRS. LE GRAND and SUTCLIFF.

Water-level 15 feet down.

		Thickness. Feet.	Depth. Feet.
Dug well (old, the rest bored)		—	45
[? Weald Clay.]	Weald clay	58	103
	Hard clay and a little sand	7	110
	Hard clay	26	136

3. THE HOMESTEAD, Mr. T. Churchill's, about ¼ mile S.E. of the Green. 1888.

Bored and communicated by MESSRS. LE GRAND and SUTCLIFF.

Water-level 66½ feet down.

		Thickness. Feet.	Depth. Feet.
Dug well (old, the rest bored)		—	66½
[Lower Greensand.]	Dark clay and sand	13	79½
	Dark green sand, with bands of sandstone	8	87½
	Green sand and clay, and bands of sandstone	10½	98

I am in doubt as to the sites of Nos. 2 and 3.

4. LUCAS notes 2 Chalk wells in the parish. *Proc. Inst. Civ. Eng.* 1877, vol. xlvii, pp. 106, 107.

5. Also 4 wells in Lower Greensand. *Ibid.* 1880, vol. lxi, pt. iii, p. 225.

Gomshall *see* Shere.

Great Bookham.

Ordnance Map 286, new ser. Geological Map 8.

1. POLESDEN LACY. South of the village.

The depth of the old well (about 1850 ?) has been variously given as 500, 507 and 525 feet. It is about 450 feet above Ordnance Datum. MR. LUCAS thinks that it has "passed through the Chalk into the Upper Greensand"[1]; but this may be open to doubt. MR. F. S. COURTNEY tells me that such small yield as there is comes in from the Chalk some way from the bottom.

MESSRS. TILLEY made another well, in 1903, 1904, at 313 feet above Ordnance Datum, 340 feet deep, with a boring of 54 feet, or a total of 394. Therefore, allowing as they do, 525 feet as the depth of the old well, the bottoms of the two are practically level.

This well is wholly in Chalk, which was very hard, except in the last 10 feet of the boring; in one place it was gritty. Sufficient water was got, about 8000 gallons a day.

2. LUCAS notes 30 other wells in, or in one case to, the Chalk in the parish. *Proc. Inst. Civ. Eng.* 1877, vol. xlvii, pp. 100, 101.

Guildford.

Ordnance Map 385, new ser. Geological Map 8.

1. CASTLE BREWERY, a little S.W. of St. Nicolas Church. 1883.

Made and communicated by MR. R. B. PATEN.

Shaft 17½ feet, the rest bored.

Gravel and sand	12	275 feet.
[Upper] Chalk and flints ...	263	

[1] *Proc. Inst. C.E.* vol. xlvii. In discussion on his paper.

Guildford—*continued.*

2. FRIARY BREWERY CO., nearly 300 yards eastward of the railway-station.

Boring, made by MESSRS. ISLER and CO.

Surrey Advertiser, 29 June, 1889.

The boring was finished on June 25, after only 17 days' work.
Lined mostly with a 6-inch pipe.
Water pumped at the rate of a barrel in 25 seconds.

Sand and ballast [gravel] ...	29	251 feet.
[Upper] Chalk, hard, and flint...	222	

The water 6° cooler than the town-water.

3. STOKE. Just W. of the Wey and N. of the railway, about half a mile north of the station. Dapdune Works of the Woking Water Co. 1899.

Made and communicated by MESSRS. LE GRAND & SUTCLIFF.

Overflowed (September). According to information from Dr. R. W. C. PIERCE (1912), water rises to within 20 feet of the surface, and the yield is about 12,000 gallons an hour, with a possibility of 17,000.

		Thickness. Feet.	Depth. Feet.
[? Alluvium.]	Soil	3	3
	Clay	2	5
[River Drift.]	Sand and gravel	10	15
Blue [London] Clay. A little sand and shells in the lowest 15 feet. Pebbles at the base ...		52	67
[Reading Beds, 73 feet.]	Brown and blue clay ...	6	73
	Coloured [mottled] clay ...	51	124
	Green sand	15	139
	Pebbles and flints	1	140
[Upper] Chalk and flints		167	307

For an analysis of the water *see* pp. 302, 337.

4. WATERWORKS. Millmead, just southward of St. Mary's Church.

Communicated by MR. C. G. MASON, Borough Surveyor. With some particulars from the Waterworks Directory, 1911 (*see also* p. 334).

Older well 36 feet deep.

Newer well, with a boring of 15 inches diameter. 1904?

Natural rest-level of water 10 feet down, or 97·4 above Ordnance Datum. When pumping 918,000 gallons a day, the level is 32 feet down.

Yearly supply from shallow well 249,923,000 gallons (estimated available 319,900,000) from boring 54,260,000 gallons (estimated available yearly supply 237,250,000).

Yearly supply,	domestic ...	212,156,000	Total 304,183,000 gallons.
	trade ...	15,419,000	
	municipal ...	23,000,000	
	to Railway ...	53,668,000	

Average daily supply per head, domestic, 21 gallons.

The above figures for supply are for a year ending 31 March, 1911. Maximum day's supply 1,200,000 gallons, 30 June, 1908.

Population supplied 27,000, including Artington and part of Shalford.

		Thickness. Feet.	Depth. Feet.
Made ground		6½	6½
[River Drift.]	Dark sand...	1	7½
	Clean sharp sand...	4	11½
	Sand and ballast [gravel] ...	6	17½
	Ballast [gravel], sand, and chalk	7	24½

Guildford—*continued.*

4. Waterworks—*continued.*

		Thickness. Feet.	Depth. Feet.
Upper and Middle Chalk.	Chalk and flints	21	45½
	Chalk with less flints	39	84½
	Grey chalk [? marl-layer] ...	1½	86
	Chalk and flints in layers ...	29	115
	Chalk and flints, with grey layers	23	138
	White chalk	49½	187½
	Chalk marl	4½	192
	Grey chalk	59	251
	Grey chalk marl	5	256
	White chalk	4	260
	Grey chalk	28	288
	White rock-chalk	24	312
	Rock-chalk with flints	6	318
	Melbourn rock	11	329

Apparently the Upper Chalk goes to 138 feet, and then the Middle Chalk is reached, if the identification of the bottom bed as Melbourn Rock be right.

According to the *Surrey Advertiser* of 15 June, 1901 the experimental boring was carried further (? to 350 feet) into soft pulpy chalk (Belemnite Marl) and water came up with such force that large pieces of flint were forced up.

Analyses of the waters of the Guildford works are given on pp. 301, 302.

5. West Surrey Dairy Co. By the back of Abbot's Hospital.

Boring made and communicated (1901) by Messrs. Isler & Co.

Lined with 90 feet of tubes, of 4 inches diameter, 2 feet down.
Water-level 73 feet down.

		Thickness. Feet.	Depth. Feet.
Well (old) ...	... ...	—	74
[Upper Chalk.]	Chalk	7	81
	Chalk and flints	60	141
	Flints	6	147
	Hard chalk ...	3	150
	Chalk and flints	100	250

6. Woodbridge. Messrs. Dennis's Motor Factory, on the west of the railway, north of the Hospital. 1911.

Made and communicated by Messrs. Duke and Ockenden.

Shaft 96 feet, the rest bored. Lined with 6-inch tubes to 222 feet down.
Water found at 260, 278 and 296 feet down.
Water-level in well 24 feet down, in bore hole 37.
Test-pumping for 27 hours at 1500 gallons an hour.

		Thickness. Feet.	Depth. Feet.
Blue [London] Clay ...	... ...	150	150
[Woolwich Beds, 70 feet.]	Mottled clay ...	56	206
	Green sand ...	4	210
	Pebbles and clay	10	220
[Upper] Chalk and flints	... ...	80	300

7. Lucas notes 5 Chalk-wells in the parish. *Proc. Inst. Civ. Eng.* 1877, vol. xlvii, p. 98.

Hambledon.

Ordnance Map 301, new ser. Geological Map 8.

1 Furze Hill. Mr. Muir's.

Communicated by Messrs. Duke and Ockenden.

[Lower Greensand.] Ferruginous sand, 75 feet.

2. Lucas notes 2 wells in Lower Greensand in the parish. *Proc. Inst. Civ. Eng.* 1880, vol. lxi, pt. iii, p. 220.

Hascombe.

Ordnance Map 301, new ser. Geological Map 8.

Communicated by MR J. H. NORRIS of Godalming, 1910.

1. Boring, recently made by MESSRS. ISLER and Co. for the Hon. S. Bouverie, on the hill-top.

Nearly 300 feet deep. Good supply got.

2. LUCAS notes 2 wells in Lower Greensand. *Proc. Inst. Civ. Eng.* 1880, vol. lxi, pt. iii, p. 220.

Haslemere.

Ordnance Map 301, new ser. Geological Maps 8, 9.

1. DENE PARK. 1901.

Made and communicated by MESSRS. DUKE & OCKENDEN.

Water first struck at 70 feet. A small quantity at 93. Increased at 100–110. Water-level, when at rest, 98 feet down. Infiltration 300 gallons an hour.

		Thickness. Feet.	Depth. Feet.
[Hythe Beds.]	Sandstone	87	87
	Clay and sandstone	9	96
	Blue rock. Sandstone and clay alternating	14	110
[? Atherfield.]	Blue clay...	9	119

2. WATERWORKS. 1907.

From Water Works Directory 1911.

Maximum day's supply 35,000 gallons, in January.
Population supplied about 2500.
Water good, chemically and bacteriologically.

The works are in the parish of Lurgashall in Sussex, near Chase Farm, Black Down, the well passing through Hythe Beds (188 feet) into Atherfield Clay, and an account of them is given in the Supplementary Memoir on that county, 1911, p. 190. The following notes, from MR. R. F. GRANTHAM, are additional to that account, not then recorded as belonging to works for another county.

The shaft was originally sunk to the depth of about 106 feet, to a bed of blue shale, when a spring yielding about 4000 gallons a day was found. The shaft was then sunk 35 feet deeper, but very little more water was met with. A boring of six inches diameter was then made to 95 feet below the bottom of the well.

The easterly heading has been carried to a length of 549 feet.

Headley.

Ordnance Map 286, new. ser. Geological Map 8.

1. LUCAS notes 2 Chalk wells, one of which, at High Ashurst is 397 feet deep and, it is doubtfully suggested, may reach Upper Greensand. I believe it does not. *Proc. Inst. Civ. Eng.* 1877, vol. xlvii, pp. 102, 103.

2. In SIR J. PRESTWICH'S MSS. is a note of a well at Headley Hill, 70 feet to Chalk, through sand with an underbed of oyster-shells and pebbles.

Hindhead *see* Frensham.

Holmwood *see* Dorking.

Honor Oak *see* Camberwell.

Hook (? in the parish of Long Ditton).

Ordnance Map 270 new ser. Geological Map, London District, Sheet 3.

Whitehall, 3 miles S. of Kingston.

J. Lucas, *Journ. Soc. Arts*, vol. xxv. pp. 602, 616.

About 115 feet above Ordnance Datum; 300 feet deep in Tertiary beds; shaft 48 feet; water never falls below the bottom of the shaft; it stood 17 feet below ground in March 1877.

Horley.

Ordnance Map 286, new ser. Geological Map 8.

1. Albert Brewery. Messrs. Youell & Elkin. 1895.

Made and communicated by Messrs. Isler & Co.

Dug 3 feet, the rest a boring of 6 inches diameter.

Water overflowed at the rate of about 9 gallons a minute. Pumping goes on at the rate of 2000 gallons an hour.

		Thickness. Feet.	Depth. Feet.
[? All Weald Clay.]	Weald clay	11	11
	Stone	8	19
	Blue marl	41	60
	Blue marl and stone	19½	79½
	Stone	1½	81
	Marl	2	83
	Marl and stone ...	5	88
	Marl	6½	94½
	Marl and stone ...	91	185½
	Sandstone *	25½	211
	Marl and stone ...	2½	213½
	Sandstone	8	221½
	Marl	3½	225
	Marl and stone ...	4½	229½
	Marl	5½	235
	Marl and stone ...	16	251
	Marl	4	255
	Marl and stone ...	9	264
	Marl	1	265
	Marl and stone ...	2½	267½
	Marl	21	288½
	Sandstone	½	289
	Stone	1½	290½
	Sandstone	4	294½
	Marl and sandstone ...	2½	297
	Marl	3	300

* A letter from Messrs. Youell & Elkin (Nov. 1895) describes this 25 feet bed as limestone, and adds that an adequate supply comes from it.

2. Elm Cottage. Mr. L. Miller's.

No supply.

Communicated by Messrs. Isler & Co.

[Weald Clay.]	Shaft	42	67 feet
	Bore, through blue slaty marl	25	

3. Rede Hall. Mr. Tebbs.

Bored and communicated by Messrs. Duke and Ockenden.

Abundance of water, rising 3½ feet above the ground.

		Thickness. Feet.	Depth. Feet.
	Well (? old), the rest bored	—	47
[Weald Clay.]	Soft blue rock	32	79
	Hard rock, with veins of clay a few inches thick	66	145
	Softer strata, with sand ...	5	150

Horley—*continued.*

4. Mr. C. E. Hawkins has noted that a boring made at the Railway Station (about 1839) is believed to be 260 or 270 feet deep, and that water overflowed to the height of 20 feet. An analysis of the water is given on p. 336.

Horsleydown *see* Bermondsey.

Kenley *see* Coulsdon.

Kennington.

Ordnance Map 270, new ser. Geological Map, London District, Sheet 4.

1. Messrs. Hayward's. Montford Place. 1907.

About 15 feet above Ordnance Datum.

Made and communicated by Messrs. Isler & Co.

40 feet of tubes 8½ inches in diameter from 4½ feet down.
130 " " 7¼ " " " 2½ " "
170 " " 6 " " " level with surface.

Water-level 83 feet down. Supply 2000 gallons an hour.

		Thickness. Feet.	Depth. Feet.
[River Gravel]	Ballast	10	10
[London Clay 74 feet.]	Clay	1½	11½
	Sand	2	13½
	Blue clay	70½	84
[Woolwich and Reading Beds, 53 feet.]	Mottled clay ...	14	98
	Light grey sand ...	7	105
	Clay and shells ...	7	112
	Mottled clay ...	8½	120½
	Conglomerate ...	4	124½
	Clay and pebbles ...	5½	130
	Green sand ...	7	137
[Thanet Sand, 32 feet.]	Light grey sand ...	6	143
	Dark " " ...	25½	168½
	Flints	½	169
[Upper] Chalk	... ...	35	204

2. Lower Kennington Lane. Messrs. Beattie. Dye Works. 1907.

About 15 feet above Ordnance Datum.

Made and communicated by Messrs. Isler & Co.

30 feet of tubes 7¼ inches in diameter from 4 feet down.
105 " " 6 " " " 3 " "
170 " " 5 " " " 2 " "

Water-level 110 feet down. Yield 2520 gallons an hour.

		Thickness. Feet.	Depth. Feet.
Made Ground	... ...	3	3
[River Drift, 20 feet.]	Loamy sand ...	3	6
	Ballast [gravel] ...	14	20
	Sand	3	23
Blue [London] Clay	... ...	57	80
[Reading Beds, 46 feet.]	Sand...	24	104
	Mottled clay ...	12	116
	Conglomerate ...	6	122
	Pebbles	1	123
	Clay and stones ...	3	126
[Thanet Sand, 41 feet.]	Green sands ...	38½	164½
	Green-coated flints...	2½	167
[Upper] Chalk and flints	... ...	183	350

Kennington—*continued.*

3. Kennington Road. Lambeth Baths.

15 feet above Ordnance Datum.

Made and communicated by Messrs. Baker.

Water-level 90 feet level below road-level. Yield 15,000 gallons an hour (1911).

		Thickness. Ft.	In.	Depth. Ft.	In.
[River Drift.]	Ballast [gravel] ...	19	0	19	0
	Bed of stones... ...	1	0	20	0
[London Clay, 79½ feet.]	Blue clay	69	6	89	6
	Sandy clay	7	3	96	9
	Pebbles	2	9	99	6
[Woolwich and Reading Beds, 67 feet.]	Fine grey sand ...	5	0	104	6
	Hard stone	1	3	105	9
	Sand	0	3	106	0
	Sandstone	0	8	106	8
	Pebbles	0	4	107	0
	Very hard stone ...	2	0	109	0
	Dark grey sand ...	6	6	115	6
	Light-coloured clay ...	11	0	126	6
	Dark clay	4	0	130	6
	Shelly bed	2	0	132	6
	Clay and shells ...	1	0	133	6
	Dark sandy clay ...	8	6	142	0
	Clay and pebbles ...	19	6	161	6
	Pebbles	5	0	166	6
[Thanet Sand, about 20 feet.]	Dark sand	2	2	168	8
	Thanet sand	16	0	184	8
	Green-coated flints ...	2	0	186	8
[Upper] Chalk	... ...	229	4	416	0

The total is given as 406 feet.

Kingston-on-Thames.

Ordnance Map 270, new ser. Geological Map, London District, Sheet 3.

1. Brook Street. Mr. W. F. Hodgson's Brewery. 1866?

From a drawing in Mr. Hodgson's office.

About 25 feet above Ordnance Datum.

Shaft for 90 feet, the rest bored.

Water overflows; estimated yield about 44,000 gallons a day. In 1911 the yield so small that the boring was disused. (G. Barrow.)

		Thickness. Ft.	In.	Depth. Ft.	In.
[River Drift, 13 feet.]	Loamy clay, with gravel ...	11	0	11	0
	Gravel	2	0	13	0
Blue [London] clay ...	... ...	245	0	258	0
[Reading Beds, 88 feet.]	Variously-coloured mottled clays	57	0	315	0
	Marl [clay]	4	0	319	0
	Vein of loamy sand	0	5	319	5
	Marl [clay]	9	0	328	5
	Vein of loamy sand	0	9	329	2
	Marl [clay]	5	0	334	2
	Dark dead sand*	12	0	346	2
Light-brown [Thanet] sand...	... ...	25	0	371	2
[Upper] Chalk, with small flints	... ...	99	0	470	2

* This bed may belong to the Thanet Sand.

An account of this well, almost in the same words as above, appeared in the *Surrey Comet*, 1866.

Kingston-on-Thames—*continued.*

1. Brook Street—*continued.*

Second Well. 1896. Some way from the other.

		Thickness. Feet.	Depth. Feet.
Ballast [Gravel]		14	14
Blue [London] clay, full of clay-stones...		245	259
[Reading and Thanet Beds.]	Mottled clays ...	65	324
	Not described, to Chalk	30	354

The following account, sent by Messrs. Isler & Co., from a drawing at Kingston, may refer to this second well, as it differs somewhat from the account of the first.

		Thickness. Ft.	In.	Depth. Ft.	In.
[River Drift] Loamy clay with gravel		11	9	11	9
Blue [London] clay		246	3	258	0
[Reading Beds, 75½ feet.]	Variously coloured mottled clays	48	0	306	0
	Loamy sand	0	5	306	5
	Mottled clay	8	7	315	0
	Loamy sand	0	9	315	9
	Mottled clay	5	3	321	0
	Dark dead sand	12	6	333	6
Green [Thanet] sand		22	6	356	0
[Upper] Chalk with flints		114	0	470	0

A newer well, made by Messrs. Isler and Co. gives the following section—

Made ground. Sand and gravel ...	14	314½ feet.
Blue London clay, full of clay-stones	245	
Mottled clay	55½	

2. Thames Street.

Communicated by Mr. C. Slagg, Borough Surveyor.

25 feet above Ordnance Datum.

Water rose to surface.

[River] Gravel	365 feet, to water.
[London Clay and Reading Beds?] Clay	

3. Union. About 1843.

F. Braithwaite, General Board of Health, Report on Supply of Water to Metropolis, Appendix 2, p. 97 (1850).

About 80 feet above Ordnance Datum.

Shaft 137 feet. Water, after rest, sometimes within 20 feet of the surface and is pumped down at least 90 feet (J. Lucas, *Journ. Soc. Arts*, vol. xxv, p. 602. Slightly different, p. 616).

To sand-spring [through London Clay] 425 feet (420 feet in *Proc. Inst. Civ. Eng.*, vol. i, 1843).

4. Mr. Fuller's. Near the Cambridge Asylum.

J Simpson, MS. in *Library Inst. Civ. Eng.;* and letter from Mr. C. Slagg.

53 feet above Ordnance Datum.

Supply 20 gallons a minute, to a height of 10 feet above the ground. Disused, and has long ceased to overflow (J. Lucas, *Journ. Soc. Arts*, vol. xxv, p. 602).

355 feet deep through [London] Clay.

"The flow of water at both of these wells has been affected by the sinking of a well in the Duke of Buccleuch's ground at Richmond, and by another at the Copper Mills, Lower Green, Esher."

Kingston-on-Thames—*continued.*

5. Mr. Palmer.

J. Simpson, MS. in *Library Inst. Civ. Eng.*

To Chalk, 412 feet.

6. Messrs. R. White & Sons.

Made and communicated by Messrs. Isler.

Shaft 9 feet, the rest bored. Lined with 365 feet of tubes, of 8½ inches diameter, from 2¾ feet down.

Water-level 2¾ feet down. Supply 540 gallons an hour.

		Thickness. Feet.	Depth. Feet.
[River Drift.]	Gravel and clay...	9	9
	Gravel	6	15
	Gravel and clay...	7	22
[London Clay, 246 feet.]	Clay and clay-stones	85	107
	Gravel [? pebbles]	4	111
	Clay	10	121
	Clay and stones...	7	128
	Clay	16	144
	Clay and stones...	3	147
	Clay	2	149
	Clay-stone	3	152
	Clay	8	160
	Clay and stones...	11	171
	Clay	8	179
	Clay and stones...	83	262
	[Basement-bed] Blue clay and pebbles	6	268
[Woolwich and Reading Beds, 85 feet.]	Mottled clay and sand... ...	6	274
	Blowing sand	2	276
	Sand and clay	2	278
	Mottled clay	51	329
	Green sand	6	335
	Mottled clay	2	337
	Sand [may be Thanet Sand]	16	353
[Upper Chalk, 262 feet.]	Flints and chalk	181	534
	Grey chalk	45	579
	Chalk	16	595
	Grey chalk	20	615

Lambeth.

Ordnance Map 270, new ser. Geological Map, London District, Sheet 4.

1. Belvidere Road. Lion Brewery (late Goding's), close to the Thames at Charing Cross Bridge, 1837, deepened 1868.

From a drawing in the office of the Company and from information communicated by Messrs. S. F. Baker & Sons. The figures in brackets from "A Treatise on Waterworks" by S. Hughes, new Ed. 1875, p. 204.

17·26 feet above Ordnance Datum.

Shaft 156 feet, the rest bored.

Water rose to 40 feet below the ground. Average quantity pumped (according to Mr. S. Hughes, as above) about 72,000 gallons a day, the water-level being reduced about 10 or 12 feet after 12 hours pumping.

Lambeth—*continued.*

1. Belvidere Road—*continued.*

Water-level in Nov. Dec. 1891, 85·74 feet below Ordnance Datum. A loss of 63 feet in 54 years. (Binnie.) Water-level fell to 180 feet below Ordnance Datum in 1911. (G. Barrow.)

	Thickness. Feet.	Depth. Feet.
Siltage [Made ground and Alluvium]	16 (14)	16 (14)
[Valley Drift, 19 feet.] Sand...	9 (10)	25 (24)
[Valley Drift, 19 feet.] Shingle [gravel]	10 (9½)	35 (33½)
Blue [London] Clay	89 (98)	124 (131½)
[Woolwich and Reading Beds.]* Variously-coloured clay	68 (41)	192 (172½)
[Woolwich and Reading Beds.]* Two beds of pebbles, with water	10	202 (182½)
[Woolwich and Reading Beds.]* Green sand, no water ... about	11 (12)	213 (194½)
[Thanet] sand, main spring; about 25 feet shown in the drawing, no bottom shown, but the bore goes down 40 feet from the top of this bed say	32 (20)	245 (214½)
Chalk, with many layers of flints and strongly charged with water	173 ? (193½)	418 (408)

* The thickness given to the Woolwich and Reading Beds seems too great. Perhaps some of the top bed may belong to the London Clay, and perhaps the lowest bed may belong to the Thanet Sand.

In R. W. Mylne's "Sections of the London Strata," the measurements below are given :—

	Thickness. Feet.	Depth. Feet.
Made ground, gravel, &c. ...	35	35
London Clay	100	135
Woolwich and Thanet Beds	115	250
Chalk	80	330

In Sheet 3 of the large "Sections of Borings in the Metropolitan District" (1849), a wrong account is given of this well, as follows :—

	Thickness. Feet.	Depth. Feet.
Made ground	15	15
Gravel ...	15	30
Blue clay ...	160	190
Chalk ...	80	270

Second Well. 1883.

16·77 feet above Ordnance Datum.

Communicated by Mr. E. Easton.

Shaft 231 feet.
Water-level in Nov. 1891, 88·23 feet below Ordnance Datum.

	Thickness. Feet.	Depth. Feet.
Surface [made ground, &c.]	15	15
Clay [Alluvium]	9	24
Thames ballast [River Gravel]	12	36
[London Clay, 104 feet.] Clay	94	130
[London Clay, 104 feet.] Loamy clay	4	134
[London Clay, 104 feet.] Large pebbles and clay	6	140

Lambeth—*continued.*

1. Belvidere Road—Second Well—*continued.*

		Thickness. Feet.	Depth. Feet.
[Woolwich and Reading Beds, 63 feet.]	Sandy clay	6	146
	Firm clay...	4	150
	Mottled clay, the bottom 4 feet less firm	7	157
	Loam and sand	3	160
	Mottled loam and sand, the bottom 5 feet of higher colour ...	7	167
	Jointy clay	5	172
	Clay and shells	4	176
	Mottled, sandy clay	7	183
	Mottled clay	4	187
	Large, black pebbles	3	190
	Pebbles and oyster-shells ...	2	192
	Green sand and pebbles... ...	6	198
	Mixed pebbles	2	200
	Grey sand and pebbles	3	203
[Thanet Sand, 28 feet.]	Grey sand...	2	205
	Grey sand and iron-pyrites ...	22	227
	Dark, silty sand	4	231
Chalk and flints	... ...	9	240

2. Bethlehem Hospital, Lambeth Road.

Sunk and communicated by Messrs. S. F. Baker & Sons.

About 12 feet above Ordnance Datum.

? Shaft about 30 feet, the rest bored.

? Water rose to about 15 feet below the surface of the ground. In Nov. 1891 the water-level was 126·35 below Ordnance Datum. A loss of 123 feet.

		Thickness. Feet.	Depth. Feet.
Gravel ...	... ...	28	28
[London Clay, 80½ feet.]	Sandy, blue clay	28	56
	Strong, blue clay	47	103
	[Basement-bed.] ... Light-coloured sand	3½	106½
	[Basement-bed.] ... Stone	2	108½
[Reading Beds, 35½ feet.]	Coloured [mottled] clay	14½	123
	Light-coloured sand and water...	7	130
	Pebbles [bottom-bed]	14	144
Hard, dead [Thanet] sand. To flints and chalk ...		47	191

Mr. Mylne gives the following thicknesses of the beds in this well in his "*Sections of the London Strata*":—

	Thickness. Feet.	Depth. Feet.
Gravel, &c.	26	26
London Clay	95	121
Reading and Thanet Beds	70	191
Chalk	20	211

According to Mr. J. Lucas (*Journ. Soc. Arts*, vol. xxv, p. 610) the shaft is 95 feet; the depth to Chalk 200; that in Chalk 55; the water-level, in 1877, was 64 feet down, and this was reduced about 20 feet by pumping. The figure for 1891, given above, gives a loss of 74 feet in 14 years, according to this.

Lambeth—*continued.*

3. COMMERCIAL ROAD. Charing Cross and Strand Electricity Supply Corporation. 1897.

17 feet above Ordnance Datum.

Made and communicated by MESSRS. ISLER & CO.

Lined with 30 feet of tubes, of 13½ inches diameter, 6 feet down ; and with 225 feet, of 10 inches diameter, 5 feet down.

Water-level 121 feet down. Yield 10,000 to 15,000 gallons an hour.

		Thickness. Feet.	Depth. Feet.
[Alluvium.] Blue clay	...	20	20
[River Drift.] Gravel	...	12	32
Blue [London] Clay	...	99	131
[Reading Beds, 71 feet.]	Mottled clay ...	6	137
	Grey sand with pebbles	31	168
	Mottled clay ...	8	176
	Green sand and pebbles	26	202
[Thanet Sand.]	Dark sand ...	19	221
	Flints ...	1	222
[Upper] Chalk	...	178	400

4. DUKE STREET, Stamford Street. Messrs. Clowes' Printing Works.

Sunk and communicated by MESSRS. S. F. BAKER & SONS.

About 15 feet above Ordnance Datum.

Shaft 119 feet, the rest bored. In 1876 the water-level before pumping (6 observations) varied from 89 to 101 feet below ground. (J. LUCAS, *Journ. Soc. Arts*, vol. xxv, p. 610.) Well failed and was not used in 1891. The water may have come from the sand. Great quantities of mud were pumped up.

		Thickness. Feet.	Depth. Feet.
Made ground	...	8	8
[River] Gravel, full of water	...	18	26
Blue London Clay	...	93	119
[Reading Beds, 57 feet.]	Plastic or coloured clay ...	35	154
	Pebbles ...	14	168
	Green sand, with a few veins of clay	8	176
Grey [Thanet] sand to Chalk	...	34	210

5. GRIFFIN STREET, York Road (Messrs. Griffiths'). 1843.

Communicated by MESSRS. S. F. BAKER & SONS.

To Chalk, 213 feet.

6. LAMBETH DISTILLERY. Messrs. Daun and Vallentin. 1897.

Made and communicated by MESSRS. ISLER.

Lined with 35 feet of tubes, 8½ inches in diameter, from 9¼ feet down ; and with 215 feet, 7¼ inches in diameter, from 9 feet down.

Water-level 81 feet down. Supply 4,000 gallons an hour.

		Thickness. Feet.	Depth. Feet.
Made ground	...	8	8
[River] Gravel	...	23½	31½
[London Clay, 93 feet.]	Blue clay ...	90½	122
	Rock ...	2½	124½
[Reading Beds, ? 47 feet.]	Mottled clay ...	37½	162
	Black [flint] pebbles	3½	165½
	Pebbles and sand ...	6	171½
[Thanet Sand, ? 43½ feet.]	Green sand ...	13	184½
	Grey sand ...	30½	215
[Upper] Chalk	...	105	320

Lambeth—*continued.*

7. LAWN LANE, South Lambeth Road. Crown Works (Mr. Higgs). 1870. Sunk and communicated by MESSRS. S. F. BAKER & SONS.

About 15 feet above Ordnance Datum.

Shaft 107 feet, the rest bored.

		Thickness. Feet.	Depth. Feet.
Made ground		3	3
[Valley Drift, 17 feet.]	Gravel	13	16
	Sharp sand	4	20
[London Clay, 90 feet.]	Blue clay	81	101
	Shelly clay and pebbles	6	107
	Hard stone	3	110
[Woolwich and Reading Beds, 48 feet.]	Coloured [mottled] clay	12	122
	Grey sand	14	136
	Stone	$\frac{3}{4}$	$136\frac{3}{4}$
	Coloured [mottled] clay	$15\frac{1}{4}$	152
	Green sand and pebbles	6	158
Grey [Thanet] sand		29	187
[Upper] Chalk		$113\frac{1}{2}$	$300\frac{1}{2}$

SIR A. R. BINNIE makes the depth to the chalk 199 feet and the total over 356, the boring having been deepened in 1885. In Nov. 1891, the water-level was about $40\frac{1}{2}$ feet below Ordnance Datum. Appendices, R. Comm. Metrop. Water, 1893, p. 163. The water-level was 54 feet below Ordnance Datum in 1911. (G. BARROW.)

8. NEW UNION. 1872.

About 12 feet above Ordnance Datum.

Sunk and communicated by MESSRS. S. F. BAKER & SONS.

		Thickness. Feet.	Depth. Feet.
[River] Gravel		25	25
London Clay		51	76
[Woolwich and Reading Beds, and Thanet Sand.]	Beds of oyster-shells	$2\frac{1}{2}$	$78\frac{1}{2}$
	Solid stone, with small shells	2	$80\frac{1}{2}$
	Sand, like Thanet Sand, with an immense body of water	$26\frac{1}{2}$	107
	Mottled clay	14	121
	Green sand and pebbles [? wholly or in great part Thanet Sand]. To chalk.	47	168

According to MR. J. LUCAS (*Journ. Soc. Arts*, vol. xxv, p. 610), carried to a depth of 300 feet. Water-level before pumping, in April 1887, 68 feet below ground. Pumped at the rate of 3,800 gallons an hour.

9. RENFREW ROAD, Lower Kennington Lane. Workhouse. 1901.

15 feet above Ordnance Datum.

Made and communicated by MESSRS. ISLER & CO.

Lined with 170 feet of tubes, of $13\frac{1}{2}$ inches diameter, a foot down. Water-level 100 feet down. Supply 10,500 gallons an hour.

		Thickness. Feet.	Depth. Feet.
Made Ground		$5\frac{1}{2}$	$5\frac{1}{2}$
[River Gravel.] Ballast		$13\frac{1}{2}$	19
Blue [London] Clay		60	79
[Reading Beds, 68 feet.]	Grey sand	27	106
	Blueclay	$1\frac{1}{2}$	$107\frac{1}{2}$
	Mottled clay	$12\frac{1}{2}$	120
	Conglomerate	5	125
	Green sand and pebbles	22	147
Grey [Thanet] sand		23	170
[Upper] Chalk and flints		230	400

Lambeth—*continued.*

10. South Lambeth Road. Beaufoys' Vinegar Works. (Engine-house Well.) ? 1836. Deepened from 201 to 375 feet in 1869.

Communicated by Messrs. Beaufoy.

16·65 feet above Ordnance Datum.

Shaft 100 feet (? more), the rest bored.

According to Mr. J. Lucas (*Journ. Soc. Arts*, vol. xxv. p. 610), the water-level was 42 feet down before pumping. In Nov., 1891, it was 33·77 feet below Ordnance Datum, before pumping 12·35. A loss of 8·42 feet in 20 years.

		Thickness Feet.	Depth. Feet.
To top of blue clay [? Gravel, &c.]	... ...	19	19
[London Clay] 107 feet.	Blue clay	93	112
	Rock at 113 (shelly) and 118 feet, claystone at 119 ... ... Light-blue, light-brown, and brown clay ... ... Brown-clay and a small pebble	about 14	126
[Woolwich and Reading Beds, 44 feet.]	Brown clay, with blue in the lower part*	„ 2	128
	Mottled red, brown, blue, yellow, black, and grey clays	„ 9	137
	Grey, shelly clay, with pyrites ...	„ 1	138
	Sand (a spring)	2	140
	Black clay and carbonate of lime, and yellow clay	about 4	144
	Variously-coloured and mottled [clays ?]	„ 9	153
	Green [? sand or clay] ... Pebbles and broken shells ... Green sand	10½	163½
	Pebbles and green sand	4½	168
	Green sand	1	169
	Variegated sand	1	170
[Thanet Sand, 31 feet.]	Grey sand, full of water	2	172
	Dark blackish-grey sand	11	183
	Black sand ... ... Thin bed of flints	18	201
[Upper] Chalk	... ...	174	375

* This bed may belong to the London Clay. Another account varies in details between 140 and 163 feet.

There is a still older well at these works (about 1816) said to be 400 feet deep, and giving an unlimited supply (at the time this information was given, long ago). This Brewhouse Well is 15·34 feet above Ordnance Datum, and in Nov., 1891, the water-level was 34·66 feet below Ordnance Datum before pumping and 51·66 after pumping.

An analysis of the water is given on p. 302.

11. South Lambeth Road. Beulah Laundry. 1908.

About 20 feet above Ordnance Datum.

Made and communicated by Messrs. Isler & Co.

25 feet of tube 11½ inches in diameter from 7½ feet down.
130 „ „ „ 10 „ „ „ „ 3½ „ „
205 „ „ „ 8½ „ „ „ „ 2 „ „

Water-level 82 feet down.
Yields 6,000 gallons an hour.

		Thickness. Feet.	Depth. Feet.
[Made ground, &c.]	Made up ground ...	1	1
	Mould	3½	4½
[River] Gravel	... ...	28	32½

Lambeth—*continued.*

11. South Lambeth Road—*continued.*

		Thickness. Feet.	Depth. Feet.
London Clay ...		80½	113
[Woolwich and Reading Beds, 52 feet.]	Clay and shells...	9	122
	Grey sands	7	129
	Mottled clay	28	157
	Green sand and pebbles	8	165
[Thanet Sand, 38 feet.]	Green sands	37	202
	Green-coated flints	1	203
[Upper] Chalk and flints ...		149	352

12. Vauxhall. Bond Street. Messrs. Barrett & Co., Zoedone Works. 1881.

Sunk and communicated by Messrs. Le Grand and Sutcliff.

15·72 feet above Ordnance Datum.

Shaft 13½ feet; the rest bored.

Water-level 52 feet down; in July 1885, according to Mr. W. H. Dalton, 58¾, and the yield 1,500 gallons an hour. In 1888 and 1889 the water-level was 47·44 feet below Ordnance Datum. A loss of 11·16 feet in 10 years. (Binnie.)

		Thickness. Feet.	Depth. Feet.
[River] Gravel		15	15
[London Clay, 110 feet.]	Blue clay	106	121
	Stones [? flint-pebbles. Basement-bed]	4	125
[Woolwich and Reading Beds, 45 feet.]	Mixed clays ...	18	143
	Sand ...	7	150
	Limestone [? race] and mottled clay	1	151
	Clay and stones [flint-pebbles]	19	170
Green [Thanet] Sand and stones		37	207
[Upper] Chalk and flints		77½	284½

Second Well. 1886.

16·07 feet above Ordnance Datum.

Made and communicated by Messrs. Le Grand and Sutcliff.

Water-level 50½ feet below the cellar-floor.

Supply 2,280 gallons an hour. (G. Barrow.)

		Thickness. Feet.	Depth. Feet.
Dry well (the rest bored)		—	6
Ballast [River Gravel]		3	9
[London Clay, 105 ft.]	Blue clay and septaria ...	69	78
	Blue clay ...	34½	112½
	Pebbles [Basement-bed]	1½	114
[Woolwich and Reading Beds, 50½ ft.]	Mixed clay	5½	119½
	Clay and shells ...	1½	121
	Clay and sand	5½	126½
	Coloured [mottled] clay and sand	20	146½
	Mottled clay	7½	154
	Clay and pebbles...	4½	158½
	Green sandy clay and pebbles ...	6	164½
[Thanet Sand.]	Grey sand...	38	202½
	Green flints	1	203½
[Upper] Chalk and flints		104½	308

Lambeth—*continued.*

13. VAUXHALL. Messrs. Burnett's Distillery (close to the Thames). 1850.

From a drawing and a few specimens in Messrs. Burnett's office.

About 15·7 feet above Ordnance Datum.

Shaft 140 feet ?, the rest bored.

Water rose to within 55 feet of the surface, but is pumped down 50 feet. In November, 1891, the water-level was 43·8 feet below Ordnance Datum. A loss of 4½ feet in 41 years. Supply 2,000 gallons or more a minute. (Now 8,000 to 10,000 an hour. G. BARROW.) For an analysis of the water *see* p. 303.

		Thickness. Feet.	Depth. Feet.
[Brownish clay ? – Alluvium]		20	20
Land-spring [gravel]		4	24
[London Clay, 118 ft.]	Blue clay	116½	140½
	Rock [? basement-bed]	1½	142
[Woolwich and Reading Beds, and Thanet Sand.]	Sand	5	147
	Mottled plastic clay* ...	4	151
	Sand†	70	221
	Green-coated flints ...	3	224
[Upper] Chalk with flints		102	326

* There is a specimen of very hard race, from this bed most likely.

† Though marked as one mass of sand, this must belong partly to the Woolwich and Reading Beds and partly to the Thanet Sand. There is a specimen of the green sand with pebbles that so often occurs at the bottom of the former Series.

14. WATERLOO.

MYLNE'S "Sections of the London Strata."

Made ground, gravel, &c ... ... London Clay	165	235 feet.
Lower London Tertiaries (not sunk through)	70	

[? The following the same well as this.]

15. WATERLOO BRIDGE. Near.

PRESTWICH, *Quart. Journ. Geol. Soc.*, vol. x. p. 153.

		Thickness. Feet.	Depth. Feet.
Gravel and sand		40	40
Blue [London] clay ...		110	150
[Woolwich and Thanet Beds.]	Red clay	10	160
	Sand ...	5	105
To Chalk.			

As PRESTWICH remarks this is "in all probability given wrong by the well-digger," for it "brings the London Clay too near to the Chalk."

16. WESTMINSTER BRIDGE ROAD. Messrs. Oakey's Emery Mills. 1873.

Sunk and communicated by MESSRS. S. F. BAKER & SONS. Deepened 1888 ? to 450 feet.

About 11 feet above Ordnance Datum.

Shaft 105 feet ; the rest bored.

Water rose to 63 feet below the ground (49·84 below Ordnance Datum, according to BINNIE). In November, 1891, the water-level was 76–84 feet below Ordnance Datum. A loss of 27 feet in 18 years (BINNIE). In 1911 the water-level was 100 feet below Ordnance Datum. (G. BARROW.)

		Thickness. Feet.	Depth. Feet.
Made ground and black ballast		15	15
[River] Gravel, with much water		11	26
[London Clay, 82 feet.]	Clay	79	105
	Sand and water [? basement-bed] ...	3	108

Lambeth—*continued.*

16. Westminster Bridge Road—*continued.*

		Thickness. Feet.	Depth. Feet.
[Reading Beds, 64 feet.]	Mottled clay...	8	116
	Sand (very strong spring)...	3	119
	Mottled clay...	16	135
	Very hard, white stone	6	141
	Pebbles in sand	31	172
[Thanet Sand.]	Grey sand	39	211
	Flints	1	212
[Upper Chalk], 192 feet.	White chalk (good)	105	317
	Layers of greenish silt [specimens of light-brown, clayey sand or loam, with bits of chalk. Dark when moist]	12	329
	Dark grey chalk, with flints [specimen, mixed with loam, as above, at 351]	51	380
	White chalk, with many flints	24	404

17 York Mead. Mr. Smart's Mill. 1828.

G. Smart. Report of the Commissioners to Inquire into the State of the Supply in the Metropolis, Fol., Lond. 1828, pp. 110, 111. Section reprinted by Prestwich, *Quart. Journ. Geol. Soc.*, vol. x, p. 141.

Mr. Smart says that the well was 6 feet (? diameter) down to the stiff clay, and the rest bored. He continues :—

" A great supply of fine pure soft water from a depth of 211 feet, which rises to within 14 feet of the surface, and my pump discharges about 32 gallons per minute . . . from my success, two of my neighbours have bored with equal success, one (a brewery) about 300 yards from mine, and the other (engine) about 100 . . . and I find my water keeps its first level."

		Thickness. Feet.	Depth. Feet.
Made ground, gravel, and clay		30	30
London Clay, 141 ft.	Clay, blue and stony [= with septaria]	139	169
	Basement-bed: Clay-stone	½	169½
	Basement-bed: Hard-rock	1½	171
Woolwich and Reading Beds, 40 ft.	Hard, mixed clay and sand	20	191
	Shells and pebbles ...	6	197
	Soft, green sandstone [? firm sand]	14	211

To sand and water.

18. Messrs. J. C. & J. Field's (? at the back of the Canterbury Music Hall). 1889 ?

15 feet above Ordnance Datum.

Made and communicated by Messrs. Isler.

Lined with 100 feet of tubes, 15½ inches in diameter, from 28 feet down ; and with 215 feet, 11½ inches in diameter, from 12 feet down.

Water-level 90 feet down. Supply 7,000 gallons an hour.

		Thickness. Feet.	Depth. Feet.
Pit...		—	15
[River Drift, 18 feet.]	Ballast [gravel] and sand	3	18
	Live sand ...	2	20
	Ballast	5	25
	Ballast and sand ...	3	28
	Ballast	5	33
[London Clay, ? 102 feet.]	Clay, with claystone at 40 to 41 feet ...	29	62
	Mixed marl and stone	1	63
	Clay	46	109
	Clay and stone	5	114
	Clay	19	133
	Pebbles and sand [? Basement-bed]	2	135

Lambeth—*continued.*

18. MESSRS. J. C. & J. FIELD'S—*continued.*

		Thickness. Feet.	Depth. Feet.
[Reading Beds, ? 55 feet.]	Mixed marl and sand	10	145
	Mixed marl	12	157
	Mottled clay	4	161
	Pebbles	1	162
	Stone	2	164
	Mottled clay	14	178
	Ballast [? pebbles]	2½	180½
	Green sand and pebbles	9½	190
[Thanet Sand, 35 feet.]	Sand	14	204
	Grey sand	7	211
	Sand	14	225
[Upper] Chalk and flints		179	440

19. For details of the following wells *see* Geol. Survey Memoir, "London Wells," 1912.

a. CAMBERWELL NEW ROAD. General Motor Cab Co. 1909.

Below road-level. Two feet above Ordnance Datum.

Water-level 67 feet down. Later 82. Yield 15,000 gallons an hour.

To Chalk 164 }
In ,, 171 } 335 feet. Deepened to 500.

b. DURHAM ROAD. New London Brewery.

Leatherhead.

Ordnance Map 286, new ser. Geological Map 8.

1. COPTHORNE'S BRICK FIELD (southern boundary).

Communicated by MR. H. H. FRENCH, from particulars given by the well-sinker, from memory.

Shaft throughout Supply plentiful.

		Thickness. Feet.	Depth. Feet.
Gravel and sand		5 to 6	5½ ?
[Woolwich and Reading Beds.]	Blue clay, with shells, described as "cockles," about the size of a thumb-nail	4 to 5	10 ?
	Red mottled clay	15 to 16	25½ ?
	Green sand, with oyster-shells ...	14 to 15	40 ?
	Blue, waxy clay, very hard and tenacious	1 to 2	41½ ?
Thanet Sand.	Loamy sand	12	53½ ?
	Flints	½	54 ?
Chalk		20	74 ?

"As the total depth is only 72 to 73 feet it is probable that the left-hand figures (for thicknesses) are most nearly correct." In the column of depths I have taken the mean.

The shelly, blue clay would seem to belong to the shell-beds of the Woolwich Series, rather than to the London Clay, judging by its vertical distance from the Thanet Sand.

2. ST. JOHN'S FOUNDATION SCHOOL.

Communicated by the Head Master, the REV. E. C. HAWKINS

Average daily consumption about 1,000 gallons.

Surface mould ... ... }
Loam and flints ... ... }
Sand, perhaps nearly 10 feet ... } about 30 feet.
Blue clay [? clayey green sand] }
Chalk ... ... ,, 70 ,,

Leatherhead—*continued.*

3. Leatherhead and District Waterworks, near the River Mole, close to the village. (? in the parish of Fetcham.) 1884.

J. W. Grover, *Proc. Inst. Civ. Eng.*, 1887, vol. xc. p. 15.

Shaft 22 feet, the rest a 13-inch bore, to the depth of 200 feet.

Water-level 2 to 3 feet above the river, rising and falling with the river. Lowered about 7 feet by pumping about 9 hours, at the rate of 15,000 gallons an hour. Abundant supply from a flint-bed 22 feet down; other like beds at 39 and 44½ feet.

Clays and Gravels [Alluvium and River Drift], 16 feet.

Chalk with flints. From 60 to 97 feet down the flints at irregular intervals. Thence to 160 feet they occur at every 2 feet and are about 6 inches thick. For the remaining 40 feet they are continuous, and water rose from them 184 feet.

Another Well. 1898.

Made and communicated by Messrs. Le Grand and Sutcliff.

Water-level 3¾ feet down (December).

		Thickness. Feet.	Depth. Feet.
Soil ...	...	2	2
[River Gravel.]	Ballast, big flints ...	18	20
[Upper Chalk.]	Rubbly chalk and flints	18	38
	Hard grey rock ...	2	40
	Chalk and flints ...	222	262

The following information from the Water Works Directory, 1911:—

Population supplied about 15,000. Besides Leatherhead, the places supplied are Ashstead, Chessington (part), Cobham, Effingham, Fetcham, Great and Little Bookham, Mickleham, and Stoke D'Abernon. The total yearly supply is 225,000,000 gallons.

Analyses of the water are given on p. 303.

Limpsfield.

Ordnance Map 287, new ser. Geological Map 6.

1. Church Missionaries' Children's Home (College, about half a mile south of the church). Boring, N.N.W. of the building. 1895.

Made and communicated by Messrs. Le Grand and Sutcliff, and from information on the spot (1900).

About 450 feet above Ordnance Datum (? less).

Water-level 122 feet down (140, later ?). Yield about 60,000 gallons a day.

		Thickness. Feet	Depth Feet.
[Folkestone Beds.]	Sand and ironstone ...	18	18
	Loamy sand (moisture at 22 ft.) ...	25	43
[? Sandgate Beds, 11 feet.]	Blue sandy clay ...	7	50
	Green sand ...	2	52
	Sand and clay ...	2	54
[Hythe Beds, 107½ feet.]	Green sand ...	4	58
	Hard sandstone ...	3¼	61¼
	Layers of soft sandstone and very hard rock (chert an inch and 2 inches thick)	2¾	64
	Layers of white sandstone (a foot to 2 feet thick) and clay (3 to 6 inches thick) ...	20	84
	Hard loamy sand ...	6	90
	Sandstone ...	1	91

Limpsfield—*continued.*

1. Church Missionaries' Children's Home—*continued.*

		Thickness. Feet.	Depth. Feet.
[Hythe Beds, 107½ feet.] —*continued.*	Hard loamy sand and thin bands of sandstone	22	113
	Hard rock and sandstone	1½	114½
	Loamy sand and sandstone	4½	119
	Coarser brown sand. Water at 124 feet	6	125
	Coarse sand and sandstone	5	130
	Loamy sand ; a foot of sand at 138 feet	14½	144½
	Hard sand and rock	6½	151
	Coarse sand and sandstone	2	153
	Blue sandy clay and sandstone	8½	161½

2. Lucas notes 7 wells in Lower Greensand in the parish, *Proc Inst. Civ. Eng.*, 1880, vol. lxi, pt. iii.

Waterworks. *See* Tatsfield.

The Limpsfield and Oxted Water Co. supplies also Titsey and part of Tatsfield, as well as two Kentish parishes, Edenbridge and part of Westerham (Dr. Seaton, Surrey County Council, Ann. Rep. 1905). Cowden added since. The population supplied was 1,469 in 1909, 7,875 in 1911. The supply is from a well, but was once wholly from springs at Limpsfield, the hardness of the water of which is given as 4·5° temporary and 2·6° permanent, by Dr. Seaton.

Lingfield.

Ordnance Maps 286, 302, new ser. Geological Map 6.

1. Chartham Park, southward of the village. 1910.

Boring. Communicated by Mr. J. S. H. Bransom.

Water-level that at which water enters from the hard rock (about 94 feet down).

		Thickness. Ft. In.	Depth. Ft. In.
[Tunbridge Wells Sand].	Clay and sandstone ...	60 0	60 0
[Grinstead Clay]	Blue clay	6 6	66 6
	Brown clay...	4 0	70 6
	Green "	13 0	83 6
	Brown "	5 2	88 8
	Hard rock (specimen), with water at the bottom ...	5 6	94 2
	Blue clay	4 4	98 6
	Shale	2 7	101 1
	Blue clay	2 6	103 7
	Hard shale...	36 0	139 7
	Green and blue clay ...	1 9	141 4
	Hard rock (specimen) ...	8 2	149 6

Mr. G. W. Lamplugh says that the specimens are probably from hard bands or concretions which often recur in the clays of the Hastings Beds.

2. Labour Colony. About ¾ of a mile East of Railway Station (L.B.S.C.R.).

Made and communicated by Messrs. Allsebrook. 1908.

Lined with tubes 7 inches in diameter to 90 feet down.

Before this boring was made the water-supply was obtained from a well about 30 feet deep and about 50 feet away. The water-level in the old well was the same as in the bore (about 15 feet down), and was subject to the same

Lingfield—*continued.*

2. Labour Colony—*continued.*

fluctuations during pumping, until the boring reached 84 feet, when the water rose to within 11 feet of the surface. On further deepening the water rose to 9 feet from surface.

Yield, 1,250 gallons per hour at suction-limit with surface-pump.

		Thickness. Ft.	In.	Depth. Ft.	In.
Weald Clay	Loamy clay ...	9	0	9	0
	Brown rock ...	3	0	12	0
	Brown sandy clay...	2	0	14	0
	Hard blue rock ...	11	8	25	8
	Hard blue clay ...	1	9	27	5
	Very hard blue rock	11	0	38	5
	Stiff clay	1	0	39	5
	Shaley rock ...	2	8	42	1
	Blue shaley clay ...	1	4	43	5
	Rock	3	8	47	1
	Clay	0	3	47	4
	Rock	2	5	49	9
	Grey sand	0	3	50	0
	Rock	5	0	55	0
	Clay	2	5	57	5
	Rock	10	10	68	3
	Rocky clay... ...	1	8	69	11
	Rock	0	3	70	2
	Rocky clay... ...	2	6	72	8
Hastings Beds	Rock	29	4	102	0
	Clay rock	24	2	126	2
	Clay	1	6	127	8
	Clay rock	22	4	150	0

Liphook.

Ordnance Map 301, new ser. Geological Map 9.

Mr. Rapley's. 1890?

From Mr. W. Topley's MSS.

	Thickness. Ft.	In.	Depth. Ft.	In.
Hassock. Yellow impure clayey sands overlying buff and finer grained sands	14	0	14	0
Rag and sand-rock...	1	2	15	2
Hassock. Yellow clayey impure sands like those above	4	10	20	0
Bargate. Not hard, unfit for building	1	7	21	7
Hassock. Yellow and impure clayey sands	4	9	26	4
Bargate. Harder and better stone than that above. Used for garden-walks	1	6	27	10
Hassock. With two courses of Bargate stone, about 3 inches thick	2	6	30	4
Bargate. Very hard; breaks with a conchoidal fracture	1	2	31	6
Hassock. Hard and compact [but with] brown impure sands	4	10	36	4
Bargate. Very hard. Upper layers siliceous (not acted on by hydrochloric acid)	1	8	38	0
Hassock	2	0	40	0
Bargate. Very hard, from under which water came ...	3	0	43	0

The Bargates not regularly bedded, but in lenticular and more or less rounded concretions.

Little Bookham.

Ordnance Map 286, new ser. Geological Map 8.

Lucas notes 3 Chalk-wells in the parish, *Proc. Inst. Civ. Eng.*, 1877, vol. xlvii, p. 100.

Malden.

Ordnance Map 270, new ser. Geological Map, London District, Sheet 3.

1. Mosper Farm, Mr. Blake's. 1865.

Sunk and communicated by Messrs. S. F. Baker & Sons.

Water within 4 feet of the ground.

Clay (? Blue [London] clay 228 feet, then plastic clay)	304	314 feet.
Sand (full of water)	6	
Coloured [mottled] clay, not bottomed	4	

So much sand came up that the well was abandoned. G. Barrow. 1911.

2. Worcester Park, near Station. (Published 1886.)

Communicated by Messrs. S. F. Baker & Sons.

About 70 feet above Ordnance Datum. Water overflowed.
To sand, with water, 281 feet; to mottled clay, 289 feet.

3. An Old Well.

Dr. J. Mitchell's MSS., vol. ii, p. 217.
Water rose to the surface.
Through blue clay to black sand, 401 feet. [This must include both London Clay and Reading Beds.]

Merrow.

Ordnance Map 285, new ser. Geological Map 8.

Lucas notes 10 Chalk-wells in the village and 3 others in the parish. *Proc Inst. Civ. Eng.* 1877, vol. xlvii, p. 98.

Merstham.

Ordnance Map 286, new ser. Geological Map 8.

1. A boring is said to have been made close to, and eastward of the railway-station, on the road to Coppice Lea, to the depth of 300 feet, without getting water. Possibly the base of the Gault was not reached.

2. Lucas notes 3 Chalk-wells in the parish, one, at the Joliffe Arms, 100 feet deep, through Chalk Marl to Upper Greensand. *Proc. Inst. Civ. Eng.* 1877, vol. xlvii. pp. 104, 105.

3. Also 2 wells in Lower Greensand. *Ibid.* 1880, vol. lxi, pt. iii, p. 224.

Merton.

Ordnance Map 270, new ser. Geological Map, London District, Sheet 3.

1. Abbey. For the Southwark and Vauxhall Water Co. On the northern side of the railway and the eastern side of Merton Lane, eastward of Merton Abbey Station. 1897. 46 feet above Ordnance Datum. Now Metrop. Water Board.

Communicated by Mr. J. W. Restler, Engineer to the Co.

Shaft, with 150 feet of heading.
Water stood $4\frac{1}{2}$ feet down; it has overflowed. The pumping has affected the Streatham well (p. 234).

		Thickness. Ft. In.	Depth. Ft. In.
Surface and ashes		5 0	5 0
[London Clay, 152 feet.]	Yellow clay	12 0	17 0
	Blue clay, with clay-stones (1 ft. at 32 feet, 4 in. at 47 feet, 6 in. at 50 feet, 1 ft. at 55 feet, $1\frac{1}{2}$ ft. at $95\frac{1}{2}$ feet)	124 0	141 0
	Clay and sand	1 0	142 0
	Shells	2 0	144 0
	Blue clay	4 0	148 0
	Sandy clay	3 4	151 4
	Blue clay (specimen of lignite, from $163\frac{1}{2}$ to $164\frac{1}{2}$)	17 8	169 0

Merton—*continued.*

1. Abbey—*continued.*

		Thickness. Ft. In.	Depth. Ft. In.
[Woolwich and Reading Beds, 32 feet.]	Mottled clay	7 0	176 0
	Light-coloured mottled clay ...	5 0	181 0
	Mottled clay	4 0	185 0
	Shells	1 2	186 2
	Mottled clay	7 8	193 10
	Black peaty clay	0 6	194 4
	Sandy clay	6 8	201 0
[Thanet Sand, 24 feet.]	Green sand	22 0	223 0
	Dark green sand	0 6	223 6
	Pebbles and flints	1 6	225 0
Chalk	... ...	10 0	235 0

Perhaps the London Clay should only be carried to 141 feet.

It is said that during the construction as much as 1,700,000 gallons a day were pumped for several days continuously. (*Times*, 30 May, 1908.)

2. Blue House Farm.

J. Lucas, *Journ. Soc. Arts*, 1877, vol. xxv, p. 614.

295 feet to plastic clay. Does not now overflow.

3. Nelson's Fields. 1874.

Mr. J. Lucas, *Journ. Soc. Arts.*, 1877, vol. xv, p. 613. (Other Merton wells noted in this paper give no geological information.)

51 feet above Ordnance Datum.

Water rises 3 feet above the ground, serving a fountain.

To Chalk ...	217	225 feet.
Chalk ...	8	

4. Raynes Park. Trial-boring, for the Southwark and Vauxhall Water Co. On the northern side of the L.S.W. Railway, a little westward of the junction with the branch to Croydon. 1897. Now Metrop. Water Board.

Communicated by Mr. J. W. Restler, Engineer to the Co.

A little over 43 feet above Ordnance Datum.

		Thickness. Ft. In.	Depth. Ft. In.
Surface [soil] ...	... ...	0 9	0 9
[Drift] ...	Yellow clay	1 4	2 1
	Gravel	0 11	3 0
	Coarse sand	2 7	5 7
[London Clay, 300½ feet.]	Blue clay, with twelve layers of clay-stones [septaria]; a foot thick 27½ feet down; 14 in. about 46 feet down; a foot 123 feet down; 1½ feet 152½ feet down; 8 in. at 174½ and 183 feet down; ? 3 in. at 206 feet down; a foot thick 235 feet down; 4 in. 260 feet down; 8 in. 262½ and 268 feet down; and 4 in. at 272 feet down	299 5	305 0
	[Basement-bed.] Pebbles ...	1 0	306 0
[Reading Beds, 66 feet.]	Coloured [mottled] clay ...	3 0	309 0
	Mottled clays	47 0	356 0
	Mottled sandy clay	5 0	361 0
	Sandy clay	0 9	361 9
	Mottled clay	5 9	367 6
	Pebbles	1 0	368 6
	Dark green sand and pebbles	3 6	372 0

Merton—*continued.*

4. Raynes Park—*continued.*

		Thickness. Ft.	In.	Depth. Ft.	In.
[Thanet Sand, nearly 27½ feet.]	Green sand	8	0	380	0
	Grey sand	4	0	384	0
	Fine grey sand	13	9	397	9
	Coarse grey sand	1	4	399	3
	Flints	0	2	399	5
[Upper] Chalk...	... ...	90	2	489	7

5. Raynes Park. Southdown Laundry, Kingston Road. 1906?

Made and communicated by Messrs. Isler and Co.

85 feet of tubes 11½ inches in diameter 6 feet below surface.
120 " " 10 " " " 4 " " "
258 " " 7¼ " " " 5 " " "
Water-level 19 feet down?

			Thickness. Feet.	Depth. Feet.
Made ground	... ...		1	1
[River Drift.]	Sand and Gravel		3	4
	Loamy Sand		1	5
[London Clay, 175½ feet.]	Blue clay, with claystone at 26 to 26¾ feet, at 60¾, and 62¼		57¼	62¼
	Hard brown clay		72¼	134½
	Blue clay		20	154½
	Brown and green clay		8	162½
	Blue clay		14	176½
	[Basement-bed.]	Yellow mottled pebbles and clay	3	179½
		Congealed pebbles ...	1	180½
[Reading Beds and Thanet Sand.]	Black clay		4½	185
	Red mottled clay		15	200
	Brown mottled clay		24	224
	Green sand and pebbles		3½	227½
	Green sand		7	234½
	Green sandy clay		3½	238
	Grey sand and pebbles		17½	255½
[Upper Chalk, 244½ feet.]	Chalk and flints		110	365½
	Hard chalk		27¼	392¾
	Chalk and flints		107¼	500

There was no water in the Chalk. A supply was got by an Air Lift Pump, from the sand above the Chalk.

An analysis of the water is given on p. 304.

6. Sewage Works (Croydon Rural Sanitary Authority), north of Wandlebank House. ? 1879.

B. Latham, *Proc. Croydon Micr. Nat. Hist. Club*, 1884, p. cliii, and information from Mr. W. S. Crimp.

36½ feet above Ordnance Datum. Bored throughout (6 inches diameter).

Water overflows at the rate of about 40,000 gallons a day (recorded as over 52,000 in *Proc. Assoc. Municipal and Sanitary Engineers* for 1879, p. 21), at a temperature of about 54°.

	Thickness. Feet.	Depth. Feet.
Alluvium. Mould and peat	10	10
Ballast [River Gravel]	1½	11½
London Clay. Blue clay with septaria...	51	62½

Merton—*continued.*

6. Sewage Works—*continued.*

		Thickness. Feet.	Depth. Feet.
[Woolwich and Reading Beds, 62½ feet.]	Shells	1	63½
	Brown sand	5	68½
	Blue clay and shells ...	7	75½
	Shell-rock	1½	77
	Dark clay	8	85
	Blue clay	3	88
	Black clay	3	91
	Yellow clay	3	94
	Purple clay	3	97
	Red clay	4	101
	Brown and green sand	1½	102½
	Brown sand	9½	112
	Brown clay	5	117
	Pebbles	1½	118½
	Green sand	6½	125
Grey [Thanet Sand]		31	156
[Upper] Chalk with flints		77	233

I am in doubt as to carrying the Woolwich and Reading Beds so low. In the abstract account in the *Proc. Assoc. Municipal Engineers* (and *Iron* vol. xv, no. 366, p. 44, 1880) the thicknesses of the formations differ from the above, London Clay being given as 80 feet, Woolwich Beds as 40, and Thanet Sand as 47, the depth to the Chalk being 179, and in Chalk 51. Mr. Crimp's MS. account makes the Thanet Sand 39½ feet thick.

Mickleham.

Ordnance Map 286, new ser. Geological Map 8.

Lucas notes 4 Chalk-wells in this parish. *Proc. Inst. Civ. Eng.*, 1877, vol. xlvii, p. 101. The one at Norbury Park is referred to on p. 318, where probably the depth is exaggerated.

Milford *see* Witley.

Mitcham.

Ordnance Map 270, new ser. Geological Map, London District, Sheet 3.

1. Surrey Brewery. Messrs. Thunder and Little.

68 feet above Ordnance Datum.

Made and communicated by Messrs. Isler.

Lined with 30 feet of tubes, 7¼ inches in diameter, and with 180 feet, 5 inches in diameter, both from 6 feet down.

Water-level 30 feet down

Supply 2,000 gallons an hour.

		Thickness. Feet.	Depth. Feet.
Well, in made Ground, the rest bored		—	7
[River Drift, 19 feet.]	Gravel	13	20
	Gravel and clay ...	6	26
[London Clay, 67 feet.]	Clay	52	78
	Blue clay	15	93
[Reading Beds, 54 feet.]	Sands	15	108
	Mottled clay ...	20	128
	Sands	11	139
	Sand and pebbles ...	8	147
Green [Thanet] sands		39	186
[Upper Chalk.]	Chalk	6	192
	Flints and chalk ...	158	350

Mr. Lucas gives the depth to the chalk as 170 feet. *Journ. Soc. Arts*, vol. xxv., p. 612.

Mitcham—*continued.*

2. CHURCH ROAD (near Harlands). About 1,000 feet from the junction with Phipps Bridge Road and Merton Road. 1880.

Communicated by MR. W. S. CRIMP.

50 feet above Ordnance Datum. Shaft. Water overflowed strongly.

		Thickness. Feet.	Depth. Feet.
Soil		4	4
[London Clay, 175 feet.]	Yellow clay	5	9
	Blue clay	170	179
[Woolwich and Reading Beds, 45½ feet.]	Shells	2½	181½
	Blue clay and shells	8	189½
	Shells	2	191½
	Coloured [mottled] clay	24	215½
	Pebbles	2	217½
	Green sand	7	224½
[Thanet sand, 30½ feet.]	Grey sand	29½	254
	Flints. To Chalk	1	255

3. COLLIERSWOOD.

Communicated by MR. W. S. CRIMP.

52½ feet above Ordnance Datum.

		Thickness. Feet.	Depth. Feet.
Surface soil		4	4
Blue [London] Clay		96	100
[Woolwich and Reading Beds, 57 feet.]	Blue clay and shells	20	120
	Coloured [mottled] clay	28	148
	Pebbles and green sand	9	167
Grey [Thanet] Sand. To Chalk		26	183

4. GAS WORKS.

63 feet above Ordnance Datum.

Boring made and communicated by MESSRS. ISLER.

Lined with 240 feet of tubes, 8½ inches in diameter, from 5 feet down.

Water flowed at first (1875) but fell to 20 feet down in 1909. Yield 3,500 gallons an hour.

		Thickness. Feet.	Depth. Feet.
Well (the rest bored), believed to be about 20 feet of sand and gravel over blue [London] clay		—	136
Blue [London] clay		34½	170½
[Reading Beds, 38½ feet.]	Blue and mottled clay	6½	177
	Mottled clay	21½	198½
	Dead green sand and pebbles	10½	209
Green [Thanet] Sand		30½	239½
[Upper Chalk, 118½ feet.]	Flints and chalk	48½	288
	Chalk	20	308
	Flints and chalk	50	358

MR. LUCAS says that there are two wells here, and that the depth to the Chalk is 225 feet, *Journ. Soc. Arts*, vol. xxv., p. 612.

5. HOLBORN UNION SCHOOLS. Upper Mitcham. 1907.

Made and communicated by MESSRS. RICHARDS & Co.

About 70 feet above Ordnance Datum.

Water-level 34½ feet down.

Supply 8,000 gallons an hour.

			Thickness. Feet.	Depth. Feet.
Made earth			3	3
[River Drift.]	Sand, Gravel and big flints		12	15
[London Clay, 129 feet.]	Blue clay, with 2 or 3 layers of hard clay stone		124	139
	[Basement-bed?]	Fossils	3½	142½
		Sandstone	1½	144

Mitcham—*continued.*

5. Holborn Union Schools—*continued.*

		Thickness. Feet.	Depth. Feet.
[Woolwich and Reading Beds, 54 feet.]	Clay and shells	23	167
	Clay...	9	176
	Bed of shells	1	177
	Sand	5	182
	Hard clay ...	1½	183½
	Mottled clay	3½	187
	Green sand and gravel	11	198
[Thanet Sand, 34 feet.]	Sand	33	231
	Green gravel	1	232
[Upper] Chalk and Flints.		118½	350½

The top of the Woolwich Beds seems doubtful.

6. Messrs. Hughes and Kimber. 1888.

55 feet above Ordnance Datum.

Bored (4 inches diameter) and communicated by Messrs. Le Grand and Sutcliff.

Water-level a foot below the surface; 42 feet down in 1904. Yield 960 gallons an hour

		Thickness. Feet.	Depth. Feet.
[River] Gravel		12	12
Blue [London] clay		168	180
[Woolwich and Reading Beds, 67 feet.]	Shells ...	4	184
	Sand ...	6	190
	Blue clay	11½	201½
	Shells ...	3½	205
	Mottled clay ...	21	226
	Brown sand ...	4	230
	Brown clay ...	5½	235½
	Green sand ...	11½	247
Gray [Thanet] sand		23½	270½
Chalk and flints ...		31½	302

Perhaps the Woolwich and Reading Beds have been carried too high, at the expense of the London Clay.

7. London, Brighton and South Coast Railway Station. 1898.

72 feet above Ordnance Datum.

Made and communicated by Messrs. Le Grand and Sutcliff.

Water-level 46½ feet down (September 1898), 60 feet down in 1904.
Yield 1,440 gallons an hour at first.

		Thickness. Feet.	Depth. Feet.
Well (old), the rest bored, 6 inches in diameter		—	61
[London Clay, 119½ feet.]	Blue clay	92	153
	Dark mottled sandy clay ...	26	179
	Blue sandy clay and pebbles...	1½	180½
[Woolwich and Reading Beds, 60½ feet?]	Hard bands, and shell and clay conglomerate	8½	189
	Mottled and sandy clay ...	4	193
	Blue clay and shells ...	2½	195½
	Black peaty clay and shells ...	4½	200
	Light-coloured mottled clay ...	19½	219½
	Green mottled clay ...	4	223½
	Green sandy clay and pebbles	17½	241
Thanet Sand		24	265
[Upper] Chalk and flints ...		169	434

Possibly the top bed classed with the Woolwich Beds may belong to the basement-bed of the London Clay.

Mitcham—*continued.*

8. MORDEN LANE, Lower Mitcham. MESSRS. HAYWOOD and SON'S Floor-cloth Manufactory. 1881.

Made and communicated by MESSRS. LE GRAND and SUTCLIFF.

Water rose to 4 feet above the ground.

		Thickness. Feet.	Depth. Feet.
[River Drift.]	Dug well [gravel ?], the rest bored	—	5
	Gravel	4	9
[London Clay, 105 feet.]	Blue clay	84	93
	Blue clay and green sand	18	111
	Stone, clay and shells	3	114
[Woolwich and Reading Beds, 43 feet.]	Sand...	3	117
	Clay and sand	7	124
	Black clay	12	136
	Mottled clay	8	144
	Sandy clay	5	149
	Red clay	2	151
	Clay and sand	6	157
Green [Thanet] sand [? partly Woolwich Beds] ...		43	200
[Upper] Chalk		55	255

9. NIGHTINGALE'S FACTORY (now Driver's Cotton Print Works). 1850.

PRESTWICH, *Quart. Journ. Geol. Soc.*, vol. x, p. 139.

About 65 feet above Ordnance Datum.

Bored the whole depth (PRESTWICH'S "Water-bearing Strata," p. 235). Water overflowed.

			Thickness. Feet.	Depth. Feet.
Black mould			3½	3½
[River] Gravel			½	4
Blue London Clay			101	105
Woolwich and Reading Beds, 46 feet.	Blue clay, with shells*		2	107
	Rock (septaria)*		3	110
	Blue sand, with a little water... ...		3	113
	Blue clay, with shells		3	116
	Very hard, black clay		1	117
	Blue clay		3	120
	Soft, peaty earth (lignite)		3	123
	Bright blue clay		3	126
	Black clay, with shells (*Cyrena*) ...		1	127
	Mottled clays of various colours (3 beds)		11	138
	Blue sand, with clay		5	143
	[Bottom-bed.]	Green sand, with clay and light-blue sand	1	144
		Hard green sand, with black pebbles and white gault [?]	7	151
Thanet Sand, 38 feet.	Blue-drab sand		22	173
	Darker, sandy loam		15	188
	Green-coated flints; a good spring of water		1	189
Chalk, with layers of flint every 3 feet, and abundance of water in every layer			22	201

* [Can these belong to the "basement-bed of the London Clay?]

Mitcham—*continued.*

10. Phipp's Bridge.

Communicated by Mr. W. S. Crimp.

46 feet above Ordnance Datum.

		Thickness. Feet.	Depth. Feet.
Alluvium ...		5	5
Ballast [River Gravel] ...		14	19
Blue [London] Clay...		151	170
[Woolwich and Reading Beds, 57 feet.]	Shells ...	1	171
	Coloured [mottled] clay	13	184
	Shells ...	1½	185½
	Coloured [mottled] clay	10	195½
	Shells ...	½	196
	Coloured [mottled] clay	14	210
	Brown sand ...	4	214
	Brown clay ...	5	219
	Pebbles ...	2	221
	Green sand ...	6	227
Grey [Thanet] sand. To Chalk. ...		28	255

11. Schools.

Made and communicated by Messrs. Tilley.

To Chalk 213 }
Chalk ... 8 } 221 feet.

12. Seringa Mills. Rubber Chemical Works. 1900.

90 feet above Ordnance Datum.

Made and communicated by Messrs. Le Grand and Sutcliff.

Boring 8½ inches diameter.
Water-level 47 feet down (October 1900). Yield 5,700 gallons an hour.

		Thickness. Feet.	Depth. Feet.
Soil ...		1½	1½
[River Gravel.]	Ballast ...	13	14½
[London Clay, 131½ feet.]	Blue clay and septaria...	110½	125
	Blue sandy clay ...	10	135
	Sandy clay and pebbles ...	11	146
[Woolwich and Reading Beds, 54 feet.]	Shell-rock ...	1	147
	Black clay and shells ...	13	160
	Black clay ...	10	170
	Sand and shells...	2	172
	Mottled clay ...	18	190
	Hard sandy clay and pebbles	10	200
Thanet Sand ...		33½	233½
[Upper] Chalk and flints ...		67½	301

13. Messrs. Typke & King. On the northern side of the Common, just north of Tamworth Lodge. 1896.

89 feet above Ordnance Datum.

Made and communicated by Messrs. Le Grand and Sutcliff,

Water-level 44 feet down. Yield 3,000 gallons an hour.

		Thickness. Feet.	Depth. Feet.
[River] Gravel ...		12	12
[London Clay, 102 feet.]	Brown clay and stones ...	2	14
	Blue clay and septaria ...	83	97
	Brown sandy clay ...	17	114
[Woolwich and Reading Beds, 54 feet.]	Clay, shells (*Ostrea & Cyrena*) and mundic (pyrites) ...	29½	143½
	Mottled clay ...	24½	168
[Thanet] Sand ...		40	208
[Upper] Chalk and flints ...		92	300

Mitcham—*continued.*

14. THE CHEMISTS AERATED AND MINERAL WATERS ASSOCIATION, 1896.

56 feet above Ordnance Datum.

Bored and communicated by MESSRS. ISLER and Co., and from information on the spot.

Water-level 19 feet down. Yield 1,000 gallons an hour.

? Well 3 feet, the rest bored, lined with 25 feet of 3 inch tube, from 2 feet below surface.

Tertiary beds ... about	220	} 333 feet.
Chalk and flints ... „	113	

For further details of this and other wells *see* Geol. Survey Memoir "London Wells," 1912.

Entered by J. LUCAS, under Raven Spring, 1875, in *Journ. Soc. Arts*, vol. xxv., p. 612.

15. VARIOUS WELLS.

J. LUCAS, *Journ. Soc. Arts.*, vol. xxv, p. 612.

Water overflowed, or rose to the surface. Figures stand for feet.

—	Level above Ordnance Datum.	To Chalk.	In Chalk.
Longley Road, 1876	About 55	187	7
Waterfall Cottages	47	157	18
Phœnix Villa, 1875	55	210	15
Acton Terrace, Clarke's	47	168	12
Byegrove House	44	180	10
Clare Villas	40	174	6
Greys	40	220 to and in Chalk.	
New Singlegate Board Schools, 1874 ...	41	220	14
Fountain Cottage...	46	260 to and in Chalk]	
Latham's Varnish Works, 1874... ...	50	250	10
Lewis' Cottages, 1865	63	225	25
Mitcham House	68	184	16
Mr. Hatfield's	54	310	5
Baron House	70	170	—
Mitcham Hall (Gedge), 1874	70	170	130
Sampson's Yard, 1871	70	180	10

And two others, which do not reach the Chalk, namely—

Hope Cottages, 48 feet above Ordnance Datum, 260 feet deep, ending in sand.

St. Saviour's Schools, 70 feet above Ordnance Datum, sunk 50, bored 160 [presumably to sand].

See also **Garratt.**

Morden.

Ordnance Map 270, new ser. Geological Map, London District, Sheet 3.

THE GREEN, Lower Morden. For MR. R. GARTH, [Public Well?]. 1863

Communicated by MESSRS. EASTON & AMOS.

About 70 feet about Ordnance Datum. Water rose to the surface.

		Thickness. Feet.	Depth. Feet.
Sunk (the rest bored) ...		—	20
[London Clay]	Blue clay ...	200	220
	Pebbles and rock [basement-bed]	¾	220¾
[Reading and Thanet Beds.]	Shelly rock...	7 or 8	228
	Mottled clay	85 ?	313
	Clay and sand	27 ?	340
Chalk ...		45	385

Mortlake.

Ordnance Map 270, new ser. Geological Map London District, Sheet 3.

1. BREWERY. 1836, Deepened 1858.

15 feet above Ordnance Datum.

PRESTWICH, *Quart. Journ. Geol. Soc.*, vol. x. p. 147.

		Thickness. Feet.	Depth. Feet.
[River] Gravel ...		10	10
London Clay, 199 ft.	Ash-coloured clay ...	90	100
	Mottled red clay,* passing into red	109	209
Woolwich and Reading Beds, 58 ft.	Green sand ...	9	218
	Yellow sand...	3	221
	Greenish sand and clay ...	17	238
	Purplish clay, with lignite ...	4	242
	Yellow sand...	2	244
	Light-green sand ...	4	248
	Ash-coloured clay, with shells ...	15	263
	Green sand ...	4	267
Chalk ...		3	270

* PRESTWICH says the term Mottled clay is most likely wrong, and that he has therefore grouped this bed with the London Clay, thereby giving that formation a thickness agreeing with neighbouring sections.

An account of this well, communicated by the owners, MESSRS. PHILLIPS & Co., differs from the above, and is as follows.

Depth of shaft, 30 feet, the rest bored.

Water rose (1868) to within 50 feet of the ground.

Yield 14,000 gallons a day.

		Thickness. Feet.	Depth. Feet.
[Valley Drift, 6 ft.]	Gravel ...	2	2
	Gravel, with sand ...	4	6
[London Clay, 209 feet.]	Blue clay ...	164	170
	Blue clay and black sand ...	8	178
	Blue clay ...	12	190
	Variegated clays ...	25	215
[Reading Beds].	White, red, and yellow variegated clay ...	72	287
Chalk ...		31	318

Further work has been done at this brewery by MESSRS. DOCWRA, who have communicated the following particulars :—

Shaft and cylinders (of newer well) carried down to 210 feet, with a heading to old boring at 105 to 110. A fissure at 284½ feet.

Water-level, February, 1890, 94¾ feet down ; 18th September, 1890, about 129 ; 19th January, 1891, 77. In 1911, 270 feet down when pumping, and the yield was 3,250 gallons an hour.

		Thickness. Feet.		Depth. Feet.
[London Clay.]	Blue clay [top beds omitted] ...	—	to	164½
	Sandy blue clay ...	20½		185
	Sand ...	1		186
	Clay-stone, the bottom 2 feet light-coloured ...	3		189
	Sand ...	1		190
[Reading (& ? Thanet), Beds.]	Mottled clay ...	30		220
	Clay and sand (water) ...	1		221
	Very sticky clay ...	23		244
	Pebbles...	1		245
	Green sand ...	12		257
	Dark sand ...	15½		272½
[Upper Chalk.]	Chalk, with flints at 305 to 305½ ...	45½		318
	Hard chalk and flints. Water at 369½ (? then softer chalk)...	82		400

Mortlake—*continued.*

2. Mr. John Randell's (within 100 feet of the Thames). 1834.

W. Richardson, *Proc. Geol. Soc.*, vol. ii. no. 48, p. 449.

Bored throughout.

Water overflowed, for a time, at the rate of 5,000 gallons a day.

		Thickness. Feet.	Depth. Feet.
[River Drift] Gravel, mixed with marl [loam ?]	...	20	20
London Clay ...	...	240	260
[Reading Beds.]	Alternations of sand and clay ...	55	315
Upper Chalk, 50 feet.	Hard chalk, with many flints ...	35	350
	Soft chalk, into which the auger suddenly went to the depth of ...	15	365

3. In Sheet 1 of the "Sections of Borings in the Metropolitan District," by J. Phillips (1849), is the following account (clearly wrong) of a well at Mortlake, over 3 feet above Trinity High-water mark :—

Made ground ...	10	190 feet to Chalk.
Blue clay ...	180	

Munstead Heath *see* Godalming.

Nine Elms *see* Battersea.

Normandy.

Ordnance Map, 285, new ser. Geological Map 8.

1. Mr. Field's, Station Road, about midway between Wanborough Railway Station and the main road from Ash to Guildford. At back of house. 1897.

Communicated by Mr. E. Nottle.

Bored to 180 feet through London Clay. Near that depth a sandy bed about a foot thick was passed through. This yielded a supply of water which made boring difficult, as the water rose considerably each night and covered the stage on which the men worked. The boring was therefore abandoned, and the water then rose to about 3 feet below the ground, and it could not be lowered to the bottom of the suction-pipe (25 feet) by continuous pumping.

The water was analysed and was not considered good for drinking purposes ; but the well has yielded a good supply for horticultural purposes ever since. 1911.

[This is an interesting case of a supply got at the base of the London Clay.]

2. MSS. of Sir J. Prestwich.

[? Bracklesham Beds] Loose black clay	90	110 feet.
[? Bagshot] sand	20	

Water rose 7 feet.

Norwood.

Ordnance Map, 270, new ser. Geological Map London District, Sheet 4.

1. Brewery Co., Chapel Road, West Norwood, midway between Knights Hill Road and Elder Road. 1889.

Made and communicated by the Aqueous Works and Diamond Rock-boring Co.

Water-level 133 feet down. Yield, 1,400 gallons an hour.

			Thickness. Ft.	In.	Depth. Ft.	In
Old well (the rest bored) ...			—	—	21	0
[London Clay.]	Blue clay ...		153	6	174	6
	[? Basement-bed, about 4 feet.]	Black pebbles	2	3	176	9
		Oyster - shell rock ...	0	6	177	3
		Pebbles and dark sand	1	2	178	5

Norwood—*continued.*

1. Brewery Co.—*continued.*

		Thickness. Ft. In.	Depth. Ft. In.
[Woolwich and Reading Beds, about 52½ feet.]	Sand ...	8 0	186 5
	Blue clay and shells ...	5 5	191 10
	Brown sand ...	7 5	199 3
	Oyster-shell rock ...	4 8	203 11
	Sand and shells ...	1 9	205 8
	Coloured [mottled] clay ...	17 10	223 6
	Pebbles and sand ...	7 6	231 0
[Thanet Sand, 38 feet.]	Grey sand ...	33 9	264 9
	Flints ...	4 3	269 0
[Upper] Chalk and flints ...		82 0	351 0

Perhaps the sand at the top of the Woolwich Beds, with the pebbles, &c., classed as basement-bed of the London Clay, may belong to the Blackheath Beds.

An account communicated by the Company differs much in details (? another well), being as follows :—

Water-level 211 feet down. Rather a large quantity of iron was found in the water at first, and was attributed to the new pipes that were used. The quantity has lessened since.

		Thickness. Feet.	Depth. Feet.
[London Clay.]	Brown clay ...	10	40
	Blue clay ...	180	220
	Pebbles [? Basement-bed] ...	5	225
[Woolwich and Reading Beds, 39 feet.]	Red shells ...	1	226
	Brown dead sand ...	10	236
	Shells and blue clay ...	1	237
	Coloured mottled plastic clay	15	252
	Brown clay and pebbles ...	6	258
	Green sand ...	6	264
[Thanet Sand, 32 feet.]	Coloured sand, very hard ...	10	274
	Thanet sand, with water ...	20	294
	Flints ...	2	296
[Upper] Chalk and flints ...		57	353

A third account, communicated by Sir B. Baker, in 1901, differs from both the above, but agrees with each in certain particulars.

192 feet above Ordnance Datum.

Shaft, of 5 feet diameter, 116 feet, with perforated tube of 11½ inches diameter, of 84 feet. Supply about 100 gallons an hour. Temperature of the water 54½° (September).

			Thickness. Ft. In.	Depth. Ft. In.
Undescribed ...			21 0	21 0
[London Clay.]	Clay ...		174 6	195 6
	[Basement Bed.]	Pebbles...	2 3	197 9
		Oyster-shell rock ...	0 6	198 3
		Pebble and dark sand	1 2	199 5
[Woolwich and Reading Beds, 67⅓ feet.]	Sand ...		8 8	208 1
	Blue clay and shells ...		5 5	213 6
	Sand ...		7 5	220 11
	Rock, sand and shells...		5 9	226 8
	Clay and marl (hard)...		7 1	233 9
	Clay ...		10 9	244 6
	Pebbles and sand ...		7 6	252 0
	Sand (hard) ...		11 6	263 6
	Sand (hard) and pebbles ...		3 3	266 9
[Thanet Sand, 29¼ feet.]	Sand ...		25 0	291 9
	Flints ...		4 3	296 0
Chalk and sand ...			?4 0	300 0

An analysis of the water is given on p. 304.

Norwood—*continued.*

2. Western side of GRANGE ROAD, just S. of Sylvan Road. 1881.

[? Monteagle, Harold Road.]

Communicated by the owner, MR. R. W. WHEELER.

Shaft 120 feet (of which 4 feet were filled up); the rest bored.
Water-level about 100 feet down.

[London Clay.] Specimens of brown clay from 190 to 255 feet, the last slightly sandy. At the bottom a few pebbles ...	about 270 feet.
Fine sand, with some clay	
Dry sand, about 8 feet	
Sand, with water, about 5 feet?	

3. WILSON & CO.

J. SIMPSON, *MS.* in *Library Inst. Civ. Eng.*

Water rose to a height of 100 feet below the ground.
Total depth 270 feet.

Nunhead *see* Camberwell.

Nutfield.

Ordnance Map 286, new ser. Geological Map 8.

1. The SPOTTED COW, N., of the village. From MR. W. TOPLEY'S Notes.
Through Gault at 124 feet.

2. The QUEEN'S HEAD. J. LUCAS, *Proc. Inst. Civ. Eng.*, vol. lxi, pt. iii, p. 224.

About 464 feet above Ordnance Datum.

20 feet deep. Water 12 feet down, October, 1878.

Ockham.

Ordnance Map 285, new ser. Geological Map 8.

AUBREY, "The Natural History . . of . . Surrey," vol. iii, p. 245. 8° *Lond.* 1718.

"In this Parish are some Wells, which in their Nature are purgative, and in them is found a Mineral, much like Allom; but with the Water the Inhabitants can neither brew nor wash."

Ockley.

Ordnance Map 302, new ser. Geological Map 8.

OCKLEY GREEN. E. W. BRAYLEY, "History of Surrey," vol. v, 1850, pp. 16, 17.

Well for the use of the village. Made a few years ago (that is before 1850).

In DR. MITCHELL'S MSS., vol. iv (at Geol. Soc.) is a note of a well at Lord Abingers, with stone at top and blue [Weald] clay to 300 feet.

Old Kent Road *see* Camberwell.

Oxted.

Ordnance Maps 286, 287, new ser. Geological Map 6.

RAILWAY STATION. 1898.

Made and communicated by MESSRS. LE GRAND and SUTCLIFF.

About 340 feet above Ordnance Datum.

Pit 7½ feet, the rest bored.

Water-level 52½ feet down, December, 1898, (? lower, 236 above O. D., later from local information, 1900). ? Abandoned.

		Thickness. Ft.	In.	Depth. Ft.	In.
[Folkestone Beds, 62¼ feet ?]	Buff sand...	34	0	34	0
	Buff sand and ferruginous sandstone ...	5	0	39	0
	Brown sandy clay	10	0	49	0
	Brown sandy clay, with bands of calcareous sandstone	11	2	60	2
	Calcareous grit	2	1	62	3
[? Sandgate Beds, 30¾ feet.]	Brown sandy clay	6	9	69	0
	Dark sandy clay	14	6	83	6
	Green sandy clay	9	6	93	0
[Hythe Beds, 152½ feet.]	Bands of green clayey sand and calcareous sandstone	11	0	104	0
	Bands of grey clayey sand and calcareous sandstone	11	3	115	3
	Bands of green clayey sand and calcareous sandstone	5	9	121	0
	Green clayey sand and thin bands of grey sandstone...	18	6	139	6
	Kentish Rag	3	0	142	6
	Soft grey sandstone and thin bands of blue clay	1	6	144	0
	Bands of hard and soft grey sandstone	6	0	150	0
	Hard grey sandstone and bands of grey sandstone	9	0	159	0
	Grey clayey sand and bands of grey sandstone	10	0	169	0
	Hard grey sandstone	2	0	171	0
	Grey sand and thin bands of grey sandstone	6	6	177	6
	Grey sandstone and bands of grey sandy clay	17	6	195	0
	Blue sandy clay and bands of grey sandstone	17	4	212	4
	Hard sandstone	2	8	215	0
	Blue sandy clay and thin bands of stone	10	0	225	0
	Hard blue sandy clay	12	6	237	6
	Grey sand	2	6	240	0
	Bands of blue sandy clay and grey sand	3	0	243	0
	Grey sand...	2	6	245	6
[? Atherfield.]	Brownish-blue clay...	4	6	250	0

I have some doubt in classifying any of the beds as Sandgate Beds, that division not having been recognized above the outcrop of the Hythe Beds, close by. It is possible that the Folkestone Beds may end at 49 feet, and that the rest may belong to the Hythe Beds, which would then have a thickness of 196½ feet, or more if the Atherfield Clay has not really been reached.

Waterworks *see* **Tatsfield.**

Peckham.

Ordnance Map 270, new ser. Geological Map, London District, Sheet 4.

1. HANOVER STREET, Rye Lane. Mr. Grigg's.

29 feet above Ordnance Datum.

Made and communicated by MESSRS. ISLER & CO.

Water-level 40 feet down; supply abundant. (1,100 gallons an hour. G. BARROW.)

		Thickness. Feet.	Depth. Feet.
Shaft (the rest bored, 5 inches diameter), through made ground, clay, and sand		23	23
Blue [? London] clay		2	25
[? Woolwich Beds, 35½ feet.]	Grey sand and small pebbles	15	40
	Grey sand	2	42
	Brown sand and pebbles ...	14	56
	Large ballast [? pebbles] ...	4½	60½
Grey blowing [Thanet] sand		30½	91
Chalk and flints		33	124

2. HIGH STREET, for Messrs. Jones & Higgins. 1893.

25·3 feet above Ordnance Datum.

Made and communicated by MESSRS. BAKER.

Shaft to the Chalk; the rest bored.

Water-level 28 feet below the road-level. Supply tested with an 8-inch pump, which lowered the water only 3 feet, and the original level was recovered in 10 minutes.

		Thickness. Feet.	Depth. Feet.
Road-level to basement-level		—	11
[River Drift.]	Loam and ballast ...	3	14
	Light-coloured ballast ...	5	19
[Woolwich and Reading Beds, 41 feet.]	Silt	8	27
	Yellow clay	10	37
	Sandy clay	1	38
	Green clay and pebbles	3	41
	Oyster-bed	1	42
	Pebbles and green sand	4	46
	Grey sand	4	50
	Black pebbles	10	60
[Thanet Sand, 33 feet.]	Brown sand	22	82
	Dark sandy clay ...	10¼	92¼
	Green-coated flints ...	¾	93
[Upper] Chalk	... ...	83½	176½

3. HILL STREET. Brewery. 1876.

About 17 feet above Ordnance Datum.

Communicated by MR. J. BROOKS.

Shaft 8 feet; the rest bored.

Water rose to 23 feet below the surface, and is not lowered more than a foot when pumping at the rate of 3,600 gallons an hour.

		Thickness. Feet.	Depth. Feet.
Top [made] ground		2	2
[Valley Drift.]	Sand and loam	13	15
	Ballast [gravel] and sand ...	11	26
[? Woolwich Beds.]	Fine sand with few pebbles ...	2	28
	Conglomerate	2	30
	Green sand and pebbles	8	38
[Thanet Sand, 48 feet ?]	Grey sand, with pebbles * ...	46	84
	Muddy clay	2	86
[Upper] Chalk and flints		167	253

* Part of this may belong to the Woolwich Beds.

Peckham—*continued.*

4. Lyndhurst Road. Messrs. Gordon's Brewery. 1876.

About 50 feet above Ordnance Datum.

Sunk and communicated by Messrs. Docwra & Son.

Shaft (chiefly cylinders) 115 feet; the rest bored, 18 inches diameter.

Water-level after pumping 9 hours, about 53 feet down; supply equal to 185.000 gallons in 24 hours. According to Mr. J. Lucas (*Journ. Soc. Arts*, vol. xxv, p. 608), the water-level before pumping, in 1877, was over 48 feet down, and the yield 7,700 gallons an hour. In 1911 it was 72 feet down.

		Thickness. Feet.	Depth. Feet.
[London Clay, 22 feet.]	Clay and sand	7	7
	Yellow clay	9	16
	Blue clay	6	22
[Woolwich and Reading Beds, 54 feet.]	Running sand	2	24
	Clay and sand	5	29
	Shells	3½	32½
	Mottled clay	3½	36
	Live sand	6	42
	Black sand	2	44
	Dark sand	3	47
	Brown sand, mixed with shells	2	49
	Mottled clay	2½	51½
	Clay and shells	2	53½
	Hard shell-bed, mixed with pebbles	1½	55
	Mottled clay	11	66
	Pebble- and shell-bed	5	71
	Live sand	1	72
	Pebbles and shells (hardened)	4	76
[Thanet Sand, 48 feet.]	Dark soft sand	25	101
	Live sand	14	115
	Hard sand	3	118
	Dark sticky sand	5	123
	Flints	1	124
[Upper] Chalk	... ...	111½	235½

5. Marlborough House.

D. Allport's "Collections Illustrative of the Geology, &c. of Camberwell," p. 8 (1841).

		Thickness. Feet.	Depth. Feet.
[Valley Drift, 20 feet.]	Gravel	3	3
	Bright loam and sand	14	17
	Sandy gravel	3	20
[Woolwich Beds.]	Yellow, soapy clay, marbled with light blue	20	40
[Thanet Sand. Including the bottom-bed of the overlying Series.]	Green sand and clay, and quick-sand	40	80
	Dark grey sand, yielding water strongly impregnated with copper [?]	16	96
	Greenish sand	2	98
	Slate-coloured clay and dark, heavy sand	2	100
[Upper] Chalk with flints, water at bottom	...	123	223

Peckham—*continued.*

6. Peckham Road. Phœnix Brewery.

Made and communicated by Messrs. Baker.

? Shaft to the Chalk.

		Thickness. Ft.	In.	Depth. Ft.	In.
Made ground ...		3	6	3	6
Ballast [gravel] ...		4	6	8	0
[Lower London Tertiaries.]	Yellow clay ...	2	6	10	6
	Decayed timber ...	4	0	14	6
	Sandy clay ...	10	0	24	6
	Sand and ballast [gravel] ...	4	0	28	6
	Ballast [gravel] ...	8	0	36	6
	Loam and ballast [gravel] ...	5	0	41	6
	Sand and coarse ballast [gravel]	19	0	60	6
	Dark sand and pebbles ...	3	6	64	0
	Fine sand ...	8	0	72	0
	Flints ...	2	0	74	0
[Upper] Chalk (bored into) ...		112	10	186	10

New Phœnix Brewery. 37, Peckham Road. Second Well.

Made and communicated by Messrs. Isler & Co.

80 feet of tubes 8½ inches in diameter from 2½ feet down.
210 „ „ 7¼ „ „ „ 1 foot „

Water-level 41 feet down.

		Thickness. Feet.	Depth. Feet.
Made ground	Paving stones and concrete	1	1
	Made ground ...	3	4
[Lower London Tertiaries.]	Loamy soil ...	4	8
	Fine ballast ...	4	12
	Peat ...	3	15
	Sand and clay ...	7	22
	Large ballast ...	19	41
	Light-coloured sand ...	34½	75½
	Flints ...	2	77½
[Upper] Chalk and Flints ...		222½	300

In these two sections at the brewery too much may have been classed with the Lower London Tertiaries. Perhaps the "gravel" or "ballast" may all belong to the River Drift, in which case there would seem to be a hollow or channel thereof. The following section points in that direction also.

An analysis of the water is given on p. 304.

7. British Ice and Refrigerator Co. Latona Road, Glengall Road.

Made and communicated by Messrs. Baker.

Cylinders to 12 feet 7 inches, the rest bored.

		Thickness. Feet.	Depth. Feet.
Made ground ...		40	40
[River Gravel.]	Rough ballast	7	47
[Thanet Sand.]	Loamy sand ...	12½	59½
	Flints ...	½	60
[Upper] Chalk ...		244	304

Peckham—*continued.*

8. For details of the following, *see Geological Survey Memoir*, "London Wells," 1912.

a. QUEEN'S ROAD. Hatcham Park Dairy. 1906.
23 feet above Ordnance Datum.

Water-level 38 feet down. Yield 1,100 gallons an hour.

To Chalk	61	200 feet.
In „	139	

b. STAFFORD STREET. Mellin's Food Works. 1904. Deepened 1905.
18 feet above Ordnance Datum.

Shaft 10 feet, the rest a bore of 12 inches diameter.
Water-level 28 feet down. Yield 6,000 gallons an hour (1904).

To Chalk	90	250 feet.
In „	160	

Penge.

Ordnance Map 270, new ser. Geological Map, London District, Sheet 4.

1. CRYSTAL PALACE. In the lower part of the Grounds. 1852.
From a Drawing at the Crystal Palace.
187 feet above Ordnance Datum.

Shaft 250 feet, the rest bored. Three short galleries at 143½ to 152 feet down [? in the Chalk].

Water rose to 90 feet below the surface of the ground. In December, 1891, the water was 84 feet above Ordnance Datum before pumping and 14½ after pumping. A loss of 9 feet in 15 years. (BINNIE.)

		Thickness. Feet.	Depth. Feet.
Soil. Ferruginous sandy loam		9	9
London Clay, with septaria. Pebbles [basement-bed] at the bottom, for about a foot		250	259
[Woolwich and Reading Beds, 47½ feet.]	Sharp sand, from which water rose to 110 feet below the surface of the ground [may be Blackheath Beds]	9	268
	Lignite (about a foot) ... ... Dun clay, with broken shells; a layer of clayey limestone [Paludina-bed?] in the middle	17	285
	Mottled plastic clay	15	300
	Green sand, with pebbles	6½	306½
[Thanet Sand, 54½ feet.]	White porous sand, from which water rose	40	346½
	Dun sand, with marly clay	11½	358
	Waterworn [?] flints	3	361
White [Upper] chalk with flints, the fissures discharging water		149	510

The following slightly different account was communicated by MESSRS. S. F. BAKER & SONS:—

		Thickness. Feet.	Depth. Feet.
[London Clay, 259 feet.]	Blue clay	90	90
	Stones (shelly)	5	95
	Blue clay	164	259
[Woolwich and Reading Beds, 47 feet.]	Sand and water ...	10	269
	Blue clay	19	288
	Red and mottled clays	18	306
[Thanet] sand	... ...	52	358
[Upper] Chalk	... ...	202	560

According to MR. J. LUCAS (*Journ. Soc. Arts*, vol. xxv, p. 608, the total depth is 600 feet.. On p. 619 he gives the following account of "Experiments at the Crystal Palace Well, by the Clerk of the Works." Made in 1875. The figures stand for feet and inches.

Penge—*continued.*

1. Crystal Palace—*continued.*

Day.	Depth to Water. Before pumping.	Depth to Water. After pumping.	Difference.	No. of Hours pumping.	Gallons pumped.
Feb. 15	100	149 2	49 2	3	34,540
,, 16	109 6	132 8	23 2	1 }	
,, 16	109 6	147 11	38 5	2 } 3	36,569
,, 16	109 6	150	40	3 }	
,, 17	109	131 3	22 3	1 }	
,, 17	109	145 1	36 10	2 }	
,, 17	109	148 4	39 4	3 } $5\frac{3}{4}$	
,, 17	109	150 4	41	4 }	64,306
,, 17	109	154 3	45 3	5 }	
,, 17	109	162	53	$5\frac{3}{4}$ }	
,, 18	118 9	143 3	24 6	1 }	
,, 18	118 9	148 7	29 10	2 } $3\frac{3}{4}$	52,750
,, 18	118 9	151 4	32 7	3 }	
,, 18	118 9	164	45 3	$3\frac{3}{4}$ }	

Water in each case having been lowered to suction (limit of suction 172 feet down), rose as follows :—

September 23.—1st 2 feet at end of 16 minutes.
2nd 2 ,, ,, ,, $18\frac{1}{2}$,,
3rd 2 ,, ,, ,, $19\frac{1}{2}$,,
4th 2 ,, ,, ,, 22 ,,
5th 2 ,, ,, ,, $24\frac{1}{2}$,,
,, 24.—1st 2 ,, ,, ,, $16\frac{1}{2}$,,
2nd 2 ,, ,, ,, 18 ,,
3rd 2 ,, ,, ,, 19 ,,
4th 2 ,, ,, ,, $22\frac{1}{2}$,,
5th 2 ,, ,, ,, 24 ,,
,, 28.—1st 2 ,, ,, ,, $15\frac{1}{2}$,,
2nd 2 ,, ,, ,, 17 ,,
3rd 2 ,, ,, ,, $18\frac{1}{2}$,,
4th 2 ,, ,, ,, 22 ,,
5th 2 ,, ,, ,, 25 ,,
,, 29.—1st 2 ,, ,, ,, 15 ,,
2nd 2 ,, ,, ,, $16\frac{1}{2}$,,
3rd 2 ,, ,, ,, $18\frac{1}{2}$,,
4th 2 ,, ,, ,, $21\frac{1}{2}$,,
5th 2 ,, ,, ,, 24 ,,

Sir A. R. Binnie said, in 1891, "Almost all the water is derived from the sand, the bore-pipe passing through it being perforated; the pumps consequently get choked with sand, and the supply is insufficient." Appendices, R. Comm. Metrop. Water Supply, 1893, p. 160.

2. London and Provincial Steam Laundry. Green Lane. On the northern side of the L. C. & D. Railway. About half-way between Penge and Kent House Stations. 1892.

Communicated by Mr. E. Turner. The section also from Messrs. Baker.

Bench-mark 93·4 feet above Ordnance Datum.

Cylinders (20 feet) and shaft to 74 feet; cement-bottom up to 62 feet; the rest bored, 12 inches diameter, pipe up to 48 feet.

Water rose to the surface.

	Thickness. Feet.	Depth. Feet.
Mould	1	1
[River Drift] Gravel	1	2

Penge—*continued.*

2. London and Provincial Steam Laundry—*continued.*

		Thickness. Feet.	Depth Feet.
[London Clay, 73 feet.]	Yellow clay, rotten ...	11	13
	Loam	21	34
	Sandy clay	4	38
	Blue clay	35	73
	Sandy clay	2	75
[? Blackheath Beds.]	Light-grey sand	5	80
	Pebbles and sand... ...	5	85
[Woolwich and Reading Beds, 32 feet.]	Petrified timber [? lignite]	3	88
	Grey sandy clay	2	90
	Shelly beds...	11	101
	Coloured [mottled] clay ...	1	102
	Shelly rock...	1½	103½
	Sandy clay	½	104
	Coloured [mottled] clay ...	5	109
	White marl...	6	115
	Pebbles	2	117
Thanet Sand	... ...	1	118

Date.	Hours pumped.	Water lowered (ft.).	Water rose (ft.).
June 27 ...	6 (12 to 6) ...	29½	14 in 12 hours.
„ 28 ...	11 (7—6) ...	32 down to 48	28½ „ 12 „
„ 29 ...	6 (7—1) ...	28 „ „ 47	3½ (from 1 to 2).
	Started again at 2.	1 „ „ 48	28 in 12 hours.
„ 30 ... July 1 ...	9 (7—1, 2—6)...	„ „	„ „ (3½ in interval).
„ 2 ...	8 (7—3) ...	46 down to 66	63 in 40 „
„ 4 ...	8 (8—1, 2—6)...	„ „ 64	30 „ 14 „ (3½ in interval).

Pump, of 6 inches diameter, 15-inch strokes, averaged 17 strokes a minute. An analysis of the water is given on p. 305.

3. Anerley. North Surrey District School, Anerley Road. 1867.

Communicated by the Board of Management.

		Thickness. Ft.	In.	Depth. Ft.	In.
[London Clay, 228 feet.]	[Clay]... ...	220	0	220	0
	Blue clay ...	8	0	228	0
[Woolwich and Reading Beds, 26½ feet.]	Clay and shells	5	6	233	6
	Plastic clay ...	7	6	241	0
	Shells	1	6	242	6
	Shells and clay	2	4	244	10
	Mottled clay ...	7	0	251	10
	Sand	0	2	252	0
	Pebbles ...	2	6	254	6
[Thanet Sand, 48½ feet.]	Green sand ...	17	6	272	0
	Grey sand ...	19	0	291	0
	Dead sand ...	9	0	300	0
	Flints	3	0	303	0
[Upper] Chalk	... ...	109	6	412	6

Further particulars from Messrs. Le Grand and Sutcliff, who deepened the work from 286 feet downwards in 1877, make this well nearly 60 feet deeper. Their work began in clay [London Clay], with a thickness of 5½ feet, when the Woolwich and Reading Beds were touched (at the depth of 291½ feet). Their details of this Series vary only in the suppression of the 2 inches of sand and its addition to the mottled clay above, leaving the total thickness the same.

Penge—*continued.*

3. Anerley—*continued.*

The Thanet Sand, however, is made only 44½ feet thick, and the total depth reaches 472 feet.

Shaft 220 feet, the rest bored.

I understand that this well was not successful in getting the supply needed, but Mr. W. H. Dalton tells me that the yield is 7,000 gallons a day, of ten hours.

According to "A Treatise on Waterworks," by S. Hughes, new Ed., 1875, p. 212, "at a depth of 243 feet . . . a bed of sand 9 feet in thickness was reached . . . very fully charged with water, which rose rapidly till it reached a height of . . . 102 feet from the surface. This spring has ever since supplied the schools . . . The level of water in this well is considerably affected when extensive pumping is going on at the Crystal Palace."

Peperharrow.

Ordnance Map 285, new ser. Geological Map 8.

Lucas notes 3 wells in Lower Greensand. *Proc. Inst. Civ. Eng.*, 1880, vol. lxi, pt. iii.

Purley *see* Coulsdon.

Putney.

Ordnance Map 270, new ser. Geological Map, London District, Sheet 3.

1. Brandon's Brewery. 1898.

29 feet above Ordnance Datum.

Made and communicated by Messrs. Le Grand and Sutcliff.

Boring of 8½ inches diameter.
Water-level 98 feet down (May).
Yield 2,400 gallons an hour. Now disused.

		Thickness. Feet.	Depth. Feet.
Pit (the rest bored)		—	10
[River Gravel.]	Ballast	16	26
[London Clay, 159 feet.]	Blue clay	150	176
	Blue sandy clay	9	185
[Reading Beds, 62 feet.]	Mottled clay	33	218
	Brown clay	17	235
	Sandy clay and pebbles	6½	241½
	Greensand	5½	247
Grey [Thanet] Sand		23	270
[Upper] Chalk and flints		230	500

2. Messrs. Tucker and Co. Weimer Street.

About 23 feet above Ordnance Datum.

Bored (diameter, 6 inches) and communicated by Messrs. A. Williams and Co. 1907.

Water rose to within 117 feet from the surface.
Supply 1,800 gallons an hour. (G. Barrow.)

		Thickness. Feet.	Depth. Feet.
Made ground...		12	12
[River Gravel.]	Ballast	11	23
[London Clay, 143 feet.]	Clay	58	81
	Dark grey clay	17	98
	" " and stones	16	114
	" "	30	144
	" " and stones	3	147
	" "	2	149
	" " and stones	6	155
	" "	11	166

Putney—*continued.*

2. MESSRS. TUCKER & CO.—*continued.*

		Thickness. Feet.	Depth. Feet.
[Reading Beds, 88 feet.]	Grey mottled clay ...	59	225
	Dark brown clay ...	18	243
	Mottled clay and pebbles	5	248
	Pebbles and green sand	6	254
[Thanet Sand, 29 feet.]	Green sand	8	262
	Grey sand	16	278
	Pebbles [flints] and sand	5	283
[Upper] Chalk and flints		217	500

3. ROEHAMPTON.

From the MSS. of SIR J. PRESTWICH.

[River Drift.]	Gravel...	10	52 feet.
[London Clay]	Blue clay full of shells	20	
	Rock full of shells ...	2	
	Blue clay full of shells	18	
	Rock full of shells ...	2	

Puttenham.

Ordnance Map 285, new ser. Geological Map 8.

1. THE PRIORY (Messrs. Bell Stewart & Co.). 1900.

Boring made and communicated by MESSRS. LE GRAND and SUTCLIFF.

Water-level 63½ feet down (October).

Well (old), the rest bored	68½	121 feet.
Sand (Folkestone Beds)...	52½	

2. LUCAS notes 4 wells in Lower Greensand. *Proc. Inst. Civ. Eng.* 1880, vol. lxi, pt. iii, p. 219.

Rayne's Park *see* Merton.

Redhill *see* Reigate.

Reigate.

Ordnance Map 286, new ser. Geological Map 8.

1. CLEARS SHAW, a mile about N.W. of the railway-station. For MR. G. TAYLOR. 1909.

307 feet above Ordnance Datum.

Made and communicated by MESSRS. ISLER and CO.

Boring, lined with 160 feet of 8½ inch tubes from 2 feet down; 115 feet of 7½ inch perforated tubes from 123 feet down; and 44 feet of 6 inch tubes from 216 feet down.

		Thickness. Feet.	Depth. Feet.
Soil		½	½
Clay and flints		5½	6
Shingle		1	7
Gault		148	155
[Folkestone Beds, 105 feet.]	Sand and hard layers ...	6	161
	Loamy sand	1	162
	Hard coarse yellow sand	27	189
	Yellow sand	23	212
	Red sand	6	218
	Sand	2	220
	Clay	10	230
	White sand	20	250
	Hard white sand ...	10	260

MR. G. TAYLOR told me that a pumping trial was made when the boring was 200 feet deep, with the result that 48 hours pumping drew up 24,000 gallons of water, lowering the water-level about 15 feet.

Reigate—*continued.*

2. CROYDON ROAD. Snowflake Laundry, near the railway-bridge. 1908 ?

Made by MESSRS. LE GRAND and SUTCLIFF. Communicated by MR. S. J. REYNOLDS.

Good water got 200 feet down, but so hard as to be useless. The water got from below the bands of clay [? 226 feet] has only 7 to 9 degrees of hardness.

	Thickness. Feet.	Depth. Feet.
Made ground ...	6	6
Brown sand ...	3	9
Light-coloured sand ...	38½	47½
Soft sandstone and light-coloured sand ...	34½	82
Hard white sand ...	18	98
Hard yellow sand ...	13	111
Hard white sand ...	21	132
Light-brown hard sand ...	33	165
Dirty grey sand ...	1	166
Black loamy sand ...	3	169
Dirty grey sand ...	1	170
Light-brown sand with very thin bands of sandstone	30	200
Hard light-brown sand ...	2	202
Brown blowing sand ...	9	211
Blowing sand with thin bands of clay and one thin band of soft sandstone ...	15	226
Light-brown blowing sand, with very occasional thin bands of clay from 233 to 244 feet ...	24	250
Blowing sand (less troublesome after 267 feet) ...	21	271
Blowing sand and bands of sandstone ...	9	280
Brown sand (not blowing) ...	14	294
Yellow sand and bands of blue clay ...	3	297

Apparently all Folkestone Beds, unless the bottom bed belongs to the Sandgate Beds.

3. EARLSWOOD ASYLUM. About 1862 or 1863.

Information got by MR. C. E. HAWKINS (from Dr. Grabham, the Superintendent, and from specimens). He says that there were many other specimens, not marked.

About 160 feet above Ordnance Datum.

Shaft 160 feet ; the rest bored. A failure as regards water.

		Depth of Specimens in feet.
[Weald Clay.]	Stiff clay ...	4
	Brown and pink mottled clay ...	50
	Clay, with thin seams of sand ...	93 ?
	Hard shaly clay, with shells ...	120
	Clay ...	200
	Stiff clay ...	300
	Hard ferruginous clay, with shells ...	408
	Clay, with traces of shells...	413
	Very stiff purplish mottled clay ...	415
	Shaly clay ...	425
	Clay, with traces of a decomposing salt ...	461
	Clay, with traces of small shells (not Cyprides)	465
	Clay, with traces of a decomposing salt ...	468
	Stiff clay ...	470B
	Sandy clay ...	470A, 472, 473 and 474
	Shaly clay ...	478
	Pinkish mottled clay ...	480
	Greenish and purplish mottled clay, a little shaly	481
	Sandy clay ...	486
	Clay, a little shaly ...	487

Reigate—*continued.*

3. Earlswood Asylum—*continued.*

		Depth of Specimens in feet.
[Weald Clay] —*cont.*	Shaly clay ...	... 488, 490, 495 and 497
	Clay ...	498
	Shaly clay ...	512
	Clay ...	513
	Clay ?, sandy ?	518
	? Sandy	534
	Shaly clay ...	53– ?
	Clay ...	536
[? Weald Clay or Hastings Beds.]	Fine clayey sand ...	538
	Bluish sandy clay ...	541
	Clay ...	553
[Hastings Beds.]	Fine sand ...	583, 586, 603, 611 and 612
	Fine sandy clay ...	700 and 744
	Sandy clay ...	760
	Clay less sandy than the above ...	765
	Very fine sand ...	773
	Clay ...	785
	Very sandy clay, fine ...	832
	Clay (plastic when wet ?) ...	833
	Very fine sandstone ...	... 845, 876, 886 and 910

According to Messrs. Baker, who made the boring, the depth is 912½ feet.

As there are sometimes considerable gaps between the specimens, it is difficult to classify the beds. The Weald Clay seems to go down to 553 feet, and the Hastings Beds may begin at 583. On the other hand, it is possible that the Weald Clay may reach deeper down (? to 833 feet), though this would give an excessive thickness to the formation. Under these circumstances it is clearly out of the question to attempt a division of the Hastings Beds.

4. Reigate Hill. Manor Farm.

614¼ feet above Ordnance Datum.

Made and communicated by Mr. W. Taylor, of Reigate (many years ago).

Shaft of 6 feet diameter, to 260 feet ; then gradually enlarged to 10 : with a heading 12 feet long.

When at rest, 43 or 44 feet of water, at all seasons : will stand 10 hours' pumping, at the rate of 10,000 gallons an hour, and then takes 3 days for the water to rise to its former level.

	Thickness. Ft.	In.	Depth. Ft.	In.
Clay with flints [on one side] ...	4	0	4	0
Chalk on one side of the well, the clay ending off at 32 feet ...	28	0	32	0
Chalk, very much shattered ...	6	4	38	4
Very hard chalk ...	4	8	43	0
Chalk, very much shattered ...	6	3	49	3
Moderately hard chalk ...	21	9	71	0
Hard chalk ...	13	5	84	5
Very hard chalk ...	6	7	91	0
Very rotten chalk, with much bad air ...	2	0	93	0
Shattered chalk, with much gas : a few round flints about 100 feet down ...	51	0	144	0
Very hard chalk, increasing in hardness ...	85	0	229	0
Extremely hard chalk ...	8	0	237	0
Very rotten clayey chalk...	1	0	238	0
Grey chalk ; water at 256 feet ...	62	0	300	0

A later communication from Mr. G. Taylor makes the well 330 feet deep, and with headings of 75, 115 and 300 feet. A 9-inch boring was then put down to the Upper Greensand, which was reached at 660 feet and was compact.

Reigate—*continued.*

5. OLD WATERWORKS, in the valley S.W. of the town. Trial-boring. 1868.
Communicated by MR. F. S. COURTNEY.

		Thickness. Feet.	Depth. Feet.
[Hythe Beds.]	Yellow running sand and water	60	60
	Loamy yellow sand	23	83
	Live yellow sand and water ...	3	86
	Loamy yellow sand	9	95
	Live yellow sand and water ...	21	116
	Dark sand and a little water ...	36	152
[? Atherfield Clay.]	Brown clay	6	158
	Green sand	41	199
	Blue clay	8	207

In 1870 a well, lined with cylinders, was sunk to the depth of 68 feet, with a boring to 110. The water is said to have risen to the surface : it was discoloured, and, despite of an elaborate arrangement for filtration, the well became choked with sand, and has been abandoned. The supply was confined to the old town of Reigate.

In 1890 an average of 133,204 gallons a day was pumped in July, of 131,213 in August, and of 140,407 in September.

For an analysis of the water from these works *see* p. 305.

The supply of Reigate is now taken from the East Surrey Water Co.

6. REDHILL BREWERY, Messrs. Cutforth's.
Made and communicated by MESSRS. ISLER and Co.

Lined with tubes of 5 inches diameter to 84 feet down.
Water-level 31 feet down. Supply about 1,000 gallons an hour.

		Thickness. Ft.	In.	Depth. Ft.	In.
Dug well (the rest bored, 5 inches diameter)		—	—	5	0
[Lower Greensand.]	Ironstone and sand ...	28	6	33	6
	Sand	4	0	37	6
	Blowing sand	53	2	90	8
	Loamy sand	7	0	97	8
	Sandstone	11	1	108	9
	Blowing sand	10	6	119	3
	Black loamy sand ...	5	6	124	9

7. REDHILL. Royal Asylum of St. Anne's Society.
Made and communicated by MESSRS. DOCWRA.

Shaft 48½ feet ; the rest bored.
Water-level 34 feet down.

		Thickness. Feet.	Depth. Feet.
[Lower Greensand.]	Sand ...	48	48
	Black sand	12	60
	Sand ...	52	112

8. REDHILL. MR. GURNEY'S

The Geology of the Weald, 1875, p. 101. The classification by W. TOPLEY.

		Thickness. Feet.	Depth. Feet.
[Hythe Beds.]	Light-coloured sand	53	53
[Atherfield Clay, 55 feet.]	Brown clay	1½	54½
	Greensand	5½	60
	Brown clay	13	73
	Stone	1	74
	Greensand	25	99
	Stone	2	101
	Greensand	7	108

Reigate—*continued.*

8. Redhill. Mr. Gurney's—*continued.*

		Thickness. Feet.	Depth. Feet.
[? Weald Clay, 334 feet.]	Blue marl, with stone at 118–119, 131–131½, 141–142, 182–183, 197–199, 241–245	147	255
	Red marl	2	257
	Blue marl	54	311
	Blue and white marl	100	411
	Stone	7	418
	Coloured [? mottled] clay	4	422
	Brown clay	2	424
	Black clay	2	426
	Coloured [? mottled] clay	6	432
	Sandstone	6	438
	Red marl	4	442

9. Workhouse.

Sir J. Prestwich's MS (1862 ?) notes a well here, dug to the depth of 230 feet and bored 65. Water 100 feet down.

10. Lucas notes 19 wells in Lower Greensand in Reigate parish, *Proc. Inst. Civ. Eng.*, 1880, vol. xli., pt. iii, p. 224.

Richmond.

Ordnance Map, 270 new ser. Geological Map, London District, Sheet 3.

1. No site given.

Dr. Mantell, in Brayley's *Topographical History of Surrey*, vol. i., p. 137 (1841).

		Feet.
Mould	... ...	1 to 2
[Valley Drift]	Loam and gravel with chalk-flints but slightly rolled	8
	Thin layer of marl.	
	Loose reddish sand	8
Blue London Clay, with septaria	... ...	200
[Reading Beds.]	Plastic clay, red, green, and bluish-black	30 to 50
	To Chalk ...	? 248 to 268

2. Duke of Buccleuch's. Not far from the Thames.

M. Héricart de Thury's "*Considérations . . . sur la Cause du Jaillissement des Eaux des Puits Forés*," 8vo., Paris, 1829.

257 feet deep. Water overflowed.

3. The Star and Garter.

J. Simpson, MS. in Library *Inst. Civ. Eng.*

Water rose to 39 feet below the ground.

To Chalk ...	416	492 feet.
In „ ...	76	

4. Waterworks (The Old).

Sunk and communicated by Messrs. S. F. Baker & Sons.

		Thickness. Feet.	Depth. Feet.
[London Clay, 191 feet.]	Yellow and brown clay	35	35
	Clay	156	191
[Reading and Thanet Beds.]	Mottled clays ...	38	229
	Yellow sand	47	276
[Upper] Chalk	... ...	103	379

Richmond—*continued.*

WATERWORKS, about 160 yards below the Bridge. 1876–1884.

PROF. JUDD. *Quart. Journ. Geol. Soc.*, vol. xl. pp. 724, &c.; vol. xli. p. 524.

About 17 feet above Ordnance Datum.

Shaft (and cylinders) 253 feet; the rest bored.

In 1884 the water overflowed. In January, 1892, after a fortnight's rest, the water-level was 133 feet below Ordnance Datum (and during pumping 213.) A loss of 150 feet in 8 years. (SIR A. R. BINNIE.)

		Thickness. Feet.	Depth. Feet.
Made ground			
Sandy gravel; 10 inches (not persistent, according to a letter from PROF. JUDD)		10	10
London Clay		160	170
Reading Beds, 59½ feet.	Mottled red and green clays	44	214
	Yellow sand	8	222
	Sandstone	4	226
	Light-coloured clay	2	228
	Clay, with much lignite, and with pebbles at the base	1½	229½
Thanet Sand, 22½ feet.	Light-grey sand	13½	243
	Dark clayey sand, with much glauconite	8	251
	Green-coated flints	1	252
Upper Chalk, 300 feet.	White chalk, with layers of flint	about 200	452
	White chalk, with few flints	about 100	552
Middle Chalk.	Cream-coloured hard nodular bed (? Chalk Rock), not over 5 feet ... Greyish chalk, without flints; about 20 feet down, a hard bed; 137 feet Hard, yellowish, crystalline chalk, partly nodular, partly conglomeratic, not over 15 feet (Melbourn Rock)	about 150	702
Lower Chalk.	Grey marly chalk, without flints, more clayey and darker lower down, and passing into:— Chalk Marl, not less than 50 feet ...	about 220	922
Upper Greensand, 16 feet.	Hard, micaceous, calcareous sandstone ...	6	928
	Softer, calcareous sandstone	6	934
	Rock, like the top bed, but with more glauconite	4	938
Gault ...	Pale blue clay with few fossils ... Dark blue, pyritous clay, with many fossils. At the bottom a sandy bed, with glauconite, passing down into:— Nodule-bed, with phosphatic nodules and fragments of various rocks ...	201½	1139½
? Neocomian [Lower Greensand], 10 feet.	Limestone, rather sandy, with particles of glauconite: made up of water-worn fragments of fossils in a sub-crystalline matrix; passes into the next	½	1140
	Limestone, consisting of a calcareous paste, with oolitic grains and fragments of shells, &c. 4 feet down, a 9-inch bed of clay, with water-worn fragments of shells, &c., grains of glauconite, of iron-pyrites, of coaly material, &c. About 1½ feet below this, a half-inch layer of pyrites	9	1149
	Clay, with oolitic grains, fragments of fossils, pieces of sandstone and of other rocks, some particles of anthracite, and phosphatic nodules	½	1149½

Richmond—*continued.*

WATERWORKS—*continued.*

		Thickness. Feet.	Depth. Feet.
Great Oolite Series, 87½ ft.	Dark limestone, made up of oolitic grains and water-worn fragments of fossils ...	5	1154½
	Paler and more marly limestone, with scattered oolitic grains and many Foraminifera	22½	1177
	Dark oolitic limestone	10	1187
	More shelly rock, with fewer oolitic grains and many Foraminifera...	11	1198
	Rock, of calcareous paste, with scattered oolitic grains. Fragments of fossils abundant	5	1203
	Dark blue clay, with limestone bands, and in places crowded with fossils	3½	1206½
	Oolitic and shelly limestone	17	1223½
	Fullers' earth	½	1224
	Fine grained, oolitic limestone, with much pyrites, more sandy downwards ; at the base a fissile, calcareous, micaceous sandstone, like Stonesfield Slate ...	9	1233
	Oolitic limestones, with many fragmentary shells	3½	1236½
	Limestone of more open texture, made up of water-worn fragments of shells, with a few grains of quartz and particles of anthracite	½	1237
Poikilitic [or New Red] beds. With dips (? or false-bedding) from 21° to 45°, 207½ ft. [Age doubtful.]	Alternations of red sandstone and variegated marls	16	1253
	Hard sandstone	1	1254
	Marls, with occasional beds of sandstone	10	1264
	Alternations of sandstone and marls ...	21	1285
	Solid sandstone	4	1289
	Red marls	2½	1291½
	Hard sandstone	4½	1296
	Soft sandstone, with many seams of marl	5	1301
	Hard, red and white sandstone, partly coarse, with some bands of clay ...	17	1318
	Red marls, with beds of sandstone ...	15	1333
	Red sandstone	13	1346
	Red and variegated marls	3	1349
	Red sandstones	3	1352
	Red and variegated marls	2	1354
	Beds of very hard, red and white sandstone, sometimes laminated, sometimes with litttle sign of bedding, with many vertical joints	19	1373
	Very hard, grey sandstone	1½	1374½
	Hard, red sandstone	2	1376½
	Softer, red and white sandstone, laminated in places ... ... about	32	1408½
	Mottled sandstone, very hard at the base	4	1412½
	Softer, mottled sandstone, with clay-galls	6	1418½
	Finely laminated, soft, mottled sandstones	12	1430½
	Very hard, red sandstones, the joint planes coated with green incrustations ...	1¼	1431¾
	Soft, green shaly rock	¾	1432½
	Hard, red sandstone, like the last sandstone	1¼	1433¾
	Softer, dark red sandstone...	1¾	1435½
	Very fine grained, red sandstone	1	1436½
	Very hard, red sandstone ; had to be ground away, and could not be brought up in cores	4	1440½
	Hard, white, fine-grained sandstone, with a rude dip...	4	1444½

Richmond—*continued.*

Waterworks—*continued.*

The total depth is given as 1,447 feet (*Quart. Journ. Geol. Soc.*, vol. xli., p. 523). This, though not the sum of the above figures, is really right, as in January, 1885, Messrs. Docwra continued the boring at their own expense. They were hindered, however (by meeting with pieces of iron that had fallen down), from going more than 4 feet 10 inches, after clearing out the bottom of the borehole. This they say made the total depth 1,446 feet 10 inches. (*Surrey Comet*, 7 Feb., 1885.) As there is no record of a change in the beds one may assume that there was none.

The above measurements are taken from the details given on pp. 731–735, 738, 739, 741, 749, 750, and 524 of Prof. Judd's papers, except for the Gault, in which the section (opp. p. 744) gives more detail than the text. These measurements differ, however, slightly from those of the section, in which, moreover, there is some discrepancy between the thickness of the beds, on the left of the column, and the depths, on the right; the latter at first erring by a slight excess, then by a slight defect, and again by a slight excess.

Mr. Jukes-Browne thinks that too little may have been assigned to the Middle and too much to the Lower Chalk.

Prof. Judd says that:—"On dissolving the chalk-marl in dilute acid, a residue, amounting in some cases to no less than 50 per cent. of the whole, is left behind. By washing this residue many beautiful specimens of fossils have been obtained. Portions of the spicular mesh of hexactinnelid sponges are common. . . Very abundant, indeed, in some cases are silicified prisms of the shell of *Inoceramus*; these sometimes, indeed, make up a large part of the mass of insoluble residue. . . With them occur a number of partially silicified Foraminifera. . . In these a more or less perfect cohesion of the sand grains composing the shells has been brought about by the deposition of siliceous material between them." (*Quart. Journ. Geol. Soc.*, vol. xli., pp. 525, 526.)

It should be remembered that the classification of the lowest set of beds as Poikilitic is doubtful. Prestwich, and some other geologists, think them to belong to the Old Red Sandstone, *see* vol. i., chapters 2, 3, of the Memoir on the Geology of London, etc., 1889.

A tracing communicated by Mr. S. C. Homersham differs in the following details:—

1. As to the junction of Reading and Thanet Beds, as follows:—Instead of "light-grey sand," classed as Thanet, gives "green sand, clay, and pebbles," which would be classed as Reading. This is succeeded by "grey sand," which of course falls into the classification above, as Thanet.

2. Makes the flints end about 246 feet down in the Chalk, and shows a 3-inch layer of dark clay some 7 feet lower.

3. For the depths to the base of the Chalk and of other underlying formations, agrees with the figure in Prof. Judd's paper, which, as above noted, differs slightly from the text.

According to a communication from Mr. W. Russ, in the earlier days of this well, when it left off in Upper Chalk, at a depth of 439 feet, the water rose slowly to the surface, on pumping being stopped, and overflowed at the rate of 2 gallons a minute; whilst the yield was about 300 gallons a minute when the water was pumped down to below 130 feet. (160 gallons later, according to Mr. C. Homersham.)

Two springs were met with in the Oolite, at 1,203 and 1,210 feet, the water overflowing from a tube 49 feet above the surface. Yield, near the surface, 1¼ gallons a minute.

Water from the red beds increased with the depth, and at 1,387 feet overflowed at the rate of 11 gallons a minute, and "rose with a force that would cause it to attain a level of 126 feet above the surface." (C. Homersham, *Quart. Journ. Geol. Soc.*, vol. xl., p. 727.) Prof Judd tells me that it was rather brackish.

A temperature of 76¾° Fahr. was registered at the bottom. The average increase was 1° for 54·09 feet of descent.

The following particulars are from the Water Works Directory, 1911:—

Estimated population supplied year ending 31 March, 1911, 36,500. Besides Richmond, Kew, North Sheen, and Petersham are supplied. The population of the area of control is only 32,000.

Yearly supply (1911) 412,000,000. Daily consumption per head, domestic 24·3, trade 7 gallons.

Richmond—*continued.*

WATERWORKS. Terrace Garden Well. 1890.

Communicated by MR. W. G. PEIRCE, Engineer.

42¾ feet above Ordnance Datum.

Shaft 320 feet; the rest bored.

Galleries from 314 to 320 feet down, in various directions, of a total length of 4,492 feet (1894), the chief one N.N.W. to the old well. Another, southward, has just touched the junction of the Tertiary beds with the Chalk at about 1,000 feet from the well (as the crow flies), showing that there is a slight southerly dip. Probably some further length of gallery will be driven in other directions.

A fissure tapped 1,730 feet from the well, in the gallery to the older well, yielded 50,000 gallons in 24 hours. Most of the fissures have a smaller yield, but one yielded nearly 100,000 gallons a day (*Surrey Comet*, 5 July 1890), some 80 feet from the well. The total yield was 220,000 gallons a day at that date.

In May 1889 the water-level was 121·1 feet below Ordnance Datum; in December 1891, after 4½ day's rest, it was 174·1. A loss of 53 feet in 3 years.

		Thickness. Feet.	Depth. Feet.
Mould, ashes, and brick-rubbish		3	3
London Clay, 211½ feet.	Brown clay, mottled with a little light-blue, with broken and scattered clay-stones	9½	12½
	Clay, with a few fossils	82½	95
	Hard clay, with a few fossils	39	134
	Clay, laminated with partings of fine black and white sand; black flint-pebbles, and a few fossils; 4-in. clay-stone at base, with a little water under	6	140
	Hard clay, with a few sandy partings	15	155
	Very hard clay, with a few fossils	30	185
	Very hard dry sandy clay: claystone at base, with fragments of plant-remains	12½	197½
	Very hard dry sandy clay, with fossils and part of a tree-trunk (9 ft. by 2½in.), much bored by *Teredo*. Thin layer of black flint pebbles at the base	16¾	214¼
Reading Beds, 65¾ feet.	Very hard dry sandy light-coloured mottled clay	3½	217¾
	Hard dark somewhat mottled clay	17	234¾
	Very hard dry sandy mottled clay	5½	240¼
	Hard mottled clay	4	244¼
	Soft dark mottled clay	5½	249¾
	Very hard dry sandy light-coloured mottled clay	2¾	252½
	Hard dark mottled clay	3½	256
	Very hard dry sandy light-coloured mottled clay	3½	259½
	Very fine dry sandy light-coloured loam	1	260½
	Fine light-brown sand, slightly mottled in parts	8¼	268¾
	Darker coarser sand, with 2½ in. of soft sandstone at top	¾	269½
	Green sand and black sandy loam, partly with soft chalk-pebbles [concretions ?]	1	270½
	Green sand and black loam, partly with flint-pebbles, hard brown and light-blue mottled clay, with fruits of plants, and brown and black laminated clay	1½	272
	Green and grey sand, and (greater part) conglomerate of flint-pebbles, in sand and loam	3	275

Richmond—*continued.*

WATERWORKS—*continued.*

		Thickness. Feet.	Depth. Feet.
Reading Beds, 65¾ feet—*cont.*	Green iron-shot sand, with many chips of flint, oyster-shells, pieces of hard chalk, and fish-teeth (in coarse greyish sand). Some rounded pieces of limestone [concretions] at the base	5	280
Thanet Sand, 10 feet.	Dark grey dry hard sand, loamy in parts, hard and clayey towards the base ...	9	289
	Continuous cemented layer of flint, 6 to 8 inches, with small flints under, green-coated, in hard sand	1	290
[Upper] Chalk. The surface smooth. The top foot bored in all directions with oval holes of all sizes up to ¾ inch diameter, some reaching a depth of over 12 feet ; all filled with grey sand. Many flints, in layers 1½ to 2½ feet apart (with few breaks), and some between the layers : a thick continuous layer, with black clay underneath, at the depth of 389 feet		180	470

This differs from the older section in starting at a rather higher level, so that the depth to the Chalk is greater. The Reading Beds are somewhat thicker, whilst the Thanet Sand is less than half the thickness.

I walked along the southerly gallery, with MR. PEIRCE, and saw that, at the end, there were, at the top, small holes in the chalk, filled with sand. These are clearly the same sort of thing as was noted in the well (*see above*) and justified his conclusion that the junction of the Thanet Sand and the Chalk had been reached. Of course the gallery was not driven further southward, lest there might be a fall of the softer beds, which would have been cut into at top.

Roehampton *see* Putney.

Rotherhithe.

Ordnance Map 270, new ser. Geological Map, London District, Sheet 4.

1. COMMERCIAL DOCK. 1854.

Sunk and communicated by MESSRS. S. F. BAKER & SONS.

		Thickness. Feet.	Depth. Feet.
[River] Gravel		3	3
[Woolwich Beds, 20 feet.]	Green sand and pebbles	10	13
	Sand and shells ...	10	23
[Thanet Sand, 43 feet.]	Loose sand	29	52
	Dead sand	13	65
	Flints. To Chalk ...	1	66

2. LOWER ROAD, Brandram Bros. and Co.'s Chemical Works. 1846.

Communicated by MESSRS. BRANDRAM.

Surface of ground 8 feet above Ordnance Datum.

Sunk 30 feet, the rest bored.

Water rises to 27 feet from the surface of the ground (? used to rise to within 9 feet). In December, 1891, the water-level before pumping was 26·5 feet below Ordnance Datum and 52 after pumping. A loss of 25½ feet in 45 years.

Yield about 100,000 gallons a day (12 hours) ; but later the suction-pipes had to be lowered and the supply became insufficient.

		Thickness. Ft. In.	Depth. Ft. In.
Made ground		3 0	3 0
[Alluvium, 5 feet.]	Blue mud	3 0	6 0
	Grey sand	2 0	8 0
[River Drift] Gravel and Sand		21 0	29 0

Rotherhithe—*continued.*

2. Lower Road—*continued.*

		Thickness. Ft.	In.	Depth. Ft.	In.
[Woolwich Beds, 35 feet.]	Blue clay	6	0	35	0
	Hard clay and shells...	5	1	40	1
	Pebbles, bound very hard with clay and sand	8	0	48	1
	Hard, dead sand	8	0	56	1
	Pebbles, bound hard with clay and sand...	8	0	64	1
[Thanet Sand, $42\frac{3}{4}$ feet.]	Grey sand	42	0	106	1
	Flints	0	8	106	9
[Upper] Chalk, with hard flint at the bottom		145	3	252	0

3. 251 Rotherhithe Street. Messrs. Dick and Co.

Made and communicated by Messrs. Isler.

Lined with 135 feet of tubes, $8\frac{1}{4}$ inches in diameter, from $1\frac{1}{2}$ feet down. Water-level 45 feet down. Supply 3,580 gallons an hour.

		Thickness. Feet.	Depth. Feet.
Pit		—	13
[? River Drift and Eocene Tertiary.]	Gravel	20	33
	Clay and stones ...	21	54
	Gravel and clay ...	5	59
	Gravel	10	69
	Gravel and clay ...	5	74
	Gravel	4	78
	Gravel and clay ...	6	84
	Gravel and sand ...	33	117
	Clay sand and flints	7	124
[Upper] Chalk and flints		139	263

This section looks as if there may be a hollow or channel of River Drift here.

4. Thames Tunnel Flour Mills. 1864.

Communicated by Mr. Cowan.

Nearly 15 feet above Ordnance Datum.

In December, 1891, the water-level before pumping was 26·37 feet below Ordnance Datum and 41·37 after pumping. (Binnie.)

Yield about 80 gallons a minute. In December, 1891, there was sometimes great difficulty in getting any water.

Shells [Woolwich Beds] found about 50 feet down.

To Chalk about 125 } 260 feet.
In „ „ 135 (? more) }

5. Road, midway between Britannia Brewery and South Bermondsey Railway Station. 1877.

Two tube-wells, made and communicated by Mr. G. Hawksley.

Water-level about 8 feet down. 20 gallons a minute pumped from each well.

	Thickness. Feet.	Depth. Feet.
Tolerably compact gravel and sand	11	11
Sand, with water, easily penetrated [a sample, from just above the Chalk, seemed like sand belonging to the River Drift]	9	20
Soft chalk, full of water ; no flints touched ...	14	34

Rotherhithe—*continued.*

6. Bermondsey Infirmary. 1908.

For details *see* Geol. Survey Memoir "London Wells 1912.

9 feet above Ordnance Datum.

Shaft 114 feet, the rest a boring of 8 inches diameter.
Water-level 46 feet down. Yield 4,500 to 5,000 gallons an hour.

To Chalk 113 }
In " 203 } 316 feet.

Runfold *see* Farnham.

Seale.

Ordnance Map 285, new ser. Geological Map 8.

1. Crooksbury. Cottages at the northern foot of the hill.

H. A. Mangles. *Proc. Geol. Assoc.*, 1893, vol. xiii, pt. 3, p. 78.
Folkestone Beds, 175 feet.
Bargate Stone, greenish and calcareous.

2. Lucas notes two Chalk-wells in this parish. *Proc. Inst. Civ. Eng.*, 1877, vol. xlvii, p. 97

3. Also nine wells in Lower Greensand. *Ibid.* 1880, vol. lxi, pt. iii, p. 218.

Shackleford *see* Godalming.

Shalford.

Ordnance Map 285, new ser. Geological Map 8.

Lucas notes three wells in Lower Greensand. *Proc. Inst. Civ. Eng.*, 1880, vol. xli, pt. iii.

Shere.

Ordnance Map 285, new ser. Geological Map 8.

1. According to Dr. Thresh a tube-well here was sunk 75 feet into the Lower Greensand, and the water overflowed. An analysis of the water is given on p. 306.

2. Colekitchen Farm, N.E. of the village.

J. Lucas, *Proc. Inst. Civ. Eng.*, 1877, vol. xlvii, p. 98.

397 feet above Ordnance Datum.

125 feet deep in Chalk. Water 118 feet down, November, 1876.

3. Gomshall. Mr. Gilligan's Tannery.

From Mr. J. H. Blake's notes.

	Thickness. Feet.	Depth. Feet.
Ballast ...	4	4
Yellow sand ...	66	70
Green sand ...	1	71
Light-green sand ...	10	81
Dark green sand, almost black, with slight layer of rock (about one inch) below, where first spring was found...	36	117
Dark red sand ...	11	128
Slight layer of rock, about 3 inches, where second spring was found, underneath 12 inches of fine transparent pebbles ...		
Sharp sand ...		

[There seems to be some doubt as to the last two beds, but there is a note that the boring reached to 140 feet.]

Shere—*continued.*

3. Gomshall—*continued.*

Second Well. November, 1888.

Tubed to 139 feet. Water rose and overflowed above 2 feet above the ground.

		Thickness.		Depth.	
		Ft.	In.	Ft.	In.
[Drift ?]	Ballast	4	0	4	0
[Lower Greensand. Division doubtful.]	Folkestone red sand, highly charged with water	66	0	70	0
	Green sand, very wet	1	0	71	0
	Red sand, highly charged with water	57	0	128	0
	Blue clay	1	0	129	0
	Shingle containing small pebbles	1	0	130	0
	Light-coloured rock	1	2	131	2
	Dark green sand	5	6	136	8
	Light-coloured rock	2	4	139	0
	Quartz and shingle, interspersed with very thin layers of chert	14	0	153	0
	Soft rock	4	0	157	0
	Hard rock	1	0	158	0
	Green sand	4	0	162	0
	Very hard rock	2	0	164	0
	Clay mixed with chalk [? concretions]	4	0	168	0
	Very hard rock	2	0	170	0
	Soft rock	1	0	171	0
	Blue clay	2	3	173	3

For an analysis of the water *see* p. 306.

4. Gomshall. Southbrook Farm.

From Mr. J. H. Blake's notes.

	Thickness.	Depth.
	Feet.	Feet.
Ballast, gravel, and sand	8	8
Yellow sand	13	21
Rock (6 inches), and then sand and rock	48	69

5. There are borings for the water-cress beds, with a constant supply.

6. Lucas notes 24 wells in Lower Greensand in the parish of Shere. *Proc. Inst. Civ. Eng.*, 1880, vol. lxi, pt. iii, p. 221.

Somers Town *see* Wandsworth.

Southwark.

Ordnance Maps 256, 270, new ser. Geological Map, London District, Sheets, 2, 4.

1. Bankside, No. 29. Belfast and London Aërated Water Company.

Made and communicated by Messrs. C. Isler & Co.

15 feet above Ordnance Datum.

Shaft 12 feet; the rest bored, 7¼ inches diameter. Water-level 114½ feet down. Yield (minimum) 3,000 gallons an hour.

		Thickness.		Depth.	
		Ft.	In.	Ft.	In.
Made ground		7	0	7	0
[River Drift, 27 feet.]	Grey sand	20	0	27	0
	Ballast [gravel]	7	0	34	0
Blue [London] Clay		75	0	109	0
[Reading Beds, 56¾ feet.]	Mottled clay	22	9	131	9
	Stone	1	0	132	9
	Sand and mud	4	6	137	3

Southwark—*continued.*

1. Bankside, No. 29—*continued.*

		Thickness. Ft.	In.	Depth. Ft.	In.
[Reading Beds, 56¾ feet]—*cont.*	Mottled clay and pebbles	14	3	151	6
	Congealed ballast [pebble-conglomerate]	1	6	153	0
	Pebbles	0	9	153	9
	Sand and ballast [pebbles]	3	3	157	0
	Clay and pebbles	8	9	165	9
Green [Thanet] Sand		37	5	203	2
[Upper] Chalk and flints		97	0	300	2

For an analysis of the water *see* p. 306.

2. Bankside. Barclay & Perkins' Brewery.

Prestwich, *Quart. Journ. Geol. Soc.*, vol. x., pp. 141, 168.

Surface about 12 feet above Ordnance Datum.

[An old note of this well gives the depth of the shaft as 115 feet, the rest being bored, and the water-level as about 50 feet down.]

			Thickness. Feet.	Depth. Feet.
[Alluvium.]	Made ground and silt, with vegetable remains		20	20
	Grey, clayey sand, with specks of phosphate of iron		1	21
[River] Gravel			6½	27½
London Clay, brown and blue (at 84 feet a thin layer of pebbles; lower down 3 layers of septaria; and at 99 feet a mass of wood pierced by *Teredo*)			77½	105
Woolwich and Reading Beds, 62 feet.	Mottled clays of many colours (mixed with light-coloured sand at 113 feet, and sandy at the very bottom)		29	134
	Light-brown sand and grey clay		1	135
	Grey clay and vegetable matter		2	137
	Grey clay, with a few shells (*Cyrena*?)		3	140
	Mottled clays of various colours (full of race at 146 feet)		8	148
	Sandy clays, partially mottled (brown and greenish) with flint-pebbles		7	155
	[Bottom-bed.]	Clayey, green sand, with pebbles and wood	2?	157
		Green sand, with larger pebbles	1	158
		Green sand (upper part bright) with a few pebbles and *Ostrea*	6	164
		Grey clayey sand, with a few *Ostrea bellovacina* at 167 feet, lower part darker, more clayey, and with more *Ostrea* at 169 feet [some error in figures ? should be 165 and 167]	3	167
Thanet Sand, 36 feet.	Grey sand, the upper part dark and greenish, the lower lighter		35	202
	Green-coated flints in clayey green-sand		1	203
[Upper] Chalk			164	367

Southwark—*continued.*

2. BANKSIDE—*continued.*

A slightly different account of this well is given in Sheet 3 of the "Section of Borings in the Metropolitan District," by J. PHILLIPS, (1849), as follows :—

		Thickness. Feet.	Depth. Feet.
Loose ground (21) over gravel (6½)...	...	27½	27½
Blue [London] clay ...	...	78½	106
[Reading Beds, 62 feet.]	Mottled clay ...	42	148
	Sand and pebbles ...	7	155
	Green sand and pebbles	7	162
	Green sand ...	5	167
	Black sand ...	1	168
[Thanet Sand, 35 feet.]	Grey sand ...	23	191
	Dead, black sand ...	12	203
To Chalk.			

For an analysis of the water *see* p. 315.

NEW WELL. 1871.

Sunk and communicated by MESSRS. DOCWRA & SON.

13·17 feet above Ordnance Datum.

Shaft (and cylinders) 211 feet ; the rest bored (10 inches diameter). Connected with the old well (disused) by a gallery, near the bottom of the London Clay.

Water-level 72½ feet down. (113 feet during pumping, April 1877, according to MR. J. LUCAS.) The following particulars as to water-level, &c., from A. R. BINNIE, Appendices R. Comm. Metrop. Water Supply, 1893, p. 164. In Nov., Dec., 1891, after standing 5½ hours, 98·83 feet below Ordnance Datum, after pumping 122·83. A loss of 42 feet in 25 years. (BINNIE.) Water-level fell to 160 feet below Ordnance Datum in 1911. (G. BARROW.)

Yield, in 1872, from 16,000 to 18,000 gallons an hour, pumps working day and night.

Water soft, the boilers being clean after being in use 14 years.

			Thickness. Feet.	Depth. Feet.
Made ground ...			15	15
[Alluvium, 20 feet.]	Black peat ...		3	18
	Blue bungham [? clay] ...		2	20
[Valley Drift, 7 feet.]	Sand ...		1	21
	Gravel ...		6	27
Blue [London] Clay ...			79	106
[Woolwich and Reading Beds, 59 feet.]	Mottled clay ...		4	110
	Sand ...		6	116
	Mottled clay ...		14	130
	Sand ...		3	133
	Dark, shelly clay ...		5	138
	Blue, shelly clay ...		2	140
	Mottled clay ...		4½	144½
	White sand and pebbles ...		3½	148
	[Bottom-bed.]	Green sand and pebbles	10	158
		Brown, sandy clay ...	4	162
		Blue, sandy clay ...	3	165
Grey [Thanet] Sand ...			37½	202½
[Upper] Chalk, with flints ...			235	437½

Southwark—*continued.*

3. Borough Road, 109–112. Messrs. R. Hoes, Printers' Engineers Works. 1908.

Made and communicated by Messrs. A. C. Potter & Co

4 feet above Ordnance Datum.

In the basement, about 10 feet below road-level.
Lined with 8-inch tubes to 197½ feet below the basement.
Water-level 66 feet below the basement.
Supply 5,000 gallons per hour.

		Thickness Feet.	Depth. Feet.
[River Gravel.]	Sand and gravel	7	7
	Gravel	11	18
	Ballast	7½	25½
[London Clay, 69½ feet.]	Blue clay	17	42½
	Blue clay and claystone	½	43
	Blue clay	20½	63½
	Blue clay and claystone	7	70½
	Blue clay	19½	90
	Pebbles, sand and shells [? Basement-bed].	5	95
[Reading Beds, 42 feet.]	Mottled clay	36	131
	Pebbles and sand	16	147
[Thanet Sand, 40 feet.]	Hard dead sand	39	186
	Flints	1	187
[Upper Chalk.]	Chalk	7	194
	Chalk and flints	23	217
	Hard grey chalk and flints	2½	219½
	Chalk and flints	134½	354

4. Deverell Street, near Great Dover Street. Messrs. Groves' Sawmills.

About 11 feet above Ordnance Datum.

Bore (lined with tubes for 120 feet), made and communicated by Messrs. Isler.

Water-level, 60 feet down. Supply abundant.

		Thickness. Feet.	Depth. Feet.
Dug well [old, through gravel and London Clay?]		—	49
[Reading Beds, 62 feet.]	Mottled clay	45	94
	Pebbles and green sand	17	111
Green, running [Thanet] sand...		39	150
[Upper Chalk], 129 feet.	Chalk	54	204
	Chalk and flints	16	220
	Chalk	59	279

5. Falcon Wharf. Central Pumping Station of the London Hydraulic Power Co., a little below Blackfriars Railroad Bridge. Sumph.

Communicated by Messrs. Ellington and Woodall.

15 feet above Ordnance Datum.

		Thickness. Feet.	Depth. Feet.
Made ground	... ...	12	12
[Alluvium.]	Silt	6	18
	Peat	4	22
[River Drift.]	Sand	2	24
	Ballast, the lower part coarse. To blue [London] clay	8	32

Southwark—*continued.*

6. Guy's Hospital. 1859.

B. Latham, *Trans. Soc. Engineers* for 1864, p. 245.

15½ feet above Ordnance Datum.

Shaft and cylinders 132 feet, the rest bored.

Water rose to a height of about 62 feet below the surface. In April, 1877, water stood within 80 feet of the surface, during deepening of bore. (J. Lucas, *Journ. Soc. Arts*, vol. xxv, p. 609.) In Nov., 1891, the water-level before pumping was 93½ feet below Ordnance Datum, and after pumping 114½. A loss of 47 feet in 32 years. (Binnie.)

		Thickness. Feet.	Depth. Feet
[Made ground, &c.]		8	8
[Alluvium, 6 feet.]	Yellow clay	2	10
	Black loam	1	11
	Peat	3	14
[River] Gravel		19	33
Blue [London] clay		63	96
[Woolwich and Reading Beds, 56 feet.]	Mottled clay	22	118
	Dark blue clay	4	122
	Shells and sand	5	127
	Mottled clay	10	137
	Sand and pebbles	4	141
	Mottled clay, green sand and pebbles	4	145
	[Bottom-bed.] Green sand and pebbles ...	4	149
	[Bottom-bed.] Green sand...	3	152
[Thanet Sand, 44½ feet.]	Grey sand	44	196
	Flints	½	196½
[Upper] Chalk (deepened in 1877)		239½	436

In "An Account of Guy's Hospital Well," by Prof. W. Odling, this section is given somewhat differently :—

Water-supply 40 gallons a minute.

		Thickness. Feet.	Depth. Feet.
Made ground (with some Roman remains underneath)		12	12
Peat (with clay, remains of bone and wood and fir-cones) [Alluvium] ...		2	14
[River] Gravel (with bones)...		20	34
London Clay (with septaria and shells)		63	97
[Woolwich and Reading Beds, 56 feet.]	Red and yellow mottled clays...	24	121
	Blue, shelly clays	6	127
	Hard, blue clay, with oyster-shells	1	128
	Red mottled clay	10	138
	Sands and clay with pebbles ...	15	153
Grey [Thanet] sand ...		44	197
[Upper] Chalk, with flints (with green-coated flints at top)		100½	297½

Sheet 3 of the "Sections of Borings in the Metropolitan District," by J. Phillips, 1849, gives the following section of this well: Made ground, &c., 31 feet; Blue clay, 100 feet. This is of course wrong.

The well has been disused for some time.

For analysis of the water *see* p. 307.

An account, presumably of an older work, is given by J. Browell in Rep., Commissioners Supply Water Metrop., 1828, p. 59. There was a well, with a spring [from gravel] 22 feet deep, and then a boring of 157 feet. The water from the boring rose to within 16 or 17 feet below the ground.

Southwark—*continued.*

7. Hibernia Chambers and Wharf, Montague Close. Just west of London Bridge. 1887.

16·8 feet above Ordnance Datum.

Made and communicated by Messrs. Isler (notes from specimens in the office in these brackets).

Shaft 12 feet, the rest bored.

Water-level 95 feet down. Yield 1,000 gallons an hour. Water-level in November, 1891, 43·17 feet below Ordnance Datum. A gain of 35 feet in 4 years; but the pumps worked only for 2 hours daily. (Binnie).

		Thickness. Feet.	Depth. Feet.
Made ground	...	12	12
[River] Gravel	...	9	21
Blue [London] Clay (brown at top, claystone)	...	77	98
[Woolwich and Reading Beds, 59 feet.]	Mottled clay (light-coloured and sandy, then less sandy) ...	9	107
	Blue silt (?mottled clay and grey, compact sand) ...	6	113
	Blue clay (mottled clay at 117) ...	6	119
	Green silt (mottled clay at 120; brown sand at 122) ...	6½	125½
	Clay and shells ...	5½	131
	Mottled clay ...	5	136
	Congealed ballast [pebble-conglomerate] (green sand) ...	6½	142½
	Green sand and pebbles ...	14½	157
Grey, running [Thanet] sand (green-goated flints at the base)	...	41½	198½
[Upper Chalk, 101½ feet.]	Chalk and flints ...	85	283½
	Very hard flints ...	3	286½
	Chalk and flints ...	13½	300

8. 22 Southwark Bridge Road (? Summer Street). Messrs. Potts' Vinegar Works. 1827.

Illustrated London News, January 2, 1847, p. 16.

About 12 feet above Ordnance Datum.

Shaft 40 feet, the rest bored.

?Water 15 feet down. In April, 1877, 91 feet down (J. Lucas).

Chalk not touched.

According to Mr. Braithwaite, *Proc. Inst. Civ. Eng.*, vol. ix., plate 7, Chalk was touched at 160 feet; but this is a mistake, for Sir A. R. Binnie records that in 1878 the shaft was sunk to the depth of 116 feet and the bore was deepened with the following result—

$$\left.\begin{array}{ll}\text{To Chalk} & 202\\ \text{In Chalk} & 234\end{array}\right\}\text{436 feet.}$$

The water-level, in Nov. Dec., 1891, was 103·33 feet below Ordnance Datum before pumping, and 119·45 after pumping. A loss of 22 feet in 13 years.

"The water is very soft, the boilers being free from deposit after being in use 12 years." Appendices R. Comm. Metrop. Water Supply, 1893, p. 164.

9. Southwark Bridge Road, South London Brewery (Messrs. Jenners').

Made and communicated by Messrs. Isler and Co.

Water-level 114½ feet down. Supply good (2,800 gallons an hour).

		Thickness. Ft. In.	Depth. Ft. In.
Dug well (the rest bored, 5 inches diameter, in the Chalk) ...	...	— —	15 0
[River Drift, 19 feet.]	Grey sand ...	12 0	27 0
	Ballast [gravel] ...	7 0	34 0
Blue [London] clay	...	75 0	109 0

Southwark—*continued.*

SOUTHWARK BRIDGE ROAD—*continued*

		Thickness. Ft. In.	Depth. Ft. In.
[Woolwich and Reading Beds, 56¾ feet.]	Mottled clay	22 9	131 9
	Stone	1 0	132 9
	Sand and mud	4 6	137 3
	Mottled clay and pebbles... ...	14 3	151 6
	Congealed [concreted] ballast ...	1 6	153 0
	Pebbles	0 9	153 9
	Sand and ballast	3 3	157 0
	Clay and pebbles	8 9	165 9
Green [Thanet] sand		37 5	203 2
[Upper] Chalk and flints		129 10	333 0

This section shows a curious likeness to another, at Bankside, near by. (No. 1, above.) There is, too, a general agreement with the sections at Barclay's brewery, also near by. (No. 2, above.)

10. BANKSIDE, Messrs. Sykes. 1902.

For details see *Geol. Survey. Memoir*, "London Wells." 1912.

16 feet above Ordnance Datum.

Water-level 122 feet down, 150 in 1910.

To Chalk 200 }
In Chalk 100 } 300 feet.

11. EXCHANGE AND HOP WAREHOUSE, Southwark Street, see p. 307.

Stockwell.

Ordnance Map 270, new ser. Geological Map, London District, Sheet 4.

1. STOCKWELL GREEN. British Brewery (Messrs. Walthams'). 1859, 1864.

From a drawing and from specimens in the possession of the Messrs. Waltham.

About 36 feet above Ordnance Datum.

Shaft for about 100 feet, the rest bored.

Water up to 46 feet below the surface of the ground. In 1866 before pumping, 59 feet below ground (LUCAS).

		Thickness. Feet.	Depth. Feet.
[River Drift] Gravel and sand		15	15
[London Clay, 122 feet.]	Blue clay	115	130
	Light-brown clay, with sand ...	7	137
[Woolwich and Reading Beds], 42 feet.	Light-grey, sandy clay, with shells	1	138
	Light-blue and brown mottled clay	3	141
	Brown clay with lignite, pyrites and shells	1½	142½
	Light-grey sand	½	143
	Dark grey clay, with shells and pyrites	1½	144½
	Light-blue and yellow mottled clay, with sand	2½	147
	Light-blue and yellow mottled clay	1	148
	Variously-coloured, mottled clay with hard, light-coloured, concretionary limestone	2½	150½
	Variously-coloured, red-mottled clay (3 beds)	8½	159
	Green and dark grey mottled clay and sand, with pebbles ...	½	159½

Stockwell—*continued.*

1. STOCKWELL GREEN. British Brewery—*continued.*

			Thickness. Feet.	Depth. Feet.
[Woolwich and Reading Beds], 42 feet—*cont.*	Blue, green and red-mottled clay with sand and many flint-pebbles		3½	163
	Bottom-bed.	Dark bright green sand, with pebbles	12	175
		Green and grey clayey sand, with pebbles and shells [?oysters] ...	4	179
[Thanet Sand], 31 feet.	Light-grey sand, with water ...		29	208
	Darker and more clayey sand		1	209
	Green-coated flints		1	210
[Upper] Chalk and flints			100	310

In "A Treatise on Waterworks," by S. HUGHES, new Ed., 1875, pp. 213, 214, the depth to the Chalk is made 192 feet, and the total 380.

2. 16 STOCKWELL GREEN. Stockwell Brewery.

Communicated by MESSRS. HAMMERTON & CO. Additional notes from J. LUCAS, *Journ. Soc. Arts.*, vol. xxv., p. 610.

About 31 feet above Ordnance Datum.

A shallow well with a bore. (Shaft 120 feet, LUCAS.)
Water-level after pumping, in 1869, within 49 feet of the surface. Supply 43,200 gallons [a day].

		Thickness. Feet.	Depth. Feet.
[River] Gravel		25	25
Blue [London] Clay ... ... about		75	100
Coloured Clay [partly London Clay and partly Woolwich Beds?] ... ... about		60	160
[Woolwich Beds.]	Hard stone	2½	162½
	Pebbles	7½	170
	Hard, white stone and shells	6	176
[Thanet Sand.]	Green sand (dead)	6	182
	Green sand, much water ...	14	196
	Grey sand	15	211
[Upper] Chalk (flints at top)		139	350

In 1903 another boring of 11½ inches diameter was made by MESSRS. ISLER & CO., in which 82 feet of the blue [London] clay were passed through and 187 feet of chalk and flints. Minimum yield 320,000 gallons a day and no variation of water-level on pumping! (*Daily Chronicle*, 7 March.) In 1904 the water-level was 77 feet down and the yield 11,000 gallons an hour.

3. STOCKWELL ROAD, Ingram House.

Made and communicated by MESSRS. ISLER & CO

About 20 feet above Ordnance Datum.

210 feet of tubes, 5 inches in diameter, from 9 feet down.
Water-level 90 feet down in 1911 (G. BARROW).
Supply tested to 1,000 gallons per hour.

		Thickness. Feet.	Depth. Feet
Made Ground		2	2
[Valley Drift, 24 feet.]	Marl [? loam] ...	6	8
	Ballast [gravel]	13	21
	Sand	5	26
[London Clay, 96 feet.]	Blue clay ...	88	114
	Green sand ...	8	122

Stockwell—*continued.*

3. Stockwell Road—*continued.*

		Thickness. Feet.	Depth. Feet.
[Reading Beds, 53 feet.]	Mottled clay ...	12	134
	Loamy sand ...	8	142
	Mottled clay ...	12	154
	Rock	3	157
	Sand and stones	10	167
	Green sand ...	8	175
Grey [Thanet] Sand		35	210
[Upper Chalk.]	Chalk	40	250
	Chalk and flints	100	350

The division between Reading Beds and Thanet Sand may be 8 feet higher.

Streatham.

Ordnance Map 270, new ser. Geological Map, London District, Sheets 3, 4.

1. Streatham Common. Messrs. Forster and Gregory's, Lonesome Chemical Works. 1899.

91 feet above Ordnance Datum.

Boring made and communicated by Messrs. Isler.

Lined with 80 feet of pipe, 10 inches in diameter, from 64 feet down.

Water-level 43 feet down. Supply 8,000 gallons an hour. In 1911 the water-level was about 60 feet down.

		Thickness. Feet.	Depth. Feet.
Well. Believed to be gravel and sand over blue clay		—	67
Blue [London] Clay		5	72
[Reading Beds, 28 feet.]	Mottled clay	16	88
	Green sands	12	100
Blowing [Thanet] Sands		29	129
[Upper Chalk.]	Chalk	8	137
	Chalk and flints	97	234

2. Streatham Common. 1823.

T. Yeats, *Trans. Geol. Soc.*, ser. 2, vol. ii., p. 135.

Sunk 100 feet, the rest bored.

		Thickness. Feet.	Depth. Feet.
Mould ...	... ...	2	2
[London Clay, 178 feet.]	Reddish-brown clay	32	34
	Septarium	1	35
	Blue clay, with shells and pyritous wood, somewhat sandy at bottom...	145 ?	180
[Woolwich and Reading Beds, 98 feet.]	Blue clay and broken shells	20	200
	Sandy, blue clay	5	205
	Ash-coloured, sandy clay	5	210
	Ash-coloured, yellow and blue clay ...	5	215
	Blackish clay, with coaly matter [lignite]	5	220
	Flint-pebbles	10	230
	Ash-coloured sand, above the hard water spring	5	235
	Mottled plastic clay	5	240
	Mottled plastic clay, with soft chalky particles [race]	6	246
	Red, green and yellow mottled plastic clay	10	256
	Green sand, with flint-pebbles ...	4	260
	Iron-pyrites and sand, very hard ...	5	265
	Green sand	13	278
Light-coloured [Thanet] sand, above the spring of soft water		7	285

Streatham—*continued.*

2. STREATHAM COMMON—*continued.*

The thickness given to the Woolwich and Reading Beds seems too great. Perhaps part of the highest bed belongs to the London Clay, or the lowest to the Thanet Sand.

The measurements are somewhat vaguely given; in the section the depth is made 280 feet and in the accompanying letter 285.

3. STREATHAM COMMON. Southwark and Vauxhall Water Co., 1882-1888. Field next L.B. & S.C. Railway, near Streatham Common Station (Manor Park Estate). Now Metrop. Water Board.

Communicated by MR. J. W. RESTLER, Engineer to the Company, and from specimens (Chalk and below).

110 feet above Ordnance Datum.

Shaft to 148 feet, lined with cylinders, which are continued down to 242 feet.

Water-level about 45 feet down. Large supply from the Thanet Sand and the top of the Chalk. The boring has been tested independently of the well, and with a difference of level of 40 feet yields about 1½ million gallons a day (letter of Feb., 1896). For an analysis of the water *see* p. 336.

			Thickness. Ft.	In.	Depth. Ft.	In.
Gravel and mud		...	10	0	10	0
[London Clay, 153 feet ?]		Yellow clay	6	0	16	0
		Blue clay, with clay-stones at 34, 59 and 67 feet	62	0	78	0
		Blue clay and sand, with clay-stones at 95 feet	25	0	103	0
		Claystone	1	0	104	0
		Blue clay, with clay-stones at 112, 116½ and 121 feet	22	0	126	0
		Blue clay and sand	33	0	159	0
	[Basement-bed, in part at least.]	Pebbles (water)	1	0	160	0
		Pebbles and shells	0	3 ?	160	3
		Conglomerate	0	6 ?	160	9
		Black clay and shells	0	9 ?	161	6
		Conglomerate	0	6 ?	162	0
		Hard conglomerate	1	0	163	0
[Woolwich and Reading Beds, ? 43½ feet.]		Black clay and shells	1	0	164	0
		Black clay and sand	0	4 ?	164	4
		Black clay and shells	? 3	0	167	4
		Hard shells	0	6 ?	167	10
		Black clay and shells	1	8 ?	169	6
		Hard layer of shells	0	3	169	9
		Oyster-shells	1	3	171	0
		Green sand	2	6 ?	173	6
		Mottled clay	2	6 ?	176	0
		Conglomerate. Shells and quartz	0	3 ?	176	3
		Clay, shells, and grey sand	5	6	181	9
		Sandy clay	1	3	183	0
		Black clay and shells	1	7 ?	184	7
		Mottled clay	19	5	204	0
		Hard, peaty clay and pebbles	0	6	204	6
		Clay, stones, and green sand	2	0	206	6
[Thanet Beds, 35 feet.]		Hard, green sand	4	6	211	0
		Very hard sandstone	0	6	211	6
		Dark sand, tinged with grey (water)	0	6	212	0
		Grey sand	12	9	224	9
		Black sand	2	8 ?	227	5
		Grey sand	13	1 ?	240	6
		Flints	1	0	241	6

Streatham—*continued.*

3. STREATHAM COMMON—*continued.*

		Thickness. Ft.	In.	Depth. Ft.	In.
	Flints, with little chalk. (Specimen, with one flint slightly green-coated.) ? Some doubt about this part ...	? 8	6	250	0
	Soft, white chalk, without flints ...	11	0	261	0
	Soft, white chalk, with flints every 2 or 3 feet (some specimens compact)	32	0	293	0
	Large flints, with but little chalk (white)	13	0	306	0
	Chalk (specimens white, and some hard), with beds of flints every 2 or 3 feet	32	0	338	0
[Upper Chalk, 198½ feet.]	Very hard, grey chalk (specimens white), with flints	8	0	346	0
	Very hard, grey chalk, with hard stone or boulders. (Specimens white, and some very hard)	23	0	369	0
	Very hard chalk, with stone like limestone (specimens white, one hard)...	15	0	384	0
	Very hard, grey chalk, with dark dirty (clayey in specimen) partings. (Specimens white, with flints)	25	0	409	0
	Very hard (firm) grey chalk, with stone or chert	31	0	440	0
[Passage-beds and flints) ...	Chalk Rock.] (Specimen of chalk and	23	0	463	0
	Hard, grey chalk, with dark (grey) partings, mixed with stone or chert. (Many specimens; one, from 525 feet, bedded)	69	0	532	0
	White chalk, much softer. (Specimens firm)	19	0	551	0
	Hard chalk	19	3	570	3
[Middle Chalk, 219 feet.]	Hard, grey chalk, with dark partings	48	9	619	0
	Hard chalk, with dark partings and fossils...	27	0	646	0
	Very hard, stony chalk	22	6	668	6
	Very hard, stony chalk, with fossils ...	2	0	670	6
	Hard and rather green chalk, with few fossils. (Specimens with irregular greenish clayey partings) ? Melbourn Rock	11	6	682	0
	Very hard chalk, with green partings	10	6	692	6
	Chalk, softer, working up into pipe-clay	35	9	728	3
	Hard, grey chalk, working up into stiff pipe-clay	57	6	785	9
	Dark grey chalk, very hard, working up into pipe-clay	21	3	807	0
[Lower Chalk, 182½ feet.]	Dark, marly chalk, working into a stiff putty. (Specimens from 786 to 840 were greyish, and some with curved, marly fracture)	3	0	840	0
	Chalk Marl, or Gault clay, with shells. (Specimens marly chalk or grey Chalk Marl)	14	0	854	0
	Very hard marl rock band. (Specimen hard, grey chalk)	1	0	855	0
	Chalk Marl or Gault clay. (Specimen hard, grey Chalk Marl, more sandy than that above)	9	6	864	6

Streatham—*continued.*

3. Streatham Common—*continued.*

		Thickness. Ft.	In.	Depth. Ft.	In.
[Upper Greensand, 28½ feet.]	Specimens of light grey (rather greenish) calcareous sandstone, with glauconite-grains; sometimes grains of mica; varying slightly	24	6	889	0
	Specimens, much the same as the above; grey, calcareous sandstone, with small, blackish glauconite-grains and small grains of mica	4	0	893	0
Gault, 188½ feet.	Clay, Specimen, from top, hard, with green grains and a phosphatic nodule	8	0	901	0
	Greensand, probably only a thin layer, as a specimen from 933 is hard clay	6	6	907	6
	Hard clay (specimen firm)	29	9	927	3
	Clay. (Specimens at 940, 960, 980, 1,000, 1,020, 1,040, 1,050, and below, all firm; with phosphatic nodules at 1,068, a layer at 1,070, and at the base	154	3	1,081	6
[Lower Jurassic Beds, (? Forest Marble), flat-bedded, 38½ feet.]	Hard, grey and cream-coloured limestone, mostly crowded with oolitic grains of fair size, with bits of shells. Signs of plant in a trace of clay. At 1,083 softer, with oolitic grains dissolved out. *Ostrea acuminata*? at 1,086½	? 8	6	1,090	0
	Greenish-grey, sandy rock, softest at the base	1	0	1,091	0
	Hard, grey, calcareous sandstone ...	1	6	1,092	6
	? Clayey layers lost. Limestone, with oyster-shells, at 1,094	2	6	1,095	0
	Greenish-grey, sandy clay, with *Ostrea acuminata* and a small Crustacean claw	2	0	1,097	0
	Harder specimen at 1,098; but apparently softer rocks missing. Clay at the bottom	10	0	1,107	0
	Clay, with hard bands				
	Clay, with oolitic grains, more numerous in the lower part				
	More like limestone, less granular ...	6	0	1,113	0
	Impure limestone, with fragments of shells				
	Clay, with oolitic grains				
	Clay				
	Clay, with *Astarte*				
	„ „ fossils (2 specimens) ...				
	„ „ shells				
	More sandy clay				
	Clay (2 specimens)				
	Sandy clay	7	0	1,120	0
	Clay, with small (phosphatic?) nodules (2 specimens)...				
	Clay, much harder, calcareous ...				
	Clay, with hard beds, harder at the base				
	Oolitic limestone				

Streatham—*continued.*

3. Streatham Common—*continued.*

		Thickness. Ft.	In.	Depth. Ft.	In.
	Pale greenish-grey, compact, calcareous sandstone; mottled reddish and purplish lower down; then with purplish bands, showing a dip of 20°. Probably about 8 feet missing (? clays)	10	0	1,130	0
	Greenish-grey sandstone, mottled purplish then reddish. Probably about 10 feet missing	17	0	1,147	0
	Dull reddish-purple, hard, sandy clay				
	Grey sandstone, mostly calcareous, with thin veins of calcite				
	Greenish-grey sandstone, with some purplish mottling and veins of calcite				
	Greenish-grey and red-mottled sandstone	6	0	1,153	0
	Greenish-grey, bedded sandstone, with iron-pyrites in the upper part and with purplish bands in the lower (dip 35°)				
	All these are more or less micaceous. ? 2 feet missing				
	Hard, purplish, clayey rock. Many feet missing	7	0	1,160	0
	Greenish-grey, calcareous sandstone ...				
Beds of doubtful age. Grey, reddish and purplish beds, 151 feet. Mostly with a tendency to break along planes at 20° to 30° dip.	Greenish-grey sandstone, mostly calcareous, clayey at the base. Only 14 inches of core?	15	0	1,175	0
	Dark dull reddish, clayey and sandy rock. Then somewhat mottled with dark grey, and breaking unevenly. A little pyrites. Small calcareous nodules at about 1,180?				
	Dull reddish, fine-grained sandstone, mottled with pale-grey, Then more of the grey. Small calcareous concretions. Then a reddish mass. Then grey, with reddish bands in bedding-planes. About half missing	15	0	1,190	0
	Reddish clayey rock, with about 6 inches of a nodular character (?) at bottom, and greenish-grey rock. About 5 feet of core...	14	0	1,204	0
	Hard, greenish-grey, micaceous sandstone, partly calcareous, and reddish, clayey, micaceous rock. About 5 feet of core	8	0	1,212	0
	No specimens seen	12	0	1,224	0
	Red, clayey rock, with greenish-grey in the midst, partly nodular below. 4 feet of core...	14	0	1,238	0
	No specimens seen	12	0	1,250	0
	Grey, micaceous sandstone, here and there with reddish bands. About 1,255 feet with fish-remains (?) ...				
	Grey and red rock, as above; a few inches	8	0	1,258	0
	Light-grey, coarse, very micaceous sandstone, with black carbonaceous patches; about 20 inches				
The boring was brought up ...	continued, but the core was not	13	0	1,271	0

Streatham—*continued.*

3. STREATHAM COMMON—*continued.*

MR. E. T. NEWTON carefully examined the cores beneath the Gault, as they came to hand, and the above description is chiefly from his notes.

The following notes of the microscopical structure of specimens from the Chalk have been contributed by MR. WILLIAM HILL :—

Between 346 and 369. "A chalk with much character, not unlike Chalk Rock in some respects."

"The chalk at 423 and 450 feet contains well-defined, but rather small, grains of glauconite, like those met with in the Chalk Rock."

In a specimen from 460 feet MR. HILL recognises "the peculiar structure of Chalk Rock."

"485. Probably the top of the zone of *Terebratulina gracilis*, in the beginning of the passage to the Chalk Rock. Specimens from 495, 505, 515, 525 and 532 are all ordinary *Globigerina*-chalk of the zone of *T. gracilis.*"

"640. Zone of *Rhynchonella Cuvieri* probably. In this, and in the following, single Foraminiferal cells are very abundant."

"From 650 to 682 the structure is that which characterises the basal part of the Middle Chalk. The presence of many, coarse, shelly fragments (prisms of *Inoceramus*) at 670, 675 and 682 indicates a close approach to the horizon of the Melbourn Rock."

"The change, at 695, to Grey [Lower] Chalk is well marked, the cells being nearly lost."

"At 780 green grains (glauconite) occur, and the structure is like that of the Chalk Marl of Hitchin. This continues to 840."

"At 864 almost entirely sand and green grains (glauconite), with a little mica."

The fossils from the Gault, chiefly determined by MR. G. SHARMAN, are as follows, with the depths at which they occurred :—

Ammonites auritus, 1,048, 1,070.
,, rostratus? 1,065.
,, varicosus, 1,065.
,, sp., at the base.
Belemnites ultimus, 1,068.
,, sp., 1,070.
Dentalium, 1,070.
Inoceramus concentricus, 1,070, and at the base.
,, sulcatus, 1,065, 1,070.
Nucula pectinata, 1,070.
Coral, 1,070.

An account of a trial-boring (1881?) differs somewhat in details, and the small shaft with which it began passed through the following :—

Mould, a foot; soil, 2 feet; gravel, 5½ feet. This boring was carried to a depth of over 200 feet.

4. VARIOUS WELLS. J. LUCAS, *Journ. Soc. Arts*, vol. xxv., p. 611.

All overflowed.

	Height. Feet.	Depth. Feet.
St. Clement's Dane's Almshouses	42	155, into grey sand.
Mr. Robinson's Cottages, close to the above	35	150 ,, ,,
Blackshaw Lane, back of cottages	32	150 ,, ,,
Rollison's Nursery	58	128, to sand.

Sutton.

Ordnance Map 270, new ser. Geological Map, London District, Sheet 3.

1. THE ARCHES; at the northern edge of the village.

Sunk and communicated by MESSRS. T. DOCWRA & SON.

		Thickness. Feet.	Depth. Feet.
[London Clay, 168 ft.]	Blue clay ...	1½	1½
	Stone [septaria]	1	2½
	Blue clay ...	164½	167
	Stone	1	168
[? Reading Beds.]	Dark sand ...	10	178
	Blue clay ...	16	194

Sutton—*continued.*

2. SUTTON COMMON. Southfields.
About 125 feet above Ordnance Datum.
Communicated by MR. E. LOCKE.

Water rose to within 17 feet of the surface.

		Thickness. Feet.	Depth. Feet.
Soil ...		½	½
London Clay, with bands of septaria in the upper part ...		288	288½
[Reading Beds.]	Mottled red and blue plastic clay; with mottled yellow and green, and yellow and brown, sandy clays, and a little fire-clay ...	28½	317
	Traces of shells [? oyster-shells].		
[? Reading Beds and Thanet Sand.]	Live, grey sand, with fine, compact and partially concretionary sand below ...	32	349
	Flints.		

I should think that the top part of the sand probably belongs to the Reading Beds, the Thanet Sand not reaching 30 feet in thickness here.

3. BELMONT ASYLUM, formerly South Metropolitan District Schools. North of California Railway Station.

Information from the school-authority and from other sources.

Two wells in the disused northern (or main) block, 16 feet apart. About 280 feet above Ordnance Datum. All chalk.

Older well 150 feet deep. Galleries, 6 feet high, 7 feet above the bottom, north and south, short. In E. corner of S. gallery a strong spring. Connecting gallery to newer well, about 11 feet above the bottom, slopes up to the newer well. Horizontal connecting bore-hole to newer well 147 feet down.

Newer well 211 feet deep. At 139 feet down gradually enlarged (in 25 feet) from 6 feet diameter to 12, and kept at that size to the depth of 201½ feet (to form a reservoir); then abruptly decreased to 6½ feet diameter. Then a 12-inch borehole to the further depth of 100 feet, making 311 in all. The boring through chalk with layers of flints, until about 20 feet from the bottom, when a bed of black flint 3 feet thick was found, and after this soft chalk. The boring yielded very little water.

When this well was finished the water gushed up and the workmen had to leave their tools. This was in 1863, the year before the Sutton Waterworks were established. Later the yield decreased.

DR. S. M. COPEMAN, in a Report to the Local Government Board on an outbreak of Enteric Fever, October, 1906, says :—

"To about the end of the first week in May last, the water from the Asylum wells had been used exclusively, the Sutton water being regarded merely as a reserve," but "all water has since been drawn from the mains."

The result of the enquiry was to free the water, of both supplies, from blame.

I was informed long ago that the normal water-level was 122 feet down, and that 15,000 gallons of water were pumped in 7 hours. Also that on stopping pumping on 27th November (? 1892) the water-level was over 139 feet down.

4. SUTTON STEAM LAUNDRY. Benhill Street.
130 feet above Ordnance Datum.
Communicated by MR. HAROLD GOUGH, the proprietor.

Diameter of bore in chalk, 4 inches. Yield not tested; about 400 gallons an hour used. Water-level varies; not more than 20 feet down.

		Thickness. Feet.	Depth. Feet.
[London Clay, Reading Beds, Thanet Sand.]	Dug well (the rest bored); mottled clay with gravelly stones ...	15	15
	Clay (? mottled in part) ...	100	115
	Greenish sand ...	15	130
	Sands and some hard band ...	19½	149½
	Flints ...	½	150
[Upper] Chalk and flints ...		50	200

Sutton—*continued.*

5. WATERWORKS. Carshalton Road. In old Chalk-pit.

Information chiefly from MR. W. V. GRAHAM.

About 150 feet above Ordnance Datum.

Old wells 35 to 40 feet deep, in Chalk. New well 129 feet, with a boring (unproductive) 348 feet deep.

I was told by MESSRS. EASTON and ANDERSON, in 1890, 1891, that the new well was lined to a depth of 83 feet, so as to exclude water from above, and that only 2 gallons of water a minute were got until a small horizontal parting was reached, at the depth of 103 feet. From this a vertical fissure went down to another horizontal parting, at the depth of 109 feet. This parting yielded 70 gallons a minute, and then the small parting at 103 feet and the vertical fissure ceased yielding. Nothing further was got to the depth of 129 feet, when a fissure was met with in the bottom of the well, yielding 180 gallons a minute, which, with the 70 gallons from above, mastered the temporary pumps.

Western heading, extended from 176 to 472 feet in length in 1898. Eastern heading 123 feet long. New headings (1902) 167 feet. Total 762 feet. Of these the western and eastern have their bottoms 112 feet above Ordnance Datum, whilst of the new heading a length of 112 feet has the bottom 101 feet above Ordnance Datum and a length of 55 feet has the bottom 68 feet above Ordnance Datum.

The average quantity pumped in 24 hours in the year 1909 was 1,307,502 gallons.

There are newer works at Woodmansterne, *see* p. 260.

The following places are within the area of control ;—Banstead, Beddington, Carshalton, Cheam, Cuddington, Ewell, Kingswood, Morden, Sutton, Wallington, Woodmansterne, a district of about 37 square miles. Population supplied estimated at 75,000.

The yearly supply for all purposes (1910) was 653,517,130 gallons, the maximum day's consumption having been 2,225,394 gallons, in June, 1906.

The water is now softened, down to 9° of hardness.

For analyses of the water *see* pp. 308–310.

6. LUCAS notes 4 Chalk-wells in the parish, *Proc. Inst. Civ. Eng.*, 1877, vol. xlvii., pp. 102, 103.

Sydenham.

Ordnance Map, 270, new ser. Geological Map, London District, Sheet 4.

Sydenham is really in Kent: so probably these places are not really in that parish, as they are all given as in Surrey.

1. SYDENHAM COMMON [?=Penge Common]. Near the Croydon [L.B.S.C.] Railway.

D. ALLPORT, *Geologist*, 1842, p. 66.

Chiefly in blue [London] clay.

Lighter, sandy soil at a depth of 115 feet.

Then a conglomerate of broken shells, about 1½ feet. With tooth of *Lophiodon*.

[? Blue clay again] to a depth of about 240 feet.

Then black gravel and sand [Blackheath Beds or Woolwich Beds?], with a fine spring.

2. For details of the following *see* Geol. Survey Memoir "London Wells," 1912."

a. LOWER SYDENHAM. South Suburban Gas Co. 1908.

66 feet above Ordnance Datum.

Water-level 16 feet down. Yield 2,000 gallons an hour.

To Chalk	204	209 feet.
In „	5	

Sydenham—*continued.*

b. South Sydenham. South Metropolitan Light and Power Co. 1904.
270 feet above Ordnance Datum.

Water-level 218 feet down. Yield 800 gallons an hour.

To Chalk 414 } 513 feet.
In „ 99 }

Tandridge.

Ordnance Map 286, new ser. Geological Map 6.

Lucas notes 3 wells in Lower Greensand. *Proc. Inst. Civ. Eng.*, 1880, vol. lxi., pt. iii.

Tatsfield.

Ordnance Map 287, new ser. Geological Map 6.

Limpsfield and Oxted Water Co. About 700 yards N.W. of Westwood Farm. Three borings.

The following probably refers to No. 1 (? trial), near the south-western corner of the engine-house, 1900. From a statement furnished by the foreman to Mr. Landale (Chairman).

(All below 305 feet and all in these brackets communicated by Mr. R. F. Grantham.)

When the boring was 296½ feet deep, water stood at the depth of 89 feet. On Nov. 17th, 1900, when over 305 feet deep, the water was 86½ feet. On Dec. 14th, the water was 78 feet down (end).

10,000 gallons an hour, day and night, were pumped for a fortnight, and Mr. Grantham thinks that more could have been got with a permanent pump (Aug., 1901).

		Thickness. Ft.	in.	Depth. Ft.	in.
Soil, clay and loam mixed		10	0	10	0
[Gault.]	Blue clay	41	6	51	6
	Loamy sand (clay)	15	0	66	6
[Folkestone Beds, 211 feet.]	White sand (water first met with at 89 feet)	26	0	92	6
	Pale yellow sand (buff)	37	6	130	0
	Yellow sand	20	0	150	0
	Rock, hard (ironstone)	1	6	151	6
	Yellow sand	12	6	164	0
	Rock, hard (ironstone)	1	0	165	0
	Yellow sand	19	0	184	0
	Pale yellow fine sand (buff)	41	0	225	0
	Yellow sand, a shade coarser (darker buff)	40	0	265	0
	Dark yellow sand	12	6	277	6
[? Sandgate Beds.] Blue clay (dark) and green sand, mixed		6	6	284	0
[Hythe Beds.] Hard rock [specimen simply dark sand, not rock]		66	0	350	0

An account from Messrs. Isler & Co. differs in details, making the thickness of the Gault and of the Sandgate Beds a little less, that of the Folkestone Beds and of the Hythe Beds a little more. This perhaps may refer to No. 2.

Further information from Mr. A. F. Phillips (1910).

No. 2 is over 50 yards northward of No. 1, and the section would probably be much the same. From these two borings a total of 26,000 gallons of water an hour was got.

No. 3 is about 75 yards S. of W. from No. 1, and therefore should show a greater thickness of Gault. It is 18 inches in diameter and 455 feet deep.

Rock met with at the depth of 275 feet [? Folkestone Beds]. Below this largely rock and green sandstone.

Yield, on a three days' test, about 11,000 gallons an hour, in addition to that from the other borings.

Thames Ditton.

Ordnance Map 270, new ser. Geological Map, London District, Sheet 3.
a little S. of the Thames. 1879. Now Metrop. Water Board.

LAMBETH WATER WORKS. Trial-boring. Western side of Filter-bed, and

Ground-surface of Engine-yard over 35½ feet above Ordnance Datum.

Communicated by MR. J. TAYLOR, Engineer to the Company.

Water rose to the surface.

		Thickness. Feet.	Depth. Feet.
Top soil and loam		2	2
[River] Gravel		20	22
London Clay		263	285
[Woolwich and Reading Beds, 74½ ft.]	Mottled clay	50	335
	Very fine sand	6	341
	Sandy, mottled, clay	5	346
	Dark green, sandy clay	13½	359½
[Thanet Sand, 25½ ft.]	Coarse sand, full of water	20½	380
	Dark, loamy sand	3	383
	Green, sandy clay, and red mottled clay	2	385
	Layer of flints. To Chalk.		

MESSRS. DOCWRA have given me a slightly different version, as follows :—

		Thickness. Feet.	Depth. Feet.
Surface soil		6½	6½
[River Drift.]	Loamy sand	8	14½
	Gravel	14	28½
Blue [London] Clay		234½	263
Brown sand [? partly belonging to London Clay]		51	314
[Woolwich and Reading Beds.]	Sandy, mottled clay	6	320
	Sandy clay	7	327
	Red mottled clay	3	330
	Green, sandy clay	9½	339½
[Thanet Beds.]	White sand	17½	357
	Dark green, sandy clay	8	365
Chalk		17	382

The total should be 402. Perhaps therefore the thickness assigned to the London Clay has been wrongly copied, 234 instead of 254.

Thornton Heath, *see* Croydon.

Thorpe.

Ordnance Map 269, new ser. Geological Map 8.

HOLLOWAY SANATORIUM. Less than a quarter of a mile N.N.E. of Virginia Water Station. 1884.

120 feet above Ordnance Datum.

Sunk and communicated by MESSRS. TILLEY.

Shaft 115 feet ; the rest bored.

Water-level (from the Chalk) about 40 feet down ; but the yield, at 360 feet, not more than 2 gallons a minute.

		Thickness. Feet.	Depth. Feet.
[Lower Bagshot Sand, and passage-beds into London Clay ?]		110	110
[London Clay.]	Clay, with beds of stone [septaria], pebbles and pyrites	325	435
	Sandy clay, and vein of hard stone	4	439

Thorpe—*continued.*

HOLLOWAY SANATORIUM—*continued.*

		Thickness. Feet.	Depth. Feet.
[Reading Beds, 86 ft.]	Mottled clay ...	32	471
	Dirty sand, beds of clay, and some water ...	20	491
	Sand ...	2	493
	Sand rock and water...	$9\frac{1}{2}$	$502\frac{1}{2}$
	Live sand ...	$1\frac{1}{2}$	504
	Dark clay, with brown spots ...	13	517
	Clay, with veins of sand, and some chalk ...	8	525
[Upper] Chalk	...	275	800

Thursley.

Ordnance Map 301, new ser. Geological Map 8.

1. Boring, made and communicated by MESSRS. DUKE and OCKENDEN. 1910.

6 inches diameter to 100 feet, $4\frac{1}{2}$ inches to $144\frac{1}{2}$ feet. Sand-screen at bottom. Water-level 123 feet down. Surface-water, 9 to 15 feet down.

		Thickness. Feet.	Depth. Feet.
[Lower Greensand.]	Sand and stone ...	2	2
	Yellow sand...	7	9
	Running sand ...	6	15
	Dry sand-rock ...	62	77
	Hard sand-rock ...	1	78
	Dry sand-rock ...	54	132
	Softer sand, with water	22	154

Probably for the most part, and perhaps altogether, Hythe Beds, the village being at the junction of this division with the Folkestone Beds.

2. For VISCOUNT COLVILLE. On the road to Hindhead, 70 yards west of Cosford Mill.

Made and communicated by MESSRS. LE GRAND and SUTCLIFF.

220 feet above Ordnance Datum.

Water-level $2\frac{1}{2}$ feet down.

	Thickness. Feet.	Depth. Feet.
Red sand and bands of ironstone ...	27	27
Buff sand and ironstone ...	9	36
Buff sand and thin bands of yellow clay ...	$8\frac{1}{2}$	$44\frac{1}{2}$
Buff sand and bands of ironstone ...	$67\frac{1}{4}$	$111\frac{3}{4}$
Fine sand and bands of ironstone ...	$44\frac{3}{4}$	$156\frac{1}{2}$
Buff sand, ironstone and clay ...	32	$188\frac{1}{2}$
Dark grey and green sandy clay ...	$1\frac{1}{2}$	190
Blue clay and sandy clay ...	$19\frac{3}{4}$	$209\frac{3}{4}$
Grey sandstone. Water rose to 2 feet 8 inches [from the surface] ...	3	$212\frac{3}{4}$
Grey sandstone and green clayey sand ...	$26\frac{3}{4}$	$239\frac{1}{2}$
Green sand, clay and bands of sandstone ...	$15\frac{1}{2}$	255
Greenish sandy clay ...	3	258

All or nearly all Hythe Beds. There may be a little Folkestone Beds at the top, and the lowest bed may be Atherfield Clay.

The analysis on p. 310 may be of water from this well.

3. LUCAS notes 3 wells in Lower Greensand in this parish. *Proc. Inst. Civ. Eng.*, 1880, vol. lxi., pt. iii., p. 218.

Tilford, *see* Farnham.

Titsey.

Ordnance Map 287, new ser. Geological Map 6.

By road and brook just north of South Green.

From Mr. Topley's MSS. Shaft.

Gault [clay] over 100 feet.

At 106 feet the rock-bed [base of Gault] was broken through, and then water burst up, rising to a level of 30 feet below the surface. The level never varied, and the water was good.

Tooting.

Ordnance Map 270, new ser. Geological Map, London District, Sheet 3.

1. The Anglo-American Laundry. Burmester Road, Sommers Town. 1905.

Made and communicated by Messrs. Isler & Co.

Dug well 6 feet (the rest bored).
300 feet of tubes 8½ inches in diameter from 5½ feet down.
244 „ „ 10 „ „ „ 60¼ „ „
Water-level 14 feet down.

		Thickness. Ft.	in.	Depth. Ft.	in.
Made ground		0	9	0	9
[River Drift] Sand and gravel		12	3	13	0
Blue [London] Clay; with claystone, from 36 to 37 feet, from 92¼ to 93¾, from 100 to 100¾, and from 159¾ to 160¾		187	0	200	0
[Woolwich and Reading Beds, 61 feet.]	Green sandy clay and pebbles	1	6	201	6
	Hard brown sand	12	0	213	6
	Congealed [cemented?] pebbles	1	0	214	6
	Grey sandy clay	19	0	233	6
	Yellow mottled clay	5	0	238	6
	Red and yellow clay	18	0	256	6
	Hard shell and flints	1	6	258	0
	Green sand and pebbles	3	0	261	0
[Thanet Sand, 39½ feet.]	Dark sand	2	6	263	6
	Hard sand	39	0?	303	?
[Upper] Chalk and Flints		97	10	400	10

2. Various Wells.

J. Lucas, *Journ. Soc. Arts*, vol. xxv., pp. 611, 612 (with some further particulars). All overflowed?, and all reached the Chalk. The figures stand for feet.

——	Level above O.D.	To Chalk.	In Chalk.
Parker's Nursery, 1864	45	126 to and in Chalk.	
Fountain Road, 1864	40	100	15
„ „ Mr. Gardner's	38	121	10
Lambeth Cemetery	40	135	10
Martin's Brickfield	40	about 145	5
Lane's Cottages	48	142	12
Wallace's Cottages	56	138	15
The Limes	54	130	10
Eldon House	60	144	12
Defoe Road, Shellard's	49	100	16
Brewer's Cottages	48	126 to and in Chalk.	
Atlee's Brewery, 1874. Supply plentiful. (The alternative figures from the sinker, Mr. Eastell)	52	116 (or 114)	1 (or 14)
Stevenson's	58	124	4
Bett's, opposite the Castle Inn	53	126	10
Park House	56	149	1
Mr. Gibson's, about 1868	58	210	20

Tooting—*continued.*

2. Various Wells—*continued.*

The following did not reach the Chalk; but all overflowed, except that at the Trafalgar Arms :—

——	Level above O.D.	Depth.	——
Bell's Farm	45	80	To grey sand.
The Fountain Inn	46	90	20 feet into sand.
Betts' Cottage	55	95	To sand.
The Trafalgar Arms (disused)...	60	130	" "
The Britannia Inn	59	136	" "
Defoe Road, No. 1	52	80	" "
Williamson's	54	113	" "
Near the Church, 1822 * ...	58	130	" "
The Rectory. Shaft 20 feet ...	—	170	14 feet in grey sand.

* E. W. Brayley in his History of Surrey, vol. iii., 1850, p. 489, says that in 1823 an artesian well was made for the parish, by the churchyard. It was about 130 feet deep, and yielded an abundant and constant supply, at the rate of about 130 gallons a minute.

3. For the well at the Ranelagh Laundry, Garratt Green, *see* 'London Wells,' *Mem. Geol. Survey*, 1912.

Vauxhall, *see* Lambeth.

Waddon, *see* Croydon.

Wanborough.

Ordnance Map 285. Geological Map 8.

1. Lucas notes 3 Chalk wells in the parish. *Proc. Inst. Civ. Eng.*, 1877, vol. xlvii., p. 97.
2. Also 3 wells in Lower Greensand. *Ibid*, 1880, vol. lxi., pt. iii., p. 219.

Walworth, *see* Camberwell.

Wandsworth.

Ordnance Map 270, new ser. Geological Map 1, London District, Sheet 3.

1. High Street. Public Baths.

20 feet above Ordnance Datum.

Made and communicated by Messrs. A. C. Potter & Co. 1901.

Bore 11 inches in diameter.
Water-level 130 feet down when made, in 1911 nearly 200 feet down.
Supply 8,000 gallons an hour when made, now (1911) 6,600 continuously.

		Thickness. Feet.	Depth. Feet.
Made ground	... ...	6	6
[River Drift.]	Sand and ballast	6	12
[London Clay, 172½ feet.]	Blue clay, with claystones at the depths of 29 to 29½, 50 to 50¼ feet	38¼	50¼
	Clay	45¾	96
	Loamy clay, 6 inches of claystone at the bottom	9	105
	Clay	68	173
	Sandy clay	10½	183½
	Hard pebbles and shells [basement-bed]...	1	184½

Wandsworth—*continued.*

1. HIGH STREET—*continued.*

		Thickness. Feet.	Depth. Feet.
[Woolwich and Reading Beds, 60½ feet.]	Clay and shells	8½	193
	Mottled clays, brown, yellow, red and grey (four beds)	34	227
	Grey sandy clay	6	233
	Pebbles and sand	11	244
	Clay and pebbles	1	245
[Thanet Sand, 30½ feet.]	Dead sand	9	254
	Sand	12	266
	Loamy sand	9	275
	Green-coated flint	½	275½
[Upper Chalk.]	Dense chalk and flints	96	371½
	Soft chalk and flints, water-bearing	79½	451

2. SOMMERS TOWN. Overflowing Wells.

J. LUCAS. *Journ. Soc. Arts*, vol. xxv., p. 611.

Sir J. Dunstan's, 31 feet above O. D., 195 feet ?, to grey sand.
Sadler's Cottages, 32 ,, ,, ,, 150 ,, ,, ,,

Mr. E. A. TURNER tells me that the first of these is at a disused public-house, the Sir Geoffrey Dunstan.

3. WANDSWORTH BREWERY. High Street. Messrs. Young and Bainbridge.

Communicated by MR. W. B. CARMICHAEL.

18½ feet above Ordnance Datum.

Shaft 170 feet, the rest bored,

Height of water about 30 feet down ; but must have been lowered since, being 70 feet down in 1877, according to J. LUCAS, *Journ. Soc. Arts*, vol. xxv., p. 614. Loss of 40 feet.

		Thickness. Feet.	Depth. Feet.
[London Clay, 170 feet.]	Yellow clay	12	12
	Blue clay	158	170
[Woolwich and Reading Beds, 66 feet.]	Black clay, sand and shells	20	190
	Mottled clay	41	231
	Yellow clay (pebbles)	5	236
[Thanet Sand, 38 feet.]	Green sand, passing into dark sand	36	272
	Flint	2	274
[Upper] Chalk	... ...	60	334

Deepened to 600 feet in 1898, by MESSRS. BAKER.

4. WANDSWORTH COMMON. Surrey County Lunatic Asylum. 1840.

MR. LAPIDGE, *Geologist*, vol. ii., p. 20 (1843), and PRESTWICH, *Quart. Journ. Geol. Soc.*, vol. x., p. 140.

87–28 feet above Ordnance Datum.

Shaft 222 feet. Water rose to within 26 feet from the surface. In May, 1873, after a rest, it stood at 43 feet. In 1891 the water-level was 18·28 above Ordnance Datum, before pumping, and 9·72 below Ordnance Datum after pumping. A loss of 43 feet in 51 years. (BINNIE.) A newer well gets its supply from the Thanet Sand [?]. (J. LUCAS, *Journ. Soc. Arts*, vol. xxv., pp. 600, 614.)

		Thickness. Feet.	Depth. Feet.
London Clay, 231 feet.	Yellow clay, with veins of sand ...	20	20
	Clay, with large claystones	211	231
Woolwich and Reading Beds, 60 feet.	Sand, with clay and shells	6½	237½
	Dark sand	4	241½
	Shelly rock	5	246½
	Brown sand	1½	248

Wandsworth—*continued.*

4. Wandsworth Common—*continued.*

		Thickness. Feet.	Depth. Feet.
Woolwich and Reading Beds, 60 feet—*cont.*	Sand and clay	2	250
	Mottled plastic clay	4	254
	Sand and clay	2	256
	Dark sand and shells	5	261
	Light-coloured sand	1	262
	Dark sand	2	264
	Sand and clay	1	265
	Pink and yellow mottled clay ...	4	269
	Light-brown and white clay ...	4	273
	Dark red and white clay	4	277
	[Bottom-bed]: Chalk [? race] and pebbles ...	1	278
	[Bottom-bed]: Green sand ...	3	281
	[Bottom-bed]: Variegated green and brown sand	6	287
	[Bottom-bed]: Green sand ...	4	291
Thanet Sand, 40½ feet.	Brown sand, with water, which rose to within 36 feet of the surface ...	5	296
	Fine, dark grey sand	33	329
	Sand and pebbles [?], from which water rose to within 28 feet of the surface	2	331
	A hard bed [? green-coated flints] ...	½	331½
Chalk... ...	Chalk*	1½	333
	Flints*	4	337

It has been suggested that some of the beds classed as Woolwich and Reading (by Prestwich) may belong to the basement-bed of the London Clay.

* "The 'chalk' is probably merely some calcareous bed overlying a thick mass of the green-coated flints . . . or else the figures are reversed." [I think *not* the former.]

According to Mr. T. Clark (*MS. in Library Inst. Civ. Eng.*) the Chalk was found at a depth of 323 feet, and water rose to within 30 feet of the ground.

Newer Well.

Sir A. R. Binnie. Appendices. R. Comm. Metrop. Water Supply, 1893 p. 162.

83 feet above Ordnance Datum.

To Chalk	330	} 502 feet.	
In „	172		

Water-levels in feet below Ordnance Datum :—

	1877.	1880.	Nov. 1891.	
Before pumping	60 ...	45 ...	7	} gain of 53 feet in 14 years.
After „	121 ...	123 ...	39	

"The apparent gain . . . is due to the fact that the consumption . . . has been reduced to less than half (from 80,000 to 35,000 gallons) since 1888. Before this they were short of water and the level was kept down."

Farm Well. Also from Sir A. R. Binnie.

41·56 feet above Ordnance Datum, 204 feet deep; water-level in 1874, 38·56 feet above Ordnance Datum; in 1890, 8·44 below Ordnance Datum. In November, 1891, 34·44 below Ordnance Datum before pumping and 88·44 after pumping. A loss of 73 feet in 17 years.

Depth not exactly known. The water is affected by pumping at the Streatham Common deep well.

Wandsworth—*continued.*

5. Wandsworth Common. Surrey County Prison. 1849.

Sunk and communicated by Messrs. T. Docwra & Son.

About 100 feet above Ordnance Datum.

Water rose to a height of 80 feet below the surface, but its level has gradually sunk. Yield 1,600 gallons an hour. Well now disused (1911).

			Thickness. Feet.	Depth. Feet.
Made ground			1½	1½
[River] Gravel			23	24½
[London Clay, 247½ feet.]	Blue clay		244½	269
	[Basement-bed.]	Hard stone, with shells	1	270
		Sand, with shells and water	1	271
		Rock with shells and pebbles	1	272
[Woolwich and Reading Beds, 48 feet.]	Shells, with vegetable remains		3	275
	Rock and shells		1	276
	Clay, with pieces of shells		1	277
	Mottled clays		41	318
	Sand and pebbles		2	320
[Thanet Beds, 37 feet.]	Green sand		3	323
	Brown sand		17	340
	Dark sand		16	356
	Flints		1	357
[Upper] Chalk			126½	483½

In Lucas' paper in *Journ. Soc. Arts*, 1877, vol. xxv., p. 619, is given the following record of pumping at this well, (there called House of Correction), by Mr. W. Spender.

Date.	Time.	Hours of Working the Pumps.	Hours of Rest.	Depth to Water from Surface.	Rise of Water.
				Feet.	Feet.
1857, Monday, March 2	6.15 a.m.	—	36¾	104	—
1860, Saturday, " 24	5 p.m.	8½	—	156½	—
" Monday, " 26	6.15 a.m.	—	36¾	104½	52
1861, " " 4	" "	—	36¾	99¾	—
" " " 11	" "	—	36¾	103	—
1862, " " 10	" "	—	36¾	109½	—
" " " 17	" "	—	36¾	109¾	—
1871, Saturday, " 25	4.15 p.m.	7	—	180	—
" Monday, " 27	6.15 a.m.	—	38	130	50
1873, " " 3	" "	—	36¾	110½	—
" Saturday, " 29	5.30 p.m.	8½	—	176½	—
" Monday, " 31	6.15 a.m.	—	36¾	111	65½
1877, Saturday, " 3	5.30 p.m.	8½	—	154	—
" Monday, " 5	6.15 a.m.	—	36¾	108	46

Wandsworth—*continued.*

6 Wandsworth Road. About 2 miles from Vauxhall.

Prestwich, "Ground Beneath Us," p. 59 (1857). Mean of two adjoining wells.

			Thickness. Ft.	In.	Depth. Ft.	In.
Old River Drift.	Brick-earth and gravel		13	0	13	0
London Clay, nearly 138 feet.	Blue clay		134	0	147	0
	Basement-bed.	Sand and flint-pebbles ...	1	8	148	8
		Shell-rock and pebbles ...	2	2	150	10
Woolwich and Reading Beds Beds, nearly 56 feet.	Black clay		1	8	152	6
	Brown clay		2	7	155	1
	Mottled red and blue clay... ...		15	8	170	9
	Greenish sand		1	0	171	9
	Grey and white sand		4	0	175	9
	Black and yellow clay, with shells		1	0	176	9
	Clayey limestone		1	8	178	5
	Mottled red, yellow and blue clays		19	0	197	5
	Black sand		1	6	198	11
	Greenish sand and flint pebbles ...		7	9	206	8
Light-coloured Thanet Sand			32	0	238	8

7. Wandsworth Road. Clapham Brewery. ? about 1820.

About 200 feet deep, through gravel and blue clay to running sand. No record.

8. Wandsworth Road. Clifton Brewery, 1888.

Made and communicated by Messrs. Baker & Son.

? Shaft to the Chalk, the rest bored. Water-level 51 feet down.

			Thickness. Feet.	Depth. Feet.
Made ground	... ...		2½	2½
[River Drift, 27¼ feet.]	Sand		2½	5
	Ballast [gravel]...		24¾	29¾
[London Clay, 98½ feet.]	Yellow clay		½	30¼
	London clay		92¼	122½
	Basement-bed	Sandy clay ...	5	127½
		Very hard clay and shells ...	¾	128¼
[Woolwich and Reading Beds, 41¼ feet.]	Grey sand, with water ...		4¾	133
	Grey, sandy rock		7	140
	Coloured [mottled] clay ...		7½	147½
	Hard, white stone and clay ...		3	150½
	Light-yellow clay and stone ...		¼	150¾
	Red clay...		11¼	162
	Pebbles		3	165
	Brown sand and pebbles ...		2	167
	Green sand and pebbles ...		2½	169½
[Thanet Sand, 41½ feet.]	Dark grey sand		9½	179
	Light-grey sand...		4	183
	Dark grey marl...		27	210
	Flints		1	211
[Upper] Chalk	... ...		152	363

The division between the London Clay and the Reading Beds is somewhat doubtful.

Wandsworth—*continued.*

9. THE FRAME FOOD CO., Southfields.

40 feet above Ordnance Datum.

Made and communicated by MESSRS. ISLER and CO.

Water-level 98 feet down. Yield 5,000 gallons down.

		Thickness. Feet.	Depth. Feet.
Made ground	...	1	1
[London Clay, 222 feet.]	Brown clay ...	12	13
	London clay, with clay-stone at 29 to 30 feet, at 34 to 34 ft. 7 ins., at 39 to 39¼ feet, at 52 to 52½ and at 56 to 57 ...	191	203
	Dark clay with green veins ...	14	217
	Clay and loam ...	6	223
[Woolwich and Reading Beds, 66 feet.]	Dark clay ...	5	228
	Mottled clay ...	7	235
	Hard layer of congealed [cemented] pebbles and shells ...	$\frac{1}{3}$	235
	Mottled clay ...	6	241
	Hard stone ...	$\frac{3}{4}$	242
	Mottled clay ...	19	261
	Mottled clay and dead sand ...	28	289
[Thanet Sand.]	Thanet sand ...	30	319
	Green-coated flints ...	1	320
[Upper Chalk, 231 feet.]	Spongy chalk ...	38	358
	Hard chalk ...	122	480
	Brittle chalk ...	34	514
	Finish on very hard grey chalk ...	57	551

Warlingham.

Ordnance Map 286, new ser. Geological Maps 6, 8.

1. WHITELEAF. Near the Rose and Crown. Gas Co. 1900.

Made and communicated by MESSRS. LE GRAND and SUTCLIFF.

Water-level 13 feet down (April).

		Thickness. Feet.	Depth. Feet.
[Valley Drift.]	Clay and flints ...	11	11
[? Middle Chalk.]	Pebbly chalks and flints ...	17	28
	Pebbly chalk ...	23	51
	Solid chalk ...	11	62
	Solid chalk with soft partings	16	78
	Solid chalk ...	16	94
	Very hard chalk ...	6	100

2. LUCAS notes 3 Chalk-wells in the parish. *Proc. Inst. Civ. Eng.*, 1877, vol. xlvii., pp. 108, 109.

West Clandon.

Ordnance Map 285, new ser. Geological Map 8.

1. WOKING WATERWORKS, northward of the village. 1882.

? 318 feet above Ordnance Datum.

Communicated by MR. H. H. FRENCH, who got informaton from the well-sinker's foreman, and from specimens.

Water rose 10 feet above the ground, but was said not to be good. When the flints above the Chalk were broken through the water broke in and drove out

West Clandon—*continued.*

1. Woking Waterworks—*continued.*

the workmen. [According to a short notice in 'The Engineer,' vol. iv. p. 27, water was found at the depth of 310 feet. The supply seemed very poor in 1887.]

		Thickness. Feet.	Depth. Feet.
Soil		2	2
Flints and yellow loamy clay [? weathered London Clay]		5	7
Blue London Clay, with septaria at 16 levels (in three cases large enough to go across the well). Black loamy sand and a little water at 37 feet. A few pebbles and a little water at 128. Veins of sand at 145, 150, and 210. Shells at 176 and 226. Reddish clay at 222. A 6 inch bed of pebbles at base		224	231
Woolwich and Reading Beds, 79 feet.	Compact bed of shells and clay ...	1	232
	" " " " (whiter)	1½	233½
	Mottled clays, varying in colour (blue, red, brown, buff, &c.)	35½	269
	Mottled clays; no particulars kept, but sandy toward the base	31	300
	Hard loamy green sand	2½	302½
	Hard grey and yellow sand	1¼	303¾
	Loamy green sand, mottled brown ...	1¼	305
	Hard dry green loamy sand, with scattered shells, much broken ...	4½ to 5	310
	Thin bed of small black flint pebbles.		
? Thanet Beds.	Greenish loamy sand	2	312
	Clean grey sand, full of water ...	2	314
	Green-coated flints	½	314½
[Upper] Chalk, with occasional beds of flints		? 99½	414

For an analysis of the water *see* p. 311.

2. Woking Waterworks. Pumping Station about 700 yards S.S.E. of the Church, below ground. 1883.

About 315 feet above Ordnance Datum.

Information refused. But according to Dr. R. W. C. Pierce, Medical Officer of the Woking Urban District (1912), the well is 104 feet deep; there are galleries from the bottom, one south-westward, as far as the chalk-pit (over 400 yards), another south-eastward for 200 yards; the rest-level of the water is 90 feet down, lowered to 98 when pumping; the yield is about 200,000 gallons a day. The average daily quantity has been returned to the Local Government Board as 216,000 gallons. The well is all in Chalk. For an analysis of the water *see* p. 337.

3. Lucas notes 4 Chalk-wells in the parish. *Proc. Inst. Civ. Eng.*, 1877, vol. xlvii., p. 98.

West Horsley.

Ordnance Map 285, new ser. Geological Map 8.

1. Woking Waterworks. On the eastern side of the cross-roads, about 1,030 yards south of west from the church. 1887.

Information refused. But according to Dr. R. W. C. Pierce, Medical Officer of the Woking Urban District (1912), the well is 130 feet deep, and galleries were driven in the Chalk for 200 yards eastward and for a quarter of a mile westward; a supply of 180,000 gallons a day was got. The average daily quantity has been returned to the Local Government Board as 88,000 gallons. For an analysis of the water *see* p. 337.

2. Lucas notes 13 Chalk-wells in the parish. *Proc. Inst. Civ. Eng.*, 1877, vol. xlvii., p. 99.

West Molesey.

Ordnance Map 270, new ser. Geological Map, London District, Sheet 3.

Lambeth Water Works. Trial-boring. 1879.

Made and communicated by MESSRS. DOCWRA.

By the side of the Thames, at the E. edge of the then new reservoir, about 33½ feet above Ordnance Datum.

Water overflowed.

		Thickness. Feet.	Depth. Feet.
Made ground ...		9½	9½
[? Alluvium or artificial] clay and loam ...		6½	16
Gravel...		10	26
Blue [London] Clay		300	326
[Woolwich and Reading Beds, 86 feet.]	Mottled clay ...	35	361
	Mottled clay and greensand...	23	384
	Sand and loam...	7	391
	Mottled clay ...	10	401
	Dark sand and clay ...	1	402
	Green sand and clay ...	10	412
[Thanet Sand, 14 feet.]	White sand ...	2	414
	Light-coloured sand and loam	12	426
[Upper] Chalk		36	462

Wey Valley Co., *see* Frensham.

Whiteleaf, *see* Warlingham.

Wimbledon.

Ordnance Map 270, new ser. Geological Map, London District, Sheet 3.

1. ATKINSON-MORLEY CONVALESCENT HOSPITAL. 1869.

Communicated by MESSRS. EASTON & AMOS.

About 140 feet above Ordnance Datum.

Sunk 200 feet, the rest bored.

Water-level about 50 feet down. In March, 1887, after rest, 118 feet. (J. LUCAS, *Journ. Soc. Arts*, vol. xxv., p. 602.)

		Thickness. Feet.	Depth. Feet.
Sand and gravel ...		10	10
[London Clay, ? 431 feet.]	Blue clay ...	419	429
	Yellowish clay ...	4	433
	Slatish [? laminated] sandy clay [? basement-bed] ...	8	441
[Woolwich and Reading Beds, 74 feet ?]	Mottled clay ...	1	442
	Mottled clay and decayed wood ...	2	444
	Decayed wood [? lignite, or peaty clay] ...	4	448
	Mottled clay ...	1	449
	Red clay ...	3	452
	Coloured [mottled] clay ...	3	455
	Bluish clay ...	5	460
	Yellow mottled clay ...	10	470
	Red mottled clay ...	3	473
	Yellow sand and clay ...	3	476
	Yellow mottled clay ...	9	485
	Yellow sand and clay ...	8	493
	Yellowish clay ...	1	494
	Mottled clay ...	7	501
	Bluish clay ...	2	503
	Bluish clay and sand ...	5	508
	Green sand ...	2	510
	Sandy clay ...	3	513
	Coloured [mottled] clay ...	1	514
	Brown clay...	1	515

Wimbledon—*continued.*

1. Atkinson-Morley Convalescent Hospital—*continued.*

		Thickness. Feet.	Depth. Feet.
[Thanet Beds, 22 feet?]	Dark, sandy clay	1	516
	Grey sand	3	519
	Greenish sand	1	520
	Dark clay and sand	15	535
	Coarse, grey sand	2	537
[Upper] Chalk		30	567

The division between the Reading Beds and the Thanet Sand cannot well be made out, nor can one be certain about that between the former and the London Clay. These doubts unfortunately are not cleared up by the notes that I took (some time before getting the above account) of some specimens from the well, shown to me by Mr. G. Smith, the resident medical officer. It is possible that some of these specimens may have had wrong depths marked on them; they were as follows, the figures of each being the depth in feet at which they were found:—

Brown London Clay			370
Woolwich and Reading Beds.	Crimson red clay		380
	Crimson and grey	Mottled Clays.	390
	Grey and crimson		395
	Brown, purple and yellow		400
	Brown and a little purple ...		430 & 432
	Brown and purple		459
	Purple and brown		464
	Brown and a little purple ...		466
	Reddish and bluish purple		468
	Reddish		469
	Brown		474 & 479
	Light-brown sand		489
	Brown clay		493
	Brown and grey mottled clay		493
	Black, peaty clay		495
	Grey sand and clay		496
	Green, sandy clay, with small flint-pebbles (bottom-bed)		497
Thanet Sand.	Fine, grey, clayey sand		504
	Do. (darker and more clayey)		505
	Do.		508, 510, & 512
	Fine quartz-grit		530

This makes the Reading Beds of far greater thickness than the other account, indeed thicker than anywhere else in the London Basin. The thickness of the Thanet Sand seems, however, to be more correctly shown.

The well is disused.

2. Chambers' Watercress Beds, close to the Wandle (on its eastern side), and just south of Plough Lane, westward of Lambeth Cemetery. 1893. Now Slennetts'.

About 35 feet above Ordnance Datum.

Bored and communicated by Messrs. Le Grand and Sutcliff.

Water rose 17 feet above the surface. Flow at the surface 2,600 gallons an hour (February, 1893).

		Thickness. Feet.	Depth. Feet.
[Alluvium.]	Yellow clay	1½	1½
	Mould	1	2½
[River Drift.]	Gravel and sand	5½	8
Blue [London] clay, with 2 inches of stone at top and a layer of pebbles at the bottom		40	48

Wimbledon—*continued.*

2. Chambers' Watercress Beds—*continued.*

		Thickness. Feet.	Depth. Feet.
[Woolwich and Reading Beds, 55 feet.]	Clay sand and shells	11	59
	Stone	½	59½
	Coloured [mottled] clay	37½	97
	Pebbles and clay	3	100
	Green sand and pebbles	3	103
[Thanet Sand, 33½ feet.]	Green sand...	8	111
	Green sand and few pebbles [fallen down]	8	119
	Sand	17½	136½
[Upper] Chalk and flints		29½	166

3. Wimbledon Common, Eastern side. (Mr. Beaumont's.)

Quart. Journ. Geol. Soc., vol. x., p. 403.

To Chalk 465 feet.

4. Manor House. About 100 yards E. of St. Mary's Church. 1798.

Manning and Bray's "History of Surrey," vol. iii., p. 272 (1814), and Bartlett's "History of Wimbledon."

About 170 feet above Ordnance Datum. Shaft throughout. Abandoned.

Water rose (from below the bottom rock) to a height of 114 feet from the surface; but with so much sand as to fill the bottom 200 feet of the well, the water rising through this sand. In 1804 there was found to be 184 feet of sand and 224 of water, the water-level therefore being then 41 feet lower than at first.

		Thickness. Feet.	Depth. Feet.
Soil and brown clay		3	3
[London Clay, 437 ft.]	Lead-coloured, hard, flaky clay	20	23
	Reddish sand and lead-coloured clay, harder, alternating in thicknesses of 3 or 4 feet for ... ... about	80	103
	Lead-coloured, strong loam, not flaky, alternating with dark, pipey matter in thicknesses of about 3 feet ... about	60	163
	Lead-coloured clay or loam, with stony nodules [septaria] ... ... about	40	203
	Hard rock, with cavities full of water ...	½	203½
	Lead-coloured clay, with much sulphur [pyrites?]; many lumps of stone; gave off noxious air (so that men could not work without ventilation). Below this was some rotten wood	236	439½
	Hard rock [? basement-bed] under which the air was again pure	½	440
Sandy loam of a foxey colour (a)		110	550
[Woolwich Beds.]	Marine shells [? estuarine shell-bed] ...	3	553
	Light-coloured sand	7	560
	Hard rock of marine shells [estuarine shell-bed]	3	563

There may be a mistake in these figures; for if the bed of sandy loam marked (a) be counted with the London Clay it will give that formation a thickness of 547 feet, about 100 feet more than it should have in this neighbourhood; and, on the other hand, if it be taken with the Woolwich Beds it will give that Series a much greater thickness than usual. It seems likely that by a printer's error 110 has been put instead of 10. Mr. G. Barrow says that this bed of loam is of common occurrence, about 10 feet thick in the neighbourhood. It probably belongs to the basement-bed of the London Clay.

Wimbledon—*continued.*

5. New Wimbledon. Opposite the "White Hart."

Sunk and communicated by Mr. G. Eastell.

		Thickness. Feet.	Depth. Feet.
[London Clay, (+ soil) 118 ft.]	Mould and yellow clay	26	26
	Clay	92	118
[Woolwich and Reading Beds, 52¼ ft.]	Clay with shells*	7	125
	Plastic clay	30	155
	Black sand, pebbles, and shells	5¼	160¼
	Green sand with pebbles	10	170¼
Grey [Thanet] sand and water		23	193¼
[Upper Chalk, 75 ft.]	Chalk and flints, with water	25	218¼
	Blocky chalk, with flints here and there, no water...	50	268¼

* I cannot be certain that this is the shell-bed of the Woolwich Series.

6. Sanitary Laundry. Cranbrook Road. By the London and South Western Railway, 700 yards W. from the Station. 1882.

Communicated by Mr. W. S. Crimp.

69 feet above Ordnance Datum.

Shaft 60 feet ; the rest a boring of 6 inches diameter.

Water rose to 14½ feet below the surface. In Nov. Dec., 1891, the water-level was 59 feet above Ordnance Datum before pumping, and 44 after pumping. A gain of 4½ feet (Binnie). Yield about 30 gallons a minute.

		Thickness. Feet.	Depth. Feet.
London Clay		168	168
[Woolwich and Reading Beds, 51 feet.]	Light-green, fine sand	1	169
	Brown mottled sand	1	170
	Green mottled sand	1	171
	Green and buff sand	5	176
	Shells	2	178
	Dark red mottled clay	16	194
	Dark red and buff mottled clay	7	201
	Fine, green sand	18	219
[Thanet] dark greenish-grey sand		44	263
[Upper] Chalk		150	413

Another account, communicated by Mr. T. Tilley, who made the boring, differs, chiefly in the details of the Reading Beds, being as follows :—

		Thickness. Feet.	Depth. Feet.
Blue [London] Clay		166	166
[Reading Beds, 53 feet.]	Coloured [mottled] clay	45	211
	Light-green sand	3	214
	Sand and pebbles	5	219
[Thanet Sand, 43 feet.]	Hard, dead sand, with water	13	232
	Green sand	30	262
Chalk ; the last 50 feet hard and dark, sometimes almost black, sometimes brownish (when water was met with) ...		149½	411½

7. Sewage Works. Hayden's Lane (Eastern side, N. of Railway Station). 1875.

Sunk and communicated by Mr. T. Tilley, with some details from Mr. W. F. Rowell.

54·3 feet above Ordnance Datum.

Shaft 25 feet ; the rest bored.

Water rose nearly to the surface. Mr. Rowell's account says that the water rose 2 feet above the surface. In Nov., 1891, the water-level was 50 feet above

Wimbledon—*continued.*

7. SEWAGE WORKS—*continued.*

Ordnance Datum before pumping, and 28·3 after pumping. A loss of 6·3 feet (BINNIE). Yield under 10 gallons a minute.

		Thickness. Feet.	Depth. Feet.
[London Clay, 186 feet.]	Dull red clay	22	22
	Blue clay	164	186
[Woolwich and Reading Beds.]	Small shells	1	187
	Mottled clay	50	237
	Pebbles	1	238
	Coloured [mottled] clay	4	242
Green and grey loamy [Thanet] sand ...		37	270
[Upper] Chalk, with flints		121	400

8. VARIOUS WELLS. J. LUCAS, *Journ. Soc. Arts*, vol. xxv., p. 613.

In all water either overflowed, or reached the surface. The figures stand for feet.

——	Level above Ordnance. Datum.	To Chalk.	In Chalk.
Hartfield Road	55 ?	193¼	75
Hamilton Terrace	47	184 ?	16
Woodbine Terrace...	46	177 ?	15
British Land Company, formerly Creeds	46	170	10
St. George's Terrace	42	170	10
South Road, Corke's Cottages	45	177	15
Hayden's Lane Railway Station	54 (or 44 ?)	160	20

And two others, not reaching the Chalk, and in which the water does not rise to the surface.

The Woodman Inn. 355 to Sand.

Bunce's Farm. 301 to grey Thanet Sand.

9. According to MR. J. SIMPSON (*MS.* in *Library Inst. Civ. Eng.*), a well at Mr. Lake's, is 434 feet deep.

Windlesham.

Ordnance Map 269, new ser. Geological Map 8.

1. The following is taken from E. W. BRAYLEY'S "History of Surrey," vol. i., 1850, p. 472.

"The Wells, in general, are about 40 feet in depth; and in some, which are dug through a blue sandy clay, is a very offensive odour. One . . yielded water almost as nauseous to the taste as the famous Sandrock Spring, near Blackgang Chine, in the Isle of Wight. This water . . was so offensive that it could be used only for watering the garden. There are other wells, also, the water of which has a strong chalybeate flavour."

2. HIGHAMS.

Boring, from bottom of old well, made and communicated by MESSRS. MERRYWEATHER.

Abandoned, not sufficient water.

		Thickness. Feet.	Depth. Feet.
Old Well. Strata not known ...		—	39
[Bracklesham Beds.]	Loam ...	4	43
	Green loam ...	5	48
	Green sand ...	5	53
	Green sand with seam of light-coloured clay	6	59
	Light-coloured clay or marl ...	6	65
	Tough clay ...	6	71
	Tough mottled clay ...	6	77
	Hard mottled clay ...	5	82
	Mottled clay ...	4	86

Windlesham—*continued.*

2. HIGHAMS—*continued.*

		Thickness. Feet.	Depth. Feet.
[Bagshot Sand, 108 feet.]	Green loam	27	113
	Green sand	25	138
	Sandstone	4	142
	Running sand	3	145
	Live sand	14	159
	Green sand and pebbles	7	166
	Dark sand	5	171
	Live sand	14	185
	Dark loam	9	194

Witley.

Ordnance Maps 285, 301, new ser. Geological Map 8.

1. MILFORD. Messrs. Rothwell's Steam Dairy.

Made and communicated by MESSRS. DULE & OCKENDEN.

Good supply of water, coming in at various depths, and standing 8 feet down

[? Hythe Beds.] Sandstone-rock, sometimes very hard, in layers, 40 feet.

2. LUCAS notes 6 wells in Lower Greensand in this parish. *Proc. Inst. Civ. Eng.*, 1880, vol. lxi., pt. iii., p. 218.

3. WATERWORKS, *see* 335.

Woking.

Ordnance Map 285, new ser. Geological Map 8.

1. RAILWAY STATION (old well).

From SIR J. PRESTWICH'S Notes.

Yellow and whitish sand	80	119 feet.
Very fine white sand, full of water	38	
Pebbles, 2 inches sand	1	

2. WOKING MILL. Same authority.

Peat-moss	6	26 feet.
Brown sand and gravel	16	
Black sand, to clay ...	4	

3. SUTTON PLACE: Boring.

To chalk	441	500 feet.
Chalk ...	59	

For an analysis of the water, *see* p. 313.

4. BROOKWOOD. Lunatic Asylum. 1885?

Communicated by SIR F. BRAMWELL.

About 150 feet above Ordnance Datum.

Shaft 186 feet, diameter 7 feet 8 inches for 37 feet and then 3 feet 9 inches; the rest a bore of large diameter (? 18 inches).

Large quantities of water found, from 17 feet below the surface, in the beds over the London Clay. A large quantity also met with in the sands from 602 to 634 feet down. On one occasion, when this water was pumped down, the sand blew in to a height of 70 feet above the bottom of the borehole.

Water, from the Chalk, has overflowed at the rate of 9 gallons an hour. A small quantity was found at 744½ feet, rising to the surface. When the boring was at 784 feet pumping experiments were tried, and, with the water kept at 25 feet down, the delivery was about 13 gallons an hour; by pumping the water down to 200 feet the quantity was not quite 300 gallons an hour. Since the boring has been at 884 feet experiments show that, with the water kept at 25 feet down, 15 gallons an hour were got.

Very soon after I had printed an account of this well (Trans. Croydon Micr. N. H. Club, 1886) a fuller account of the section was given by the REV. A. IRVING (*Geol. Mag.*, 1886, pp. 353-356), and to this we are indebted for the

Woking—*continued.*

4. Brookwood—*continued.*

following details of the Tertiary beds. He had the advantage of seeing the specimens that had been kept (remarks from which are in these brackets, as also a few other words).

		Thickness. Feet.	Depth. Feet.
Reconstructed Upper Bagshot.	Brown sandy bed ...	3	3
Middle Bagshot [Bracklesham] Beds, 65 feet.	Gravel (pebbles of flint in greenish sand)	1	4
	Dark sand ...	5¼	9¼
	Iron band ...	1½	10¾
	Shaly band...	½	11¼
	Dark sand ...	2¼	13½
	Marly, with sandy veins ...	3½	17
	Light-coloured marl (pipe-clay)...	8	25
	Brown clay (stiff, slightly laminated) ...	1	26
	Greenish clay ...	4¾	30¾
	Dark brown sand ...	6¾	37½
	Dark sand with pyrites and cement-stones	30½	68
Lower Bagshot Beds, 105½ feet.	Hard dark loamy sand (carbonaceous, with some black grains) ...	10	78
	Lighter grey sand (carbonaceous ; black grains more numerous) ...	19	97
	Darkish grey sand (loamy) ...	5	102
	Grey loose sand (with black grains) ...	3½	105½
	Light-grey sand ...	3½	109
	Grey sand (with black grains) ...	11	120
	Dark grey carbonaceous coherent sand, with pyrites ...	23½	143½
	Hard dark shaly sand and clay ...	6½	150
	Grey sand ...	1	151
	Dark clay ...	1	152
	Nearly black shale, with layers of grey sand, many green and black grains ...	2½	154½
	Thinly laminated sandy shale (light-grey), with minute black grains and spangles of mica ...	9½	164
	Fine clay and sand ...	5½	169½
	Clay...	2	171½
	Light-grey sand ...	2	173½
London Clay, 371 feet.	London clay, with beds of stone (septaria) at 343–343½, 374½–375, 400–400½ and 508–508½ ; with pyrites 362–367 ; with pebbles 438½–447, 460–479 and 518–519...	360½	534
	Dark sandy clay (basement-bed) ...	10½	544½
Reading Beds, 89½ feet.	Dark brown mottled clay...	21½	566
	Stone ...	1	567
	Red mottled clay ...	6½	573½
	Red sandy clay ...	10	583½
	Fine sand ...	7½	591
	Red sandy clay ...	3	594
	Coarse brownish red sand (ferruginous, with black and green grains) ...	8	602
	Red mottled clay, interbedded with dark grey sand, with green grains and traces of pyrites ...	22	624
	Loose grey sand, like that in the bed above ...	10	634
[Upper Chalk].	Chalk, with very many flints ...	220	854
	Chalk, with fewer flints ...	30	884

The classification given is that of Dr. Irving. In the very much less detailed account that I published, the London Clay was carried down, but with doubt, to 566 feet, the bed next above that depth being described as sandy clay in the account given me. There were differences also in the details of the Reading

Woking—*continued.*

4. Brookwood—*continued.*

Beds, of no great moment; thus the bed from 594 to 602 feet was described as red sandy clay and the bed next beneath as coarse red sand. Another account that I had varied also from the published one in this matter.

Dr. Irving says that the bed from 3–4 feet down is "The widely extended pebble-bed at the base of the Upper Bagshot Sands;" and that it is "by no means easy to draw a line between the Lower Bagshot Beds and the London Clay." The beds from 4 to 17 feet down are described generally as dark grey and black sand, with traces of pyrites and weathered fragments of clay-ironstone. The pyrites in the Bagshot Sand is probably pyritized wood in place; but the cement-stones are much weathered, and, he thinks, probably derived from the London Clay.

5. Knaphill.

In the MSS. of Sir J. Prestwich there is a note of a well here 425 feet deep, in August, 1840.

[Bagshot.] Whitish and yellow sand, 100 feet.
[London Clay.] { Blue clay with cement-stones and shells, 260 feet.
Black sand with a few shells (? 6 inches).
[Reading Beds.] Variable beds of coloured clays and sands, each 5 or 6 feet thick. At 370 feet a bed of pebble, 4 inches thick [? basement-bed of London Clay]. No further details.

6. Woking and District Company.

From the Water Works Directory, 1909. Population supplied 35,000. Places in the area supplied:—Bisley, East and West Clandon, East and West Horsley, Horsell, Merrow, Ockham, Pirbright, Pyrford, Ripley, Send, Wisley, Woking and Worplesdon. Population supplied 35,000. Yearly supply 241,174,000 gallons. This statement repeated in the Directory of 1911, though the figures must have changed. For analyses *see* pp. 302, 313, 337.

See **Guildford, West Clandon,** and **West Horsley** for wells.

Wonersh.

Ordnance Map 285, new ser. Geological Map 8.

1. Chilworth Waterworks. In the northern part of the eastern half of Brooks Wood, about a third of a mile N.E. of Great Tangley Manor House.

Information from Mr. F. S Courtney, and from inspection.

Two shallow wells in Drift (through loam to gravel) 165 feet apart.

At the eastern well the ground-level is 174½ feet above Ordnance Datum and the water-level 168 (1902). At the western the figures are 176 and 167. The two are connected by a pipe, which is carried on northward to another well, by the northern end of a pond on the north of the road beyond the railway, and thence to the overflow at the enlargement of the stream on the eastern side of the road by the southern end of St. Martha's Works (of the six-inch map).

It is said that the pipe connecting the two wells was continued some way in the wood toward Tangley Mere (northward or north-eastward), where it ended in a third well, which has been covered up and lost sight of.

Water said to be constant, with a considerable overflow at the old paper-mill, which with some neighbouring houses had used this supply for 50 years or more (1902). The paper-mill has been abandoned.

Chemical and bacteriologic analyses by Dr. Rideal gave satisfactory results, *see* p. 313.

2. Chinthurst Lodge. 1887.

Made and communicated by Messrs. Le Grand and Sutcliff.

		Thickness. Feet.	Depth. Feet
[Lower Greensand.]	Sand	14	14
	Blue clay	12	26
	Blue sand... ...	4	30
	Hard clay and sand	20	50
	Hard clay	2	52

Wonersh—*continued.*

3. FRANCISCAN NOVICIATE. ? Greyfriars. About 720 yards S. of Chilworth Railway Station. 1892 ?

Made and communicated by MESSRS. LE GRAND and SUTCLIFF.

Water-level 114 feet down.

		Thickness. Feet.	Depth. Feet.
[Lower Greensand.]	Sand and ironstone ...	65	65
	Loamy sand	56	121
	Hard sand	3	124
	Loamy sand and ironstone	31	155

4. Two test-holes for waterworks.

Made and communicated by MESSRS. DUKE and OCKENDEN.

(*a*) CHINTHURST LANE.

Running sand	8	40 feet.
Running sand and iron-rock ...	30	
Sand and brown micaceous clay	2	

(*b*) WONERSH BRICKYARD (N. of the village).

Black sand...	15	46 feet.
Hard blue clay	7	
Hard brown and blue clay ...	2	
Black sand-rock	21	
Clay	1	

5. LUCAS notes 5 wells in Lower Greensand in this parish. *Proc. Inst. Civ. Eng.*, 1880, vol. lxi., pt. iii, p. 220.

Woodmansterne.

Ordnance Map 286, new ser. Geological Map 8.

1. SUTTON WATER COMPANY. In the valley, about half a mile from Chipstead Railway Station. 1905.

Communicated by MR. W. V. GRAHAM and MR. R. D. BATCHELOR (who made the borings).

Two borings of 3 feet diameter, 60 feet apart, lined to 100 feet down. In Chalk, to the depth of 450 feet, or 150 below Ordnance Datum.

Rest-water-level about 93 feet down.

Yield about $1\frac{1}{2}$ million gallons in 24 hours. Average quantity pumped in 24 hours in 1909, 320,029 gallons.

		Thickness. Ft.	In.	Depth. Ft.	In.
Mould ...		1	6	1	6
Gravel...		2	6	4	0
[Upper Chalk.]	Chalk and flint ...	3	0	7	0
	Loose brownish chalk...	24	0	31	0
	Solid chalk ...	22	0	53	0
	Chalk and flint ...	11	0	64	0
	Solid chalk, with a 6-inch bed of flint at $69\frac{1}{2}$ feet ...	6	0	70	0
	Chalk and flints ...	75	0	145	0
[Middle Chalk.]	Hard chalk ...	101	0	246	0
	Soft chalk ...	3	0	249	0
	Hard chalk ...	99	6	348	6
[? Lower Chalk.]	Sticky yellow clay ...	1	0	349	6
	Hard chalk ...	2	6	352	0
	Dark chalk ...	98	8	450	8

2. LUCAS notes 6 Chalk-wells in the parish. *Proc. Inst. Civ. Eng.*, 1877, vol. xlvii., pp. 104, 105.

Wotton.

Ordnance Map 286, new ser. Geological Map 8.

LUCAS notes 3 wells in Lower Greensand. *Proc. Inst. Civ. Eng.*, 1880 vol. lxi., pt. iii.

Wrecclesham, *see* Farnham.

TRIAL BORINGS NOT FOR WATER.

Of these borings none are specially notable. We have not yet bored in search of coal in Surrey, save for the curious attempt chronicled by AUBREY (*see* p. 284): the records we have depend mostly on work done for sewers, foundations, and such commonplace matters. Consequently we have no very deep works, our records on the contrary being chiefly of shallow trials. In the following pages there are noticed only 8 borings of a depth of from 50 to over 80 feet, and only 4 of 100 feet or more.

Those now recorded for the first time are for the London County Council and the City and South London Railway, and at Balham, Barnes, Beddington, Egham, and Reigate, along the Richmond Main Drainage (a long set), at Rotherhithe (Surrey Commercial Docks), and at Southwark (Horsleydown).

BORINGS FOR THE METROPOLITAN BOARD OF WORKS.

From Contract Drawings, communicated by the Board.

High Level Sewer, South Side.

MAIN LINE.

1. DEPTFORD BROADWAY, Church Street.

		Thickness. Feet.	Depth. Feet.
Made ground		6	6
[Valley Drift]	Loam and gravel	6	12
	Loam and sand	3½	15½

2. NEW CROSS, MR. TROWEL'S Farm, E. of Somerville Road.

		Thickness. Feet.	Depth. Feet.
Made ground		3	3
[Woolwich Beds.]	Brown clay and sand	9	12
	Grey, sandy clay	4	16
	Dark grey clay	13	29
	Clay, cockle [shells] and gravel	1	30
	Sandy clay	1	31

3. PECKHAM. Eastwood's Brickyard. About an eighth of a mile W. of St. Mary's Church.

		Thickness. Feet.	Depth. Feet.
Mould		2½	2½
[Woolwich Beds ?]	Yellow, clayey sand	11¼	13¾
	Yellow, sandy clay	4	17¾
	Light-brown sandy clay, with a little sand	4	21¾

4. PECKHAM. Denman Road, just W. of Hanover Road.

		Thickness. Feet.	Depth. Feet.
Made ground		2	2
[Valley Drift, 4 feet.]	Yellow clay (brick-earth)	2	4
	Sand and gravel	2	6
[Woolwich Beds.]	Greenish, mottled, sandy clay	18	24
	Clay, very shelly	3	27
	Clayey greensand, with a few shells	5	32

5. CAMBERWELL. De Crespigny Park, a little E. of Denmark Hill.

		Thickness. Feet.	Depth. Feet.
Made ground		2	2
[Valley Drift, 24¼ feet.]	Brick-earth clay	7	9
	Sand, with a little gravel	½	9½
	Sandy clay	6	15½
	Fine gravel and sand	3	18½
	Gravel	7¾	26¼
[London Clay.]	Loamy, yellow clay	1	27¼
	Blue clay	3	30¼

High Level Sewer, South Side—*continued.*

MAIN LINE—continued.

6. CAMBERWELL. Lilford Road, N. of Lilford Street.

		Thickness. Feet.	Depth. Feet.
[Valley Drift.]	Loamy gravel and sand	2	2
	Sand and gravel	3	5
	Coarse gravel	14	19

7. STOCKWELL GREEN, Western Corner.

Made ground	2½	2½
Coarse gravel	10	12½
Blue London Clay	6	18½

8. STOCKWELL. Private Road (or New Street), Fenwick Place.

Made ground		½	½
[London Clay.]	Mild, yellow clay	9½	10
	Strong, yellow clay	16	26
	Blue clay	2	28

9. CLAPHAM COMMON, Eastern Corner, The Plough Inn.

Made ground		2½	2½
[Valley Drift, 9 feet.]	Light-green sand	2	4½
	Gravel	7	11½
[London] Clay, top foot yellow, the rest blue ...		13	24½

EFFRA BRANCH.

10. PECKHAM. Evelina Road, Cemetery Road.

		Ft.	In.	Ft.	In.
Mould		3	0	3	0
[Woolwich Beds.]	Yellow sand and clay	5	0	8	0
	Blue clay and cockle [shells] ...	1	3	9	3
	Comminuted shells	2	0	11	3
	Band of limestone, with shells ...	0	4	11	7
	Indurated clay, with oyster and other shells	0	8	12	3
	Hard, bluish clay	6	0	18	3
	Ash-coloured sand	9	0	27	3
	Dark grey, clayey sand	0	6	27	9
	Dark grey, sandy clay	0	5	28	2

11. South-eastern end of NUNHEAD GREEN.

		Feet.	Feet.
Made ground		2½	2½
[London Clay.]	Brown clay, with a little sand and pebbles	8	10½
	[Basement-bed] brown clay and flint pebbles	1	11½
[Woolwich Beds, 25½ feet.]	Brown, clayey sand	4	15½
	Blue clay	1	16½
	Blue cockle [shelly] clay ...	7	23½
	Blue clay	1	24½
	Light-brown sand	8	32½
	Grey clay and sand	1½	34
	Carbonaceous sand	1	35
	Laminated, sandy clay	1	36
	Carbonaceous, shelly clay ...	1	37

High Level Sewer, South Side—*continued.*

EFFRA BRANCH.—continued.

12. PECKHAM RYE ROAD, East Dulwich Road.

		Thickness. Feet.	Depth. Feet.
Made ground	... ...	1	1
[Woolwich Beds.]	Yellow and brown sand and clay	6	7
	Laminated, grey clay and sand ...	3	10
	Grey clay	1	11
	Clay and cockle [shells] ...	3	14
	Grey, sandy clay, with a few shells	2	16

13. DULWICH. Lordship Lane, North Cross Road.

Made ground	... ...	2½	2½
[Woolwich Beds.]	Yellow clay	5½	8
	Dark grey, carbonaceous clay ...	½	8½
	Ash-coloured sand and clay, with a few shells	3½	12
	Blue clay...	4½	16½
	Blue, cockle [shelly] clay ...	9½	26
	Mottled, sandy, yellow clay ...	4	30

14. DULWICH. Five Fields, westward of Elm Lodge.

[London Clay.]	Sandy clay	2	2
	Brown, mottled clay	13	15
[Woolwich Beds.]	Yellow sand	5	20
	Brown clay, with veins of yellow sand	2	22
	Cockle [shells]	3	25
	Sandy clay	2	27
	Laminated, grey sand and clay ...	12½	39½
	Comminuted shells and sand ...	1½	41

15. DULWICH. Five Fields, S.W. of 14, between the two footpaths.

[London Clay.]	Brown clay	12	12
	Brown clay, with a little sand ...	2	14
[Woolwich Beds.]	Yellow sand	3	17
	Yellow, clayey sand	3	20
	Blue clay	4	24
	Cockle [shells]	2	26
	Blue clay	2	28
	Grey sand	4	32
	Running sand	8	40
	Comminuted shells and sand ...	5	45

16. DULWICH. Fork of Back Lane and College Road.

Made ground	... ...	2	2
[Woolwich Beds.]	Brown, sandy clay	1½	3½
	Brown, laminated clay	12	15½
	Grey, sandy clay	7	22½
	Very sandy, grey clay	3½	26
	Very shelly clay	2½	28½
	Grey, sandy clay, with a few shells	2	30½
	Brownish clay	3	33½
	Ash-coloured sand	3	36½
	Dark grey, sandy clay	2	38½
	Darker grey clay, very shelly ...	1	39½
	Dark grey clay, with a few shells	1½	41

17. DULWICH COMMON, Back Lane.

A foot of mould over 42 feet of London Clay.

Low Level Sewer, South Side.

MAIN LINE.

1. PUTNEY. Wandsworth Lane, a little eastward of Brewhouse Lane.

30·53 feet above Ordnance Datum.

		Thickness. Feet.	Depth. Feet.
Made ground	...	2½	2½
[Valley Drift, 23½ feet.]	Yellow, and then ochreous, gravelly sand ...	6½	9
	Yellow, and then ochreous, gravel ...	8	17
	Gravel ...	9	26

2. WANDSWORTH. Wandsworth Lane, just S. of the South Western Railway.

20·9 feet above Ordnance Datum.

Soil	...	½	½
[Valley Drift, 15 feet.]	Brown gravel ...	1½	2
	Ochreous, gravelly sand ...	½	2½
	Sandy gravel ...	6½	9
	Gravelly sand ...	1	10
	Gravel ...	5½	15½
Brown London Clay ...		3½	19

3. WANDSWORTH. High Street, just W. of Wandsworth Plain.

13·5 feet above Ordnance Datum.

Made ground, with 6 inches of road-metal ...	4½	4½
Sandy gravel ...	7½	12
London Clay ...	14	26

4. WANDSWORTH. Junction of Alma Road and North Street.

20 feet above Ordnance Datum.

Road-metal	...	½	½
[Valley Drift, 22½ feet.]	Coarse loam ...	5½	6
	Gravel ...	5	11
	Yellow sand and gravel ...	9	20
	Fine sand ...	3	23
Blue [London] Clay ...		5	28

5. WANDSWORTH. York Road, Jews Row.

16·33 feet above Ordnance Datum.

Peaty soil	...	1½	1½
[Valley Drift, 15 feet.]	Brown, gravelly sand ...	1½	3
	Brown, sandy gravel ...	7	10
	Yellow, gravelly sand ...	1½	11½
	Sandy gravel ...	5	16½

6. BATTERSEA. York Road, Creek Road.

14·13 feet above Ordnance Datum.

Mould, with 4 inches of road-metal ...		3⅓	3⅓
[Valley Drift, 21⅔ feet.]	Clayey gravel ...	1⅔	5
	Sand ...	5	10
	Coarse and fine gravel ...	15	25
London Clay ...		4	29

Low Level Sewer, South Side—*continued.*

MAIN LINE—continued.

7. BATTERSEA. York Road, High Street.

13·32 feet above Ordnance Datum.

		Thickness. Feet.	Depth. Feet.
Soil and made ground ...		2½	2½
[Valley Drift, 14½ feet.]	Clayey sand and gravel ...	1½	4
	Coarse, gravelly sand ...	6	10
	Ochreous sand ...	4	14
	Grey, sandy clay ...	1	15
	Coarse, yellow sand ...	¾	15¾
	Grave land grey, sandy clay	1¼	17

8. BATTERSEA ROAD, just westward of Culvert Road.

14½ feet above Ordnance Datum.

Road-metal ...		½	½
[Valley Drift, 25 feet.]	Loam ...	3	3½
	Gravel ...	6½	10
	Gravelly sand ...	5	15
	Sand ...	2	17
	Coarse gravel ...	8½	25½

9. BATTERSEA ROAD. Russell Street.

15·18 feet above Ordnance Datum.

Soil, with 6 inches of made ground ...		2	2
[Valley Drift, 20 feet.]	Sandy gravel ...	2¾	4¾
	Gravelly sand ...	3	7¾
	Sandy gravel ...	11½	19¼
	Gravelly sand ...	2¾	22

10. BATTERSEA ROAD. Stewart's Lane.

14 feet above Ordnance Datum.

Made ground a foot; Mould a foot ...		2	2
[Valley Drift, 13¼ feet.]	Sandy loam ...	1½	3½
	Gravel and sand ...	7½	11
	Grey sand	2	13
	Gravel ...	2¼	15¼

11. NINE ELMS. London Gasworks.

2 feet above Ordnance Datum.

Made ground, 6 feet; soil, 1½ ...		7½	7½
[Alluvium, 4½ feet.]	Loamy sand ...	2½	10
	Mud-deposit ...	2	12
[Valley Drift, 38 feet.]	Sand and gravel ...	18	30
	Firm sand ...	20	50
Clay-stone [London Clay septaria] ...		1	51

12. WANDSWORTH ROAD. Nine Elms.

11·1 feet above Ordnance Datum.

Made ground, 3 feet.
[Valley Drift.] Gravelly sand and sandy gravel, 17 feet.

13. KENNINGTON OVAL. Harleyford Street.

15·3 feet above Ordnance Datum.

Made ground ...		1½	1½
[Valley Drift, 22¼ feet.]	Clayey gravel ...	4½	6
	Coarse, gravelly sand, and then sandy gravel ...	17¾	23¾
Brown London Clay ...		3	26¾

Low Level Sewer, South Side—*continued.*

MAIN LINE—continued.

14. James Street. Camberwell New Road (just N. of junction with Vassal Road).

11·5 feet above Ordnance Datum.

		Thickness. Feet.	Depth Feet.
Road-metal (3 inches) and made ground		1¾	1¾
[Valley Drift, 7½ feet.]	Stiff clay	1½	3¼
	Coarse gravel ...	6	9¼
London Clay		22	31¼

15. Camberwell Road. Grosvenor Street.

10·85 feet above Ordnance Datum.

Made ground		1	1
[Valley Drift, 21 feet.]	Grey loam...	1	2
	Mixed brown clay and gravel ...	3½	5½
	Sandy gravel	12½	18
	Clayey, brown sand	4	22
Grey, sandy [London ?] Clay		3	25

16. Neate Street. Jardin Street.

6·35 feet above Ordnance Datum.

Road-metal		1½	1½
Grey clay and sand, with traces of vegetable matter		2½	4
[Valley Drift, 14 feet.]	Gravel, top foot sandy, the rest compact	3	7
	Clayey gravel	2½	9½
	Brown clay	1½	11
	Hard, grey sand	3	14
	Brown gravel, rather clayey ...	4	18
[Reading Beds ?]	Mottled red and green clay ...	2	20
	Green sand, rather clayey ...	12	32
	Brownish yellow sand	¾	32¾
	Grey sand, with pebbles... ...	½	33¼
	Dark gray sand	2¾	36

17. Neate Street, just W. of Trafalgar Road.

6·6 below Ordnance Datum.

Made ground		5	5
Gravel		14	19
[? Reading Beds.]	Blue sand	15	34
	Blue sand and marl	15½	49½
	Loamy clay	1	50½

18. Old Kent Road. Close to Grand Surrey Canal.

11½ feet above Ordnance Datum.

[? Alluvial.]	Natural soil or clay	4	4
	Clay, with river-deposit intermixed	3	7
[? River Drift.]	Loamy sand	2	9
	Sand, with water	4	13
	Stiff, brown clay	1	14
	Large pebbles	½	14½
	Smaller pebbles, with sharp clean grit sand (much water) ...	4	18½
	Coarse grit sand (much water) ...	2	20½
Fine sand, full of water		4	24½
Very fine sand, full of water		10	34½

Low Level Sewer, South Side—*continued.*

MAIN LINE—continued.

19. Old Kent Road. Shenton Street.

11 feet above Ordnance Datum.

		Thickness. Feet.	Depth. Feet.
Road-metal (3 inches) and made ground		3	3
[Valley Drift, 29 feet.]	Sand	14	17
	Gravel	12	29
	Gravelly sand	3	32

20. Old Kent Road. White Post Lane.

10¼ feet above Ordnance Datum.

Mould		1½	1½
[Valley Drift, 29½ feet.]	Yellow clay or sand	5	6½
	Gravel and sand	16½	23
	Gravel	8	31

21. Old Kent Road. Cold Blow Lane.

12½ feet above Ordnance Datum.

Strong made ground		2½	2½
[Valley Drift, 21¼ feet.]	Coarse sand, with a little gravel	2	4½
	Greyish sand, with traces of vegetable matter and gravel ...	1¾	6¼
	Black sand, with vegetable matter	1½	7¾
	Gravel	16	23¾
Grey Thanet sand, to Chalk		10¼	34

22. Cold Blow Lane, just N. of Hatcham Dairy.

11 feet above Ordnance Datum.

Made ground		½	½
[Valley Drift, 22½ feet.]	Stiff loam	6½	7
	Grey, silty sand	1	8
	Red, silty sand, with a little gravel	1½	9½
	Grey sand	8½	18
	Gravel	3	21
	Coarse gravel	2	23
Chalk		6	29

BERMONDSEY BRANCH. 1862.

1. Spa Road. Corner near St. James' Church.

10·43 feet above Ordnance Datum.

Water-level about 10½ feet down.

Mould		2	2
[Valley Drift, 22½ feet.]	Gravel	1½	3½
	Peaty sand	3	6½
	Sand	10	16½
	Gravel	8	24½
[Woolwich Beds ?].	Clay	2½	27
	Sand	4	31
	Grey clay, with shelly matter and remains of vegetable matter ...	2	33
	Grey sand...	4	37
	Greyish gravel and sand ...	1	38
	Grey sand...	4	42
	Clay	12	54

Low Level Sewer, South Side—*continued.*

BERMONDSEY BRANCH—continued.

2. Blue Anchor Lane. By Dockley Road.

9·42 feet above Ordnance Datum.

		Thickness. Feet.	Depth. Feet.
Made ground	...	3¼	3¼
[Valley Drift, 13¼ feet.]	Yellow clay	3¾	7
	Gravel and sand ...	1	8
	Sand, the bottom 3 inches dark and hard	5	13
	Quick sand	3½	16½

3. Between Storks Road and Keeton Road.

7·19 feet above Ordnance Datum.

Water-level 6 feet down.

Mould	...	2½	2½
[Valley Drift, 23½ feet.]	Loam	5½	8
	Coarse gravel	18	26
[Woolwich Beds?]	Sand	3	29
	Clayey sand	1	30
	Sand	10	40
	Grey clay, with shelly matter and remains of vegetable matter ...	13	53

4. Jamaica Level. By Clements Road.

10·95 feet above Ordnance Datum.

Water-level 8 feet down.

Made ground	...	4	4
[Alluvium ?— 4 feet.]	Peaty sand...	2	6
	Yellow, clayey sand	2	8
[Valley Drift, 15 feet.]	Greyish, and then light-coloured, gravel ...	13	21
	Yellow sand, with a little gravel	2	23

5. In Cart-road (now eastern edge of Southwark Park), leading to Gomm Road.

6·59 feet above Ordnance Datum.

Water-level over 7 feet down.

Mould	...	2	2
[Valley Drift, 18 feet.]	Loam	5	7
	Gravel	13	20
[Lower London Tertiaries.]	Fine, grey sand ...	3	23
	Grey clay, with shelly matter and remains of vegetable matter ...	3	26
	Gravel and sand ...	6	32
	Dark grey sand ...	5	37
	Dark, silty sand ...	18	55

6. Deptford Lower Road. Near Baltic Place.

6·37 feet above Ordnance Datum.

Water-level 6 feet down.

[Made ground?]	Flint ...	1½	1½
[Alluvium, 16½ feet,]	Loam...	1	2½
	Hard silt	5	7½
	Peat ...	1½	9
	Marl peat	7½	16½
	Clay ...	1½	18
[Valley Drift, 19 feet.]	Sand, and then gravel	2	20
	Gravel and sand	8	28
	Grey gravel ...	9	37
[Lower London Tertiaries.]	Sand ...	15	52

Thames Embankment, South Side.

Nos. 1–6 were in the bed of the river ; all are along the edge of the Embankment.

1. S. of Westminster Bridge. About opposite Crosier Street.

5·23 feet below Ordnance Datum.

		Thickness. Feet.	Depth. Feet.
[River Deposit and Valley Drift, 9 feet.]	Loamy sand	2	2
	Dark sand	3	5
	Coarse sand, with stones...	4	9
Blue [London] Clay		20	29

2. About opposite the southern end of the Houses of Parliament.

1·02 feet below Ordnance Datum.

Sandy clay [River-mud] ...		2½	2½
[Valley Drift, 19 feet.]	Fine sand ...	2	4½
	Coarse gravel	17	21½
Blue [London] Clay		22	43½

3. About the southern end of St. Thomas' Hospital.

1·83 feet above Ordnance Datum.

[River Deposit and Valley Drift, 19 feet.]	Loamy sand	1	1
	Sand, dark 1 foot, fine 2 feet ...	3	4
	Gravel, the lower part sandy ...	15	19
Blue [London] Clay		10	29

4. Opposite the Medical School, St. Thomas' Hospital.

·08 feet above Ordnance Datum.

		Ft. In.	Ft. In.
[River Deposit and Valley Drift.]	Loamy gravel	1 9	1 9
	Sand and gravel	8 8	10 5
	Gravel and stones	1 4	11 9
[London] Clay, the top 6 inches sandy, the rest blue		18 6	30 3

5. By the southern end of the Medical School.

1·93 feet above Ordnance Datum.

		Feet.	Feet.
[River Deposit and Valley Drift.]	Loamy sand ...	2	2
	Sand	9	11
	Sand and gravel ...	1½	12½
[London] Clay		6	18½

6. A little S. of the last.

3·18 feet above Ordnance Datum.

[River Deposit and Valley Drift.]	Loamy sand, with stones...	8	8
	Coarse sand, with stones...	17	25
Blue [London] Clay		25	50

7. Lambeth. Lower Fore Street. End of Doulton's Pottery (a little southward of the bridge).

13·39 feet above Ordnance Datum.

Made ground		3½	3½
[Valley Drift, 18½ feet.]	Loamy gravel ...	1½	5
	Loamy sand ...	3	8
	Sand	7½	15½
	Sand and gravel ...	6½	22
Blue [London] Clay		5	27

Thames Embankment—*continued.*

8. LAMBETH. Opposite William Street.

15·61 feet above Ordnance Datum.

		Thickness. Feet.	Depth. Feet.
Made ground		12	12
[Valley Drift, 18 feet.]	Fine sand	6	18
	Sand, with stones ...	8	26
	Sharp sand... ...	4	30
[London] Clay		6½	36½

9. LAMBETH. Opposite Salaman Street.

14·74 feet above Ordnance Datum.

		Ft. In.	Ft. In.
Made ground		7 0	7 0
[Valley Drift, 16¾ feet.]	Gravel	7 3	14 3
	Fine sand	1 5	15 8
	Sand, with stones	1 8	17 4
	Fine sand	3 5	20 9
	Sand, mostly coarse, with stones	3 0	23 9
[London] Clay, top 4 inches sandy, the rest blue ...		14 10	38 7

10. LAMBETH. Nearly opposite Jonathan Street.

16·81 feet above Ordnance Datum.

		Feet.	Feet.
Made ground		5	5
[Valley Drift, 21¾ feet.]	Loam, with gravel in the bottom 2 feet	3¾	8¾
	Gravel	8	16¾
	Sandy clay...	1½	18¼
	Sand	8½	26¾
Blue [London] Clay		5	31¾

11. LAMBETH. Opposite London Gas Works.

15·85 feet above Ordnance Datum.

Made ground		5½	5½
[Valley Drift, 19½ feet.]	Gravel, top 4 feet loamy...	7½	13
	Sand	1¾	14¾
	Gravel	10¼	25
Blue [London] Clay		5	30

12. (? Nearly opposite Glasshouse Street.)

3 feet above Ordnance Datum.

[Valley Drift] Sand and gravel, top 2¼ feet coarse, the rest fine, 6 feet.
[London] Clay, top 4 inches sandy, the rest blue, 16¼ feet.

M.S. Borings.

5. HATCHAM PARK ROAD. Five Bells Lane, Old Kent Road.

15¼ feet above Ordnance Datum.

Made ground		2	2
[? Valley Drift, 23 feet.]	Sandy loam	1	3
	Clayey loam	7	10
	Yellow clay	1	11
	Dark sand...	1½	12½
	Quick sand	5½	18
	Sand and gravel	3½	21½
	Sand and gravel, with shells ...	3½	25

M.S. Borings—*continued.*

6. Cooper's Road. Old Kent Road.

4 feet above Ordnance Datum.

		Thickness. Feet.	Depth. Feet.
Made ground	...	1	1
[Alluvium.]	Yellow clay	¾	1¾
	Peat	1½	3¼
[Valley Drift, 10¾ feet.]	Clay, mixed with gravel	2¾	6
	Sand and gravel	1	7
	Ferruginous gravel, with much water	7	14

7 Lorrimore Road. Near the former Surrey Zoological Gardens.

9¼ feet above Ordnance Datum.

Made ground	...	1	1
[Valley Drift, 15¼ feet.]	Gravel	7½	8½
	Ferruginous gravel	2	10½
	Sand and gravel	1½	12
	Coarse gravel	2½	14½
	Boulders	¾	15¼
	Thames sand	1	16¼

11 = No. 18 of the Low Level Sewer, South Side, Main Line (*see* p. 266). Others are not in Surrey.

FOR THE LONDON COUNTY COUNCIL.

Borings made and communicated by Messrs. Baker.

Battersea.

	Ft.	In.	Ft.	In.
Grant Road—				
Stones and made ground	1	9	1	9
Mould	0	6	2	3
Loamy sand	2	6	4	9
Gravel	4	9	9	6
Sand and stones	1	0	10	6
Sand	12	0	22	6
Sand and stones	0	6	23	0
Cologne Road—				
Macadam and made ground	3	0	3	0
Ballast [gravel]	7	0	10	0
Brown clay	8	0	18	0
Blue clay	8	3	26	3
Ringford Road—				
Stones, mould and made ground	4	0	4	0
Sandy clay	2	0	6	0
Blue Clay	20	3	26	3
Garratt Lane—				
Made ground and mould	4	0	4	0
Loam	2	0	6	0
Brown sandy clay	4	0	10	0
Yellow clay	3	0	13	0
Brown clay	4	6	17	6
Blue clay	11	9	29	3
Windmill Road—				
Made ground	14	0	14	0
Sand and pebbles	1	0	15	0
Brown clay	2	0	17	0
Blue clay	12	0	29	0

L.C.C. Borings—*continued.*

Battersea—*continued.*

	Thickness. Ft.	In.	Depth. Ft.	In.
Bucharest Road—				
Made Ground	4	6	4	6
Brown clay	17	0	21	6
Blue clay	4	0	25	6

Wandsworth.

	Thickness. Ft.	In.	Depth. Ft.	In.
St. Ann's Hill—				
Made ground	6	6	6	6
Loamy sand	0	9	7	3
Gravel	4	9	12	0
Sand and stones	1	0	13	0
Sandy clay	0	6	13	6
Blue clay	18	6	32	0
Trinity Road—				
Mould and made ground	3	10	3	10
Ballast	4	0	7	10
Gravel	2	6	10	4
Stones	0	11	11	3
Yellow clay	1	3	12	6
Blue clay	4	6	17	0
Sandy blue clay	1	0	18	0
Blue clay	2	9	20	9
Spencer Road—				
Made ground and mould	2	0	2	0
Coarse gravel	5	8	7	8
Sand and ballast	2	3	9	11
Brown clay	3	0	12	11
Blue clay	12	3	25	2
Boutflower Road—				
Made ground	3	0	3	0
Brown clay	15	0	18	0
Blue clay	8	9	26	9
Sangora Road—				
Made ground and mould	5	6	5	6
Yellow clay	5	6	11	0
Sand and ballast	1	0	12	0
Blue clay	14	3	26	3

Those of the Bermondsey and Southwark borings, to which a letter or number is prefixed, refer to the *Southwark and Bermondsey Storm Relief Sewer*, and of these particulars, additional to those given by Messrs. Baker, have been taken from the Contract Drawings, communicated by Mr. M. Fitzmaurice. From that source alone have come the accounts of Nos. 1, 2 (Bermondsey), and of the sump (Southwark).

Bermondsey.

D. Market Street, by Upper Russell Street, 9·83 feet above Ordnance Datum. Water-level nearly 13¾ feet down.

	Thickness. Ft.	In.	Depth. Ft.	In.
Concrete and made ground	3	3	3	3
Mud	2	9	6	0
Loam	1	3	7	3
Peat	2	0	9	3
Clay	3	0	12	3
Sandy loam with water	2	3	14	6
Sand and stones	1	6	16	0
Ballast [gravel]	9	6	25	6
London clay	6	6	32	0

L.C.C. Borings—*continued.*

BERMONDSEY—*continued.*

E. New Square, by site of intended pumping station, near the Thames. Nearly 14½ feet above Ordnance Datum. Water-level 17¾ feet down.

	Thickness. Ft.	In.	Depth. Ft.	In.
Concrete and made ground ...	10	6	10	6
Mud	2	0	12	6
Peat	1	0	13	6
Sandy loam	2	3	15	9
Loam	1	9	17	6
Sandy clay	3	3	20	9
Red ballast [gravel]...	3	3	24	0
Ballast	9	0	33	0
London clay	3	0	36	0

Alscot Road—

Concrete and made ground ...	3	0	3	0
Loam	0	8	3	8
Sand and stones	2	11	6	7
Loamy sand	0	5	7	0
Gravel	7	9	14	9
Ballast [gravel]	10	0	24	9
Stone	2	0	26	9
Loamy sand	1	3	28	0
Mud	2	0	30	0
Coloured clay...	5	0	35	0

Charlotte Street—

Granite and made ground	3	3	3	3
Gravel and flints	0	9	4	0
Mud	0	6	4	6
Peat	2	6	7	0
Sandy loam	0	10	7	10
Sand and stones	7	2	15	0
Ballast [gravel]	5	9	20	9
Sand	5	3	26	9

1. TOWER BRIDGE ROAD, just N. of and by W. side of railway

11¾ feet above Ordnance Datum. Water-level 13¾ feet down.

Made ground and mould ...	6	6	6	6
[Alluvium] { River peat ...	1	—	7	6
[Alluvium] { Sand... ...	—	6	8	—
[River Gravel] { Dirty ballast	7	—	15	—
[River Gravel] { Clean ballast	? 13	—	28	—
Blue [London] clay ...	? 9	—	37	—

2. TOWER BRIDGE ROAD, N. side, under E. side of railway.

12·84 feet above Ordnance Datum. Water-level about 14 feet down.

Made ground	7	9	7	9
[River Gravel, 27¾ feet.] { Coarse gravel	2	9	10	6
Coarse sand	—	6	11	—
Sandy loam	1	—	12	—
Ballast...	18	3	30	3
Sand and ballast, lower part coarse	5	3	35	6
[London Clay.] { Yellow clay	—	3	35	9
Blue clay	6	3	42	—

L.C.C. Borings—*continued.*

Southwark.

H. Avonmouth Street, near S. end, 5·13 feet above Ordnance Datum. Water-level 4 feet down.

	Thickness.		Depth.	
	Ft.	In.	Ft.	In.
Granite and made ground	4	6	4	6
Peat	10	6	15	0
Mud	9	9	24	9
Sand	1	3	26	0
Sand and stones	3	0	29	0
Ballast	2	3	31	3
Sandy clay	1	0	32	3
London clay	4	3	36	6

J. Borough Road, W. corner of Dantzic Street. About 12 feet above Ordnance Datum.

Paving stone, ballast, made ground and mould	4	10	4	8
Red gravel	6	4	11	0
Light-coloured sand	1	6	12	6
Sand and ballast	14	6	27	0
London clay	3	0	30	0

K. Tabard Street and Law Street, between. 14·9 feet above Ordnance Datum.

Made ground and mould	9	8	9	8
Sand and gravel	5	4	15	0
Sand	2	9	17	9
Gravel	8	3	26	0
Ballast	6	2	32	2
London clay	9	10	42	0

L. Tower Bridge Road, vacant ground just W. of. 11·6 feet above Ordnance Datum. Water-level over 12 feet down.

Rotten wood and made ground ...	1	6	1	6
Mud	3	5	4	11
Peat	2	0	6	11
Timber	0	5	7	4
Mud	3	10	11	2
Peat	2	0	13	2
Mud	3	0	16	2
Light-coloured sandy mud	3	6	19	8
Loamy sand	0	6	20	2
Sand and stones	3	0	23	2
Ballast	5	7	28	9
Gravel and flints	0	6	29	3
London clay	10	9	40	0

A. Rockingham Street, at S. corner. Nearly 5 feet above Ordnance Datum. Water-level 10 feet down.

Made ground and mould	7	9	7	9
Peat	7	3	15	0
Mud, to sand	11	0	26	0

B. Ralph Street, triangle at N.W. end, 13·34 feet above Ordnance Datum. Water-level $14\frac{3}{4}$ feet down.

Gravel, flints and made ground ...	4	9	4	9
Mould...	2	0	6	9
Loamy sand	1	6	8	3
Red ballast	1	6	9	9
Gravel (with water)...	2	6	12	3
Sand and stones	1	0	13	3
Ballast	2	0	15	3
Gravel	11	9	27	0
Sand and stones	5	0	32	0

L.C.C. Borings—*continued.*

SOUTHWARK—*continued.*

Staple Street—	Thickness. Ft.	In.	Depth. Ft.	In.
Made ground	7	0	7	0
Ballast	4	6	11	6
Sand	0	8	12	2
Gravel	4	9	16	11
Sand and stones	10	3	27	2
Gravel and flints	0	8	27	10
Sandy clay	1	0	28	10
London clay	5	2	34	0

ST. GEORGE'S CIRCUS. Sump. 15 feet above Ordnance Datum.
Water-level 15¾ feet down.

Road-materials ; filling ... ... about	6	9	6	9
[River Drift, 20¾ feet.] Red gravel	3	—	9	9
Loam	2	3	12	—
Loamy sand	1	6	13	6
Clean red sandy ballast	10	6	24	—
Red sand	1	—	25	—
Red sandy ballast ...	2	6	27	6
Dark slate-coloured [London] clay	4	6	32	—

CITY AND SOUTH LONDON RAILWAY.

Borings made and communicated by MESSRS. BAKER.

BRIXTON.

	Thickness. Ft.	In.	Depth. Ft.	In.
322 Brixton Road—				
Mould	1	0	1	0
Rough ballast [gravel] ...	8	0	9	0
Fine ballast	3	0	12	0
Sand	1	0	13	0
Yellow clay (to blue clay) ...	2	6	15	6
99 Brixton Road—				
Concrete and made ground ...	3	0	3	0
Rough ballast [gravel] ...	16	6	19	6
Coarse ballast (to blue clay) ...	3	10	23	4
Lorn Road—				
Mould	1	6	1	6
Loamy ballast	2	6	4	0
Ballast [gravel]	4	0	8	0
Sand and fine ballast	4	6	12	6
Dark coarse ballast (to blue clay)	6	0	18	6

KENNINGTON.

Kennington Cross—				
Mould, brick-rubbish, and made ground	6	3	6	3
Fine ballast	10	9	17	0
Coarse ballast (to blue clay) ...	8	9	25	9

MISCELLANEOUS BORINGS.

As with the Wells these are arranged in alphabetical order of places ; but it seems needless to repeat the Nos. of the maps in which those places are shown.

Balham.

NIGHTINGALE SQUARE.

Made and communicated by MESSRS. TILLEY.

	Thickness. Feet.	Depth. Feet.
Made ground	4½	4½
[River.] Gravel	1½	6
[London Clay.] Coloured clay	9	15
Blue clay ...	10	25

Barnes.

Railway Bridge (L.S.W.R.). Widening. 1892.

Borings in the river-bed passed through 18 inches of mud and gravel, and then 28½ feet of London Clay, with a few clay-stones. A. W. Szlumper.

Battersea.

1. Nine Elms. London Gaslight Company.

Trial-boring, made and communicated by Messrs. T. Docwra & Son.

		Thickness. Feet.	Depth. Feet.
Made ground		3	3
[River Drift.]	Yellow clay	2	5
	Loamy sand	3	8
	Rough gravel, full of water	6	14
	Gravel, not so rough, full of water ...	5	19
	Rough gravel, to blue [London] Clay	2	21

The borings (for gasometer) showed a depth of from 10½ to 29 feet to the clay.

2. West London Docks and Warehouses Company (proposed), eastward and southward of the works of the Southwark and Vauxhall Water Company, below Victoria Bridge.

Made and communicated by Messrs. Docwra.

Information as to sites from Sir C. D. Fox.

The borings, which were made many years ago, are noted in the order of nearness to the Thames. The measurements are in feet.

Nos. 1, 3, 2, close to or near the Thames, by the western edge of the Alluvium of the tributary-stream.

—		1.	3.	2.
Made ground		9½	7	9
[Alluvium.]	River mud	11	—	11
	Peat ...	1½	5	2
[River Drift.]	Sand ...	5	5	—
	Gravel ...	5	4	8
Blue [London] Clay ...		2	6	2
Total		34	27	32

Nos. 4, 5, 6, a little N. of Prince of Wales Road; 7, in that road; from E. of the Filter-beds to S. of them; 8, just N.E of the crossing of the railways, Stewarts Lane; 9, over 8 chains S.E. (? York Road).

—		4.	5.	6.	7.	8.	9.
Made ground, mould, or soil ...		1½	1½	3	1	5	2
[River Drift.]	Loam (Marl in 9)	2	2½	2	1½	3	½
	Gravel and sand ...	23	20	28	23	10	14½
Blue [London] Clay		2	2	2	2	2	2
Total		28½	26	35	37½	20	19

Nos. 10 and 11, about 14 chains south-south-eastward of 9, on the Alluvium, between Stewarts Lane and New Road.

[Alluvium.]	Peat; about ...	9	15 feet.
	Mud	2	
[River.]	Gravel	2	
Blue [London) Clay		2	

Beddington.

CEMETERY. On the hill south of the village, adjoining the grounds of Queenswood.

1. Close to the border of the Queenswood grounds and about 135 yards westward from the road, along that border.
2. Close to the same border and about 280 yards along it, westward from the road.
3. Close to the N.W. corner of the cemetery and the S.W. corner of Queenswood grounds.
4. About 80 yards south of 3.
5. About 80 yards a little E. of S. from 2.
6. About 85 yards a little E. of S. from 1.
7. Close to the western side of the road a little north of the fork, and over 80 yards a little N. of E. from 6.

No. of Boring.	Height above Ordnance Datum.	Depth, through Thanet Sand (and Soil) to Chalk.
	Feet.	Feet.
1.	176	33¼
2.	190	38½
3.	? 190	39
4.	185	29
5. (dug for 20 feet)	184	28½
6.	lower than No. 5	17
7.	155	4½ (? no Thanet Sand)

Bermondsey.

SOUTHERN SHAFT OF TOWER SUBWAY, Vine Street. ? 1869.

Communicated by MR. J. H. GREATHEAD.

About 15 feet above Ordnance Datum.

		Thickness. Feet.	Depth. Feet.
Made ground		7	7
Mud and peat [Alluvium] ...		11½	18½
[River Gravel.]	Gravel and sand	14½	33
	Gravel	2½	35½
Blue [London] Clay		37	72½

PRESTWICH gives the following figures (*Nature*, No. 11, p. 281) :—

Made ground, alluvium and gravel	35 feet.
London Clay	17 ,,

Camberwell ?

[? OLD] KENT ROAD, St. James' Road.

D. Allport's "Collections illustrative of the Geology, &c. of Camberwell," p. 9. (1841.)

Mould and clay	3 feet.
Peat. Decomposed vegetable matter	9 ,,

To white sand, with many nuts, and piece of deer's antler.

Egham.

For MR. RAPHAEL. Trial-boring.

Made and communicated by MESSRS. DOCWRA.

	Thickness. Feet.	Depth. Feet.
Soil	1½	1½
Red sand	10	11½
Light-blue clay	2½	14
Sand	3	17
Sandy clay	½	17½
Yellow sand	8	25½
Mottled clay	1	26½
Green [damp ?] sand. At the base the sand blew into the bore-pipe	2½	29
Green [damp ?] sandy clay	4	33
Blue clay	36	69

Perhaps Bagshot Sand down to 29 feet, and then London Clay.

Peckham.

PECKHAM NEW TOWN. By the side of the Grand Surrey Canal, opposite Canterbury Road [White Post Lane].

Made (for the Metropolitan Board of Works) and communicated by MESSRS. DOCWRA.

	Thickness. Ft. In.	Depth. Ft. In.
Made ground	2 2	2 2
Soil	1 10	4 0
Clay [Alluvium]	4 0	8 0
Ballast [River gravel]; the top foot dirty, the rest clean, with a hard layer 3 to 3½ feet down	12 0	20 0

Reigate.

A little N. of the railway about 1,000 yards westward of Notley Lane.
Information from MR. G. TAYLOR.

Clayey top, in square hole.
Sand [Folkestone Beds] to about 95 feet.
Then Fullers' earth [clay], 5 or 6 feet.

In MR. TAYLOR's sand-pit, touching the railway about 130 yards eastward, a boring has also been put down through the sand.

Richmond.

MAIN DRAINAGE. 1891. Trial Shafts. (51–108 and the Works are in MORTLAKE Parish.)

Communicated by MR. J. C. MELLISS.

In many cases details were not noted, only the depth to the London Clay, to which all were taken, being recorded. The gravel and sand varied from coarse to fine gravel and sometimes to sand alone, all three being sometimes mixed together. In some pits the sand passed into very sandy loam, but not to any great extent. In one part there was a yellow clay overlying the London Clay [probably discoloured London Clay].

Shafts 17, 27, 39, 55, 69, 93, 98, 101 and 107 were not made.

1–4 were shallow and not reaching the London Clay.

The heights are above Ordnance Datum. The measurements are in feet.

1–18 along the bank of the Thames, from S. of the Railway Bridge to Terrace Gardens. 19–21 along Lower Road.

—	Height.	Made Ground.	Ballast.	Clay.	Dirty Ballast.	Clay.	Ballast.
5. Nearly ¼ mile from Railway ...	13	4	—	—	—	—	8
6. At road to Queensbury Villa ...	13·81	10	—	—	—	—	5
7. At northern side of Water Lane	14·61	4	—	—	11	—	—
8. Southward of Water Lane ...	13·57	3	3	1	3½	—	—
9. Northward of Bridge	14·02	3	3	1	3½	—	—
10. A little S. „ „	15	3	3	1	4½	—	—
11. Westward of Cambourne House	14·03	3	—	—	11	—	—
12. South-westward of „ „	14·31	3	—	—	7	—	—
13. S. of Cambourne House ...	14·39	4	—	—	—	—	7
14. Westward of Cardigan House	13·93	4	—	—	—	—	7
15. W.S.W. „ „ „	14	4	—	—	—	—	7
16. S.W. „ „ „	15	4	—	—	—	—	7
18. Corner of walk (up to Lower Road)	14·56	To London Clay 11.					
19. Southward of the turning, to river-side	25	5	—	16	—	—	—
20. By northern end of Buccleugh (late Richmond) House ...	27·75	5	—	21	—	—	—
21. Southward of Buccleugh House	3·4	5	—	6½	8½	6	4
22. Meeting of lane and footpath N.W. of Devonshire Cottage	18·4	6	—	4	—	—	11

Richmond—*continued.*

Main Drainage—*continued.*

23–25. In Queensbury Lane from St. Helen's Terrace to Richmond Green.
30–33. Along Green Side and Park Street.
34–38. Along Kew Road.
40–65. Along Mortlake Road.

——	Height.	Made Ground, &c.	Mud.	Loamy and Sandy Gravel.	Ballast.
23. Corner, southward of Queensbury Villa	16·65	8	6	—	5
24. Eastward of Queensbury Villa	22·47	12	—	—	—
25. Junction with King Street ...	28·92	12	—	—	—
26. Near end of footpath across Green	28·04	2	—	7	6
28. Footpath across Richmond Green	25·23	3	—	—	11½
29. Ditto ditto	24·64	3	—	—	15
30. By southern corner of Little Green	26·37	3	—	—	16
31. Near middle of Little Green ...	26·66	3	—	—	17
32. A little S. of Railway	28·23	6	—	—	16½
33. " " N. " "	28·57	8	—	—	18½
34. Just N. " "	28·35	6	—	—	18
35. Halfway between 34 and 36 ...	23·88	5	—	—	15
36. By Church Road	23·04	2	—	—	16½
37. Just S. of St. John's Grove ...	22·86	3	—	—	13½
38. By junction with Mortlake Road	23·76	2	—	—	20½
40. Just W. of lane by Lumley Lodge	21·72	2	—	—	19
41. N.E. of Lumley Lodge ...	22·56	2	—	—	22½
42. W. of S. of Pagoda House ...	21·72	3	—	—	20½
43. E. " " " " ...	22·06	3	—	—	23
44. S.S.E. " " " ...	22·53	4	—	—	20
45. S.E. of Pagoda House at road on S.	23·1	4	—	—	20
46. S. of Drill Ground at road on S.	23·42	3	—	—	21½
47. S. of E. end of Barracks ...	22·97	3	—	—	20
48. E. of Barracks, by road on N.	22·73	5	—	—	18
49. Halfway between 48 and 50 ...	26·87	8	—	—	21
50. Just W. of Railway	33·71	18	—	—	21
51. " E. " "	33·08	10	—	—	34½
52. N. of Gasworks...	25·64	2	—	—	30
53. By next road on S.	22·56	2	—	—	25
54. " " "	21·93	3	—	23	—
56. } 56 to 62 are at about equal distances between 54 and 63	21·33	10	—	14	—
57.	20·95	3	—	17	—
58.	20·44	3	—	3	14

	Height.	To London Clay.
59. } 56 to 62 are at about equal distances between 54 and 63	20·23	20·53
60.	19·77	19·97
61.	18·41	23·41
62.	17·92	20·72
63. At Junction with Kew Lane ...	18·05	21·85
64. } At about equal distances northward along Kew Lane, from 65 to the corner south-eastward of West Lodge	20·15	22·85
65.	22·59	23·59
66.	22·05	26·65
67.	21·93	24·33
68.	22·17	27·27
70.	22·7	21·9

Richmond—*continued.*

Main Drainage—*continued.*

71–77 and 94–108 south-eastward along lane and path from the border of Kew Parish about a quarter of a mile N. of Kew Gardens Railway Station to near Cromwell House, Mortlake.

	Height.	To London Clay.
99. A little W. of Railway	17·26	19·06
100. At the eastern side of Railway ...	15·74	17·94
102. About equal distances between 100 and 104	16·21	19·21
103.	16·74	20·24
104. Gipsy Corner Cross-roads	17	21·3
105 About equal distances between 104 and 97	17·9	22
106	15·81	19·61
108	15·57	19·37
97 By the northern and southern ponds north-eastward of West Lodge	14·84	15·84
96	14·42	21·02
95. About equal distances between 96 and 71 ...	13·89	21·39
94.	13·95	16·85
71. By pond N. of corner of Kew Lane	14·31	11·11
72. About equal distances between 71 and 75 ...	16·44	16·24
73.	16·13	14·63
74.	16·82	15·32
75. By fork of footpaths	16	14
76. Halfway between 75 and 77... ...	15·21	13·21
77. At lane on S.	15·17	14·67

78–92. Along the road and path on the river-bank, Mortlake.

	Height.	To London Clay.	
78. At Cromwell House	15·5	13·2	
79. Half-way between 78 and 80 ...	14·31	14	
80. At Ship Lane...	14·13	12·93	
81. At about equal distances between 80 and 84 ...	15·97	11·57	
82.	15·52	11·12	
83.	15·22	10·42	
84. Broad part of road E. of Brewery	12·62	9·72	
85. Half-way between 84 and 86 ...	12·13	11·43	
86. By path or lane to Church	13·75	12·65	
		Made Ground.	Ballast.
87. Half-way between 86 and 88 ...	13·26	—	11½
88. By path W. of Castelnau House	13·53	4½	5½
89. Just W. of Castelnau House ...	13·65	4	7
90. A little W. of The Limes	12·2	3	8½
91. Half-way between 90 and 92 ...	12·11	3	11
92. By White Hart Lane	12·71	7	7

At the Works, by the river E. of West Park, the level is 12 feet above Ordnance Datum and the depth to the London Clay is 15 feet.

As a whole these borings show a fairly level top to the London Clay, varying but a little from Ordnance Datum.

Rotherhithe.

1. Globe Dock.

From the "Sections of Borings for the proposed Tunnel Sewer," by J. Phillips, Surveyor (1849).

Surface 3½ feet below Trinity high-water mark.

		Thickness. Ft. In.	Depth. Ft. In.
[Alluvium, 12 feet.]	Made ground and yellow silt ...	8 6	8 6
	Sand and gravel, mixed with silt	3 6	12 0
[River Drift]	Sand and gravel	23 6	35 6

Rotherhithe—*continued.*

1. Globe Dock—*continued.*

		Thickness. Ft.	In.	Depth. Ft.	In.
[Woolwich Beds, 35 feet.]	Dark grey clay, with traces of shell	2	0	37	6
	Yellow sand	1	0	38	6
	Light-grey sand	4	6	43	0
	Grey clay, with shells in the upper part	7	6	50	6
	Calcareous concretion	1	6	52	0
	Mixed sand and white marl ...	4	8	56	8
	[Bottom-bed.] Green sand and pebbles ...	8	0	64	8
	[Bottom-bed.] Green sand ...	5	0	69	8
	[Bottom-bed.] Sand and pebbles	1	0	70	8
Green [Thanet] sand		51	4	122	0
Chalk		2	6	124	6

2. Surrey Commercial Docks. 1891.

Made and communicated by Messrs. Docwra.

(A.) About 180 feet N. of the north-eastern corner of South Dock, and close to Greenland Dock. Dug 6 feet.

Water-level, before touching Thanet Sand, 21 feet down.

		Thickness. Feet.	Depth. Feet.
Made ground.	Made ground	3	3
	Brickwork	2½	5½
	Oak	½	6
[Alluvium, 11 feet.]	Peat	5	11
	Bungham [marsh-clay]	5	16
	Peat	1	17
[River Drift, 17 feet.]	Sand	9	26
	Ballast [gravel] ...	8	34
[Woolwich and Reading Beds, 24½ feet.]	Sand and clay	1	35
	Chalky clay	2	37
	Mottled clay	2	39
	Green sand	3	42
	Pebbles	½	42½
	Sand and pebbles ...	7½	50
	Thanet sand	8	58
	Pebbles	½	58½
[Thanet Sand, 47¼ feet.]	Thanet sand	46¾	105¼
	Flints	½	105¾
Chalk		¼	106

(B.) About 210 feet N. of "The Plough" and 80 from the south-western corner of Greenland Dock. Dug 7 feet.

		Thickness. Feet.	Depth. Feet.
Made ground		12	12
[Alluvium, 10 feet.]	Bungham [marsh-clay]	3	15
	Peat	2	17
	Bungham	5	22
[River Gravel.]	Ballast	14	36
[? Reading Beds.]	Clay, green sand, and pebbles	6	42
	Clay and green sand... ...	2	44
	Dark grey sand ...	5	49

Rotherhithe—*continued.*

2. Surrey Commercial Docks—*continued.*

(C.) Close to the southern edge of Commercial Basin, a little W. of the middle. Dug 7 feet.

		Thickness. Feet.	Depth. Feet.
Soil...		4	4
[Alluvium, 14 feet.]	Yellow clay	2	6
	Red sand	2	8
	Grey sand and clay	10	18
[River Gravel.]	Ballast	17	35
Thanet sand [Reading Beds ?]...		10	45

(D.) Between the two Delivery Offices, Brunswick Yard, and about half-way between Commercial Basin and Quebec Pond. Dug 7 feet.

		Thickness. Feet.	Depth. Feet.
Made ground		5	5
[Alluvium, 8 feet.]	Yellow clay...	2	7
	Peat	2	9
	Grey sand and clay	4	13
[River Gravel.]	Ballast	15	28
[Reading Beds.]	Green sand and clay	2	30
	Blue clay and sand	10	40
	Thanet sand ?	5	45

(E.) A little W. of the southern end of the Canal Lock at the southern end of Russia Dock. Dug 7½ feet.
Water-level 15 feet down.

		Thickness. Feet.	Depth. Feet.
Made ground		10	10
[Alluvium.]	Sand and clay	5	15
[River Gravel.]	Ballast ...	22	37
[Woolwich and Reading Beds.]	Blue clay, sand and pebbles	3	40
	Chalky clay and sand	4	44
	Blue clay	6	50

(F.) A little N. of the northern side of Greenland Dock, about half way from the western end to the passage through to Norway Dock. Dug 8 feet.

		Thickness. Feet.	Depth. Feet.
Made ground		10	10
[Alluvium.]	Blue clay ...	14	24
[River Gravel.]	Ballast ...	14	38
[Woolwich and Reading Beds.]	Chalky clay	1	39
	Mottled clay ...	2	41
	Green sand, pebbles and clay	4	45

3. Thames Tunnel, southern shaft. 8 feet below high-water mark.
J. Farey, *Phil. Mag.*, vol. xxxiii., p. 376 (1809).

	Thickness. Ft.	In.	Depth. Ft.	In.
Brown clay ...	9	0	9	0
Loose gravel (with much water) ...	26	8	35	8
Blue, alluvial, clayey earth ...	3	0	38	8
Loam ...	5	1	43	9
Blue, alluvial, clayey earth, with shells ...	3	9	47	6
Calcareous rock, with hard stones ...	7	6	55	0
Light-coloured, muddy shale, with pyrites and calcareous stones ...	4	6	59	6
Green sand, with gravel and a little water	0	6	60	0
Green sand ...	8	4	68	4

Rotherhithe—*continued.*

3. Thames Tunnel—*continued.*

"In proceeding with the drift-way from the south to the north shore, the strata were constantly varying." The Woolwich shell-beds seem to occur at from 931 to 992 feet from the shaft.

A slightly different account is given, by Mr. T. Webster, in *Trans. Geol. Soc.*, vol. ii., p. 197 (1814 ?), in which 6 feet 9 inches of vegetable mould heads the section, whilst the last bed is given as leafy [laminated] clay, and that next above is made 1 foot 9 inches thick.

An account of a boring at this spot in *Phil. Mag.*, vol. xxv., p. 46 (1806), is as follows, the surface of the ground being 6 feet below high-water level :—

	Thickness. Feet.	Depth. Feet.
Brown clay	9	9
Gravel	21	30
Strong, blue clay ...	19	49
Chalk	8	57
Concreted rock ...	4	61
Green, dry sand ...	16	77
Firm, grey, wet sand	3	80

A later account, in *Phil. Mag.*, vol. lxii., p. 142, gives a section showing the "nature of the ground under the bed of the River at Rotherhithe, at a short distance below the place now proposed for opening a Roadway," which agrees with the former of the above.

Southwark.

Horsleydown. For the Tower Bridge. Three Borings.

From a tracing communicated by Mr. J. W. Bang.

(A.) About 40 feet northward from Great Elizabeth Street. Hole dug some way into the gravel.

Made ground		$7\frac{1}{2}$	$34\frac{1}{2}$ feet. (Into London Clay.)
Dirty ballast		27	
[River Drift.]	Loam ...		
	Sand ...		
	Rough ballast		

Perhaps the Dirty ballast may be artificial, and the loam and sand Alluvium.

(B.) About 170 feet from Great Elizabeth Street.

Made ground...		7	$36\frac{1}{2}$ feet. (Into London Clay.)
[Alluvium ?]	Loamy clay, Sandy clay	$8\frac{1}{2}$	
[River Drift.]	Clean fine ballast, changing to clean sand	21	

(C.) About 370 feet from Great Elizabeth Street and 105 from the river-bank. Hole dug some way into the gravel.

		Thickness. Feet.	Depth. Feet.
Made ground		9	9
[Alluvium.]	Peat, changing to brown silt	$8\frac{1}{2}$	$17\frac{1}{2}$
	Sandy loam	5	$22\frac{1}{2}$
[River Gravel.]	Clean rough ballast into London Clay ...	$11\frac{1}{2}$	34

Here the surface of the London Clay is nearly even, while that of the gravel slopes toward the river.

Walworth.

Made and communicated by Messrs. Tilley. 1874.

Made ground	13	$19\frac{1}{2}$ feet.
Gravel and water, to clay	$6\frac{1}{2}$	

Worplesdon.

SLYFOLD GREEN. Digging and Boring for Coal.

AUBREY'S Natural History of Surrey, vol. iii., pp. 327, 328.

Sand and gravel, 7 feet.

Then a spring.

A bed of stones, like square caps, white outside, within full of sulphur. Tin got from them ! ? about 3 feet.

Black clay, 15 fathoms = 90 feet.

Rock of stone, about 3 feet.

Black clay, about 3 fathoms = 18 feet.

Rock.

Clay mixed with minerals.

Then cockles, mussels, and periwinkles, some filled with ore, some with clay.

Bed of ochre, 12 feet.

Kind of mother of pearl, about 1 foot.

Green quicksand.

Coal [lignite].

Fullers' earth, like clay, 120 feet deep.

The total of the figures given is 134 feet ; but several beds have no thickness noted. This curious old account is hard to understand.

ANALYSES OF SPRING WATERS.

We have no great number of Analyses of Surrey Spring-waters. Of Mineral Springs, however, there must be a number of published Analyses, beyond those now given, in old works on the subject; but such works are not easily to be found, being to a large extent wanting in scientific or general libraries, and a search for them would probably take more time than can be spared.

Of the Analyses now collected together, I believe that those of Spring-waters at Frimley and Seale have not been printed before.

Ascot.

By R. PHILLIPS, then Chemist and Curator at the Museum of Practical Geology. "General Board of Health. Report on the Supply of Water to the Metropolis." Appendix iii., p. 197. (1850.) ? From Bagshot Sand.

	In grains per gallon
Carbonate of lime and common salt	5·
Silica	1·
Magnesia, minute trace of oxide of iron, and vegetable matter	·4
	6·4

Clapham.

By H. M. NOAD. 1848. *Journ. Chem. Soc.*, 1852, vol. iv., p. 24.

	In grains per gallon.
Silica	·24
Carbonate of lime ...	15·09
" magnesia ...	13·97
Sulphate of lime ...	15·32
" potassa ...	6·79
" soda ...	10·77
Chloride of sodium ...	11·46
Organic matter	4·1
Total	77·74

The above supplies an instance of a water containing abundance of "preservative salts" [carbonate of lime, etc.], corroding lead with remarkable energy. The water in a [lead] cistern was covered with a thick greasy scum which could be skimmed from the surface in abundance, and which proved to consist almost entirely of oxide of lead. The water, after skimming, shewed no signs of lead in solution, and the explanation offered is that the organic matter in active decomposition evolved carbonic acid, which attacked the *surface* oxide on the leaden walls, to form insoluble carbonate of lead. That the corrosion took place so rapidly in the summer-months is adduced as evidence of this, as the organic decomposition would be then most rapid. Mr. Noad was shewn a piece of the bottom of the cistern which had been eaten into holes in six months.

Croydon.

BEULAH SPA. Norwood. *See* p. 54.

The following analysis (1) by MESSRS. FARADAY and HUME, is taken from a pamphlet by DR. G. H. WEATHERHEAD.* He says: "The water drawn fresh

* An Account of the Beulah Spa . . . 8vo., *Lond.* 1832.

Croydon—*continued.*

Beulah Spa—*continued.*

from the well is beautifully transparent and sparkling. . . Its taste is distinctly bitter. . . The temperature of the water, at the bottom of the well is 52° of Fahrenheit; its specific gravity 1011. . . The following are the solid contents of a quart."

Another version (2) by Faraday in "A Guide to Beulah Spa, Norwood." . . . By J. W. W. Small 8vo. Lond., 1838, is given in grains per pint, now converted into grains per quart, for comparison.

Adding carbonic acid gas, 7·6 cubic inches.

"Its supply is uniformly abundant."

	Grains per quart. (1)	(2)
Sulphate of magnesia	123	122·7
„ soda and magnesia	32	—
Muriate of soda [sodium-chloride] ...	19	35·48
„ magnesia [magnesium-chloride]	18½	18·56
Carbonate of lime	15	15·6
„ soda	3	3·8
Total ...	210½	

To compare with other analyses, in grains per gallon, these figures must be multiplied by 4.

Epsom.

Mineral Water. *See* pp. 55, 56.

By Daubeny. 1830. In parts per 10,000 (?).

Dr. M. Gairdner's "Essay on . . Mineral and Thermal Springs." 12mo. *Edin.* and *Lond.*, 1832, p. 415.

Carbonic acid	2·5
Sulphuric „	14·8
Muriatic „	4·21
Soda	5·64
Lime	11·8
Magnesia, oxide of iron and silica	—
Bromine, trace.	
Total	38·95

(Given as 37·94.)

There must be some error, inasmuch as sulphate of *magnesia* is known as Epsom Salts, from its occurrence in this water.

Farnham.

1. Moor Park. Spring from Mother Ludlaw's (? Ludlams) Cave. 1868. *See* pp. 39, 40.

[Sir] E. Frankland, Royal Commission on Water Supply. Minutes of Evidence, p. 347. Fol. *Lond.*, 1869.

"The spring issues from the far end of a deep cave, from a cleft in the lower greensand rock, and is fed by the water falling on a heather-covered moor, and filtering through the sand several hundred feet in thickness."

Farnham—*continued.*

1. Moor Park—*continued.*

Total solid residue	4·55	Parts per 100,000.
Organic carbon	·03	
Organic nitrogen	·01	
Nitrogen as nitrates and nitrites	·034	
Ammonia	·001	
Total combined nitrogen ...	·045	
Previous sewage contamination	·3	
Hardness...	·7	

"We have, therefore, here an example of a spring water which has been extensively in contact with peaty matter; but which exhibits only a mere trace of previous sewage contamination."

The analysis is reprinted in Rivers Pollution Commission. Sixth Report, 1874.

2. Farnham Common. Taken for public supply.

By Professor Way. *Gen. Board Health Rep. Supply Water Metrop.* Appendix iii. 1850. pp. 130–134.

Two analyses (*a*) and (*b*); (*b*) having been taken (? shortly) after (*a*) and after heavy rain and a very recent cleaning out of its "well."

In grains per gallon.

(*a*)

Saline contents	1·5
Lime (probably partly calcium chloride)	·168 (= $\frac{3}{10}$ of a degree of hardness. Clark's Test.)

Fit for public supply both from the economical and sanitary points of view, being a near approach to distilled water (rain-water), the slight saline impurities having been acquired in its passage through the soil, &c., into the sand; the chlorides being possibly due to wind-borne sea-spray. Is in fact rain-water, excellently collected.

Organic matter barely perceptible.

(*b*)

Organic matter and combined water	1·245
Silica	·55
Lime (as silicate ?)	·375
Sulphate of lime	·28
Sulphate of magnesia	·557
Chloride of magnesium	·522
Chloride of sodium...	1·44
Chloride of potassium	·354
Total	5·323
Total (found by evaporation)	5·191

Hardness, 2 degrees.

No trace of carbonate of lime or other earthy or alkaline carbonates.

The organic matter present, Prof. Way thinks, not due to manure on the surface as nitrates were not detectable.

Less bright than at other times, but "wholesome and agreeable." Still, though at its worst, fit for public supply.

[The increase in the chlorides is hardly explained by "heavy rain" and "recent cleaning."]

Farnham—*continued.*

3. Farnham and six springs in the Hindhead district.

Report by the Government Commission on the Chemical Quality of the Supply of Water to the Metropolis, 1851, by Messrs. T. Graham, W. A. Miller, and A. W. Hoffman. Reprinted in *Journ. Chem. Soc.*, 1852, vol. iv. p. 397. Made in Feb., 1851. In grains per gallon.

—	Farnham.	Spring flowing into Sweet Water, Witley.	Critchmere Springs (W. of Haslemere).	Vellwool, 1½ miles from Haslemere.	The Punch Bowl, near summit of Hindhead.	Barford Mill-stream.	The Moors, Cosford House (Thursley).
Lime	·6685	·7938	·4427	·6801	·626	1·694	6·1298
Magnesia	·3118	·21	Trace.	Trace.	·094	·129	·2905
Potassium	·1939	·1617	·1554	·1806	·0429	·1047	·3472
Sodium	·3927	·448	·3465	·4641	·303	·369	·6216
Iron, Alumina, and Phosphates	·893	—	—	—	·023	·08	·0868
Sulphuric Acid (SO_3) ...	1·0115	·7763	·6461	·973	·4132	·328	1·93
Chlorine	·567	·896	·6617	·5315	·45	·5853	·8484
Carbonic Acid	Trace.	Trace.	Trace.	Trace.	Trace.	Trace.	Trace.
Silica	·9947	·8638	1·0045	1·2152	·831	·72	·7287
Nitric Acid	Trace.	—	Trace.	—	—	—	—
The above Acids and Bases were arranged as follows:							
Carbonate of Lime ...	·23	—	—	—	—	2·39	8·31
Sulphate of Lime	1·31	1·32	1·07	·86	·59	·4	2·48
Silicate of Lime	—	·65	—	·45	1·0	—	1·17
Nitrate of Lime	Trace.	—	Trace.	—	—	—	—
Silicate of Magnesia ...	—	—	—	—	·3	—	—
Carbonate of Magnesia ...	·64	·43	Traces.	Traces.	—	·27	·6
Chloride of Sodium ...	·93	1·14	·88	·87	·74	·94	1·4
Sulphate of Soda	·07	—	—	·44	·04	—	·22
Chloride of Potassium ...	—	·31	·26	—	—	·03	—
Sulphate of Potassa ...	·43	—	·03	·4	·09	·2	·77
Silica...	·99	·45	1·0	·93	·1	·72	—
Iron, Alumina, and Phosphates	·88	—	—	—	·02	·08	·08
Organic Matter	1·78	1·11	·9	1·24	1·3	1·[illegible]5	·95
Total	7·26	5·41	4·14	5·19	4·18	6·08	15·98
Solid residue obtained on evaporation	7·33	5·31	4·37	5·17	4·34	5·65	15·75
Free Carbonic Acid in cubic inches at 44° F.	Trace.	Trace.	Trace.	Trace.	Trace.	Trace.	Trace.
Free Carbonic Acid grains per gallon	Trace.	Trace.	Trace.	Trace.	Trace.	Trace.	Trace.
Hardness	2·27	1·95	1·86	1·86	2·45	2·7	10·8

The first (collected after heavy rain) was slightly turbid. The others pure and brilliant and unexceptionable in aeration and colour. Their taste betrayed no organic taint, though flavourless and vapid to one accustomed to hard waters.

The fourth spring must be at Vale Wood in Sussex. The sixth I cannot find.

Frimley.

Water from gravel-pit.

Made and communicated by Dr. J. C. Thresh. Jan., 1909.

	In parts per 100,000.
Total solid matter dried at 180°C.	24
Chlorine	2·8
Nitric Nitrogen	0·41
Nitrites	nil.

Frimley—*continued.*

	In parts per 100,000.
Lead, Copper, Zinc, Iron	nil.
Free Ammonia	·0046
Organic „	·0174
Oxygen absorbed at 98°F. in 3 hours	·16
Hardness.—Permanent 7° ; Temporary 9° ; Total 16°	

Turbidity.—Slight deposit of fine sand and vegetable debris. Colour.—Yellow green tint. Odour.—None.

The water contains a little vegetable matter.

Godalming.

By W. W. Fisher, *Analyst*, July, 1902.

	In grains per gallon.
Total Solids	20·4
Chlorine in Chlorides ...	1·2
Nitrogen in Nitrates ...	·028
Saline Ammonia	·003
Albumenoid Ammonia ...	·001
Oxygen absorbed in 3 hours	·005
Total hardness 16°.	

Contains a little Iron.

Haslemere.

By Thomas Taylor. *Gen. Board Health Rep. Supply Water Metrop.* 1850. Appendix iv. pp. 51, 52.

Spring issuing from a low sand-hill into a natural basin and thence into a moderate-sized shallow pond.

Perfectly clear and brilliant and with no appreciable taste.

In grains per gallon.

		Combined as :—	
Chlorine	·84	Chloride of calcium ...	·71
Sulphuric acid	·47	Chloride of magnesium ...	·37
Lime	·69	Sulphate of lime	·79
Magnesia	·15	Chloride of sodium ...	·16
Potass	·12	Silicates of soda and potass	2·22
Soda	·94	Nitrates of potass	trace
Silicic acid	1·25	Organic matter	trace
Nitric acid	trace		
Organic matter	trace		4·25

Hardness (distilled water being taken as unit) = 2·6.

Another portion of the water gave residue on evaporation, dried at 230° F. = 5·58, very nearly if not absolutely free from uncombined carbonic acid, "a remarkable fact, and one which I have since found to be the case in other waters from the same district."

Residue nearly white. On heating to redness there was slight and evanescent charring.

Seale.

Hampton Lodge, Tongham.

Made and communicated by Dr. J. C. Thresh. March, 1909.

	In parts per 100,000.
Total solid matter dried at 180° C.	9·6
Chlorine	1·6
Nitric Nitrogen	·15
Nitrites, Lead, Copper, Zinc, Iron	nil.
Free Ammonia	·0172
Organic	·002
Oxygen absorbed at 98°F. in 3 hours	nil.

Streatham.

Mineral spring. *See* p. 53.

By MESSRS. REDWOOD and DE HAILES, April, 1895. In Foord's "Springs . . and Spas of London," 1910, pp. 235, 236.

	Grains per gallon.
Magnesium Sulphate	415·1
Sodium Chloride ...	19·65
Ferrous Carbonate ...	3·04
Potassium Chloride...	Traces.
Calcium Carbonate ...	76·67
Sodium " ...	18·

Naturally charged with Carbonic Acid. Would act as a mild aperient.

Witley.

A spring adjacent to and running into Sweetwater Ponds, and which is collected in a brick well in the grounds of the Rectory.

By THOMAS TAYLOR. *Gen. Board Health Rep. Supply Water Metrop.* 1850. Appendix iv. pp. 50, 51.

In grains per gallon.

		Possibly combined as :—	
Chlorine...	·53	Chloride of calcium ...	·5
Sulphuric acid	·31	Chloride of magnesium	·28
Lime	·48	Sulphate of lime ...	·53
Magnesia	·15	Nitrate of magnesia ...	·12
Potass	·14	Nitrate of potass ...	·3
Soda	·67	Nitrate of soda ...	·49
Silicic acid	·61	Silicate of soda ...	1·1
Nitric acid ...	undetermined	Organic matter... ...	trace
Organic matter... ...	trace		
			3·32

Hardness (by soap-test, distilled water being unity) = 3·2. Another portion of this water gave, by experiment, 4·4 grains of solid matter per gallon, dried at 230° F.

For an analysis of the water of the Croydon Bourne, *see* p. 338.

ANALYSES OF WELL-WATERS.

Many of the following analyses are of considerable age and perhaps therefore of little value; but all of these are more or less of historic interest. The great majority are of an imperfect kind, giving little information as to mineral contents. Some are of waters not now used. Nevertheless it is better to collect them together, and to give them for what they are worth.

Some remarks made by PROF. ODLING in treating of the water of the Guy's Hospital well (*see* p. 307) are of a general character, and should be referred to by way of caution as to the interpretation of the results of analyses. Though made more than 50 years ago they still hold, though of course more certainty may now be within reach than then.

Alphabetic arrangement, by places, is adopted here as with Wells.

Those analyses which, I believe, have not been published before are from the following places, and for twelve of them we have to thank that ever ready helper DR. THRESH.

Compton, Coulsdon (Kenley), Croydon (Empress Laundry and Waddon Waterworks), Dunsfold, Frensham (Wey Valley Works), Godalming Waterworks (all but one), Guildford (Waterworks, by THRESH, and Woking Waterworks), Leatherhead (two), Merton, Norwood, Peckham (No. 1), Penge, Shere (two), Southwark (Hop Warehouse), Sutton (Waterworks, all), Thursley, West Clandon, Witley, Woking and Wonersh (Chilworth).

Addington.

CROYDON WATERWORKS, *see* pp. 104, 105.

By W. J. DIBDIN. November, 1906.

From a Report by the Borough Engineer. Corporation of Croydon. Vol. xxv, No. 35, pp. 921, 922 (1907).

Appearance. Very faintly opalescent.	
Odour at 100° F. None.	
Total solids. Grains per gallon	26·3
„ „ Appearance on ignition	No blackening.
Phosphoric Acid	Very slight trace.
Hardness.—Permanent 3·8°. Total 17·8°	
Ammonia. Free	Trace.
„ Albuminoid...	„
Chlorine. Grains per gallon	1·03
Oxygen absorbed from permanganate at 80° F.—	
In 15 minutes. Grains per gallon	—
„ 4 hours. „ „	·0049
Organic elements in parts per 100,000.	
Carbon	·072
Nitrogen	·034
Total	·106
Nitrogen as nitrates, etc. Grains per gallon... ...	·173
Bacteriologic examination—	
Cultivation on gelatine plates. Colonies, per c.c.	1495
Micro-filter. m.m. per litre	·1
Pathogenic organisms. B. coli communis in ·1 c.c.	No streptococci.

Microscopical examination.—Mineral debris with fibrous particles of peaty character. Many fibres and starch-cells.

Remarks.—Shows all the characteristics which appear in this supply occasionally after very heavy rains. The organic constituents are high and correspond to the microscopical examination, which shewed the presence of an unusual quantity for this water of organic debris and many starch-cells.

Beddington.

ROYAL FEMALE ORPHAN ASYLUM. Well of 1872.

By DR. [SIR] T. STEVENSON, p. 7 of Dr. Gresswell's Report to the Local Government Board, 1886.

	In grains per gallon.
Total solid matter (losing on ignition 4·2) ...	22·12
Combined chlorine (= common salt 1·85) ...	1·12
Nitrogen as nitrates	·27
Nitrites	None
Ammonia (free)	None
Albuminoid or organic ammonia	·0015
Oxygen required to oxydise the organic matters	·01
Hardness, 15·6°.	

" This water, judging from the results of chemical analysis, is one of a high degree of organic purity. I see no reason to doubt that it is perfectly wholesome and well adapted for domestic purposes."

Referring to an older supply, DR. GRESWELL says it " was found . . . at the time of the outbreak of enteric fever [1869, 70] to be so seriously polluted that in 1872 a fresh supply was obtained by boring an artesian well some 60 feet into the chalk."

Bermondsey.

STAPLE STREET. Messrs. Pink's. *See* p. 118.

By DR. OGSTON.

From *Geology of London*, 1889, vol. i, Table opp. p. 533. Compiled by R. B. HAYWARD.

	In parts per 100,000.
Total solid contents	62·9
Calcium	2·1
Magnesium	1·0
Sulphuric acid (SO_4)	13·9
Chlorine	4·6
Hardness—Temporary 17° ; Permanent 4·3° ; Total 6°	

Caterham.

1. ASYLUM. *See* p. 130.

Two samples by DR. JOHN MUTER. June, 1890.

	? In grains per gallon. (1).	(2).
Total solids	27·3	27·3
Chlorine...	1·5	1·5
Total hardness	18·	18·
Permanent hardness	3·5	3·5
Nitrogen as Nitrates	·35	·35
Free ammonia	none.	none.
Albuminoid ammonia	·0019	·0018
Oxygen consumed by organic matter in 15 minutes	·007	·007
" " " 4 hours...	·014	·014
Microscopic tests	satisfactory (a few organisms)	satisfactory.

The two are practically identical, (2) being very slightly the better.

" I cannot see how either could be a cause of disease."

Caterham—*continued.*

1. Asylum—*continued.*

Eight samples by J. Muter. (1) and (2), 24 Feb., 1894; (3) and (4), 5 March, 1894; (5), 20 March, 1894; (6), 27 March, 1894; (7) and (8), 10 April, 1894.

—	In grains per gallon.							
	(1).	(2).	(3).	(4).	(5).	(6).	(7).	(8).
Ammonia	none	none	none	none	none	none	none	none
Albuminoid ammonia	·001	·001	·0007	·001	·0021	·0021	·0021	·0021
Oxygen consumed in 15 minutes... ...	·0028	·0028	·0028	·0042	·0042	·0042	·0042	·0042
Oxygen consumed in 4 hours	·0056	·0056	·0056	·0084	·0084	·0084	·0084	·0084

Remarks.

(1) and (2). Both now at their normal standard of purity.

(3) and (4). Certainly nothing wrong with the well. Fully up to the standard. The stored water (? 4) not quite so pure, but the difference so slight that it may be due to unavoidable circumstances, possibly to slight concentration by evaporation.

(6). Still shews the very slight increase in organic contamination found in the last analysis.

(7) and (8). No change since last analysis. No impurity entering anywhere above the well, as both samples are identical. [It would seem that one sample was taken from the upper part and one from the lower part of the water in the well.]

2. Water Company. (*See* p. 130.) Since absorbed by the East Surrey Co.

By D. Campbell. 1862. Royal Commission on Water Supply. Minutes of Evidence, p. 409. Fol. Lond. 1869.

Temperature 50° F. Pleasant taste. Colourless and brilliant. Well aërated and gave no deposit on standing.

Total solid contents at 60° F. 8·96 grains a gallon, consisting of mineral matter 8·64 and volatilized matter ·32. Hardness by soap-test 3·5°.

The sample was of softened water, and an analysis of the precipitate from softening is given.

An analysis of the unsoftened water by [Sir] E. Frankland, R. Comm. Water Supply. Appendix to Minutes of Evidence, 1869. Fol. *Lond.*, p. 104. Partly reproduced in Rivers Pollution Committee; Sixth Report, 1874 (*see* below, p.).

	In parts per 100,000
Total solid residue dried at 100° C.	31·08
Lime	10·6
Magnesia	2·48
Potash	1·11
Soda	1·44
Sulphuric acid	1·96
Carbonic acid	10·66
Silica	2·59
Chlorine	1·35
Nitrogen as nitrates and nitrites	·027
Ammonia	nil.
Organic nitrogen	·006
,, carbon	·02
Hardness in parts per 100,000 before boiling	23·4
,, ,, ,, after ,,	9·0

Caterham—*continued.*

2. Water Company—*continued.*

Another analysis by D. Campbell.

Proc. Inst. Civ. Eng., 1877, vol. xlvii, p. 159, and *Journ. Soc. Arts*, 1877, vol. xxv, no. 1278, p. 657.

	Grains per gallon.
Sulphate of soda	1·1
Chloride of sodium	1·55
Chloride of potassium... ...	1·96
Carbonate of lime	13·
Sulphate of lime	1·21
Magnesia (probably as silicate)	·46
Silica	1·04
Oxide of iron	·8
Volatilised matter	·8
Total	21·92

Compton.

Watts' Memorial Burial Ground. *See* p. 99.

Made and communicated by W. T. Burgess. June, 1909.

	In parts per 100,000.
Total solid residue	30
Ammonia, free	·057
„ albuminoid	·017
Oxygen consumed by organic matter in 4 hours at 26·7° C.	·298
Nitrogen as nitrates	·924
„ „ nitrites	·02
Chlorine	1·05
Total hardness (by soap-test)	18·9
Hardness due to carbonates (temporary)	14·6

Slightly turbid.

The water is polluted, but less so than the situation of the well might lead one to expect. [It is at the foot of the dip-slope on which the cemetery is placed.]

Coulsdon.

1. East Surrey Water Co. Kenley Works. *See* p. 137.

Made by W. T. Burgess. June, 1911.

	Parts per 100,000. Unsoftened.	Softened.
Total solid residue	32·88	12·54
Organic carbon	·014	·013
„ nitrogen	·003	·003
Ammonia, free	0	0
„ albuminoid	·0005	·0005
Nitrogen as nitrates	·543	·546
„ „ nitrites	0	0
Total combined nitrogen	·546	·549
"Oxygen consumed" (4 hours at 25·7°)	·005	·005
Combined chlorine	1·3	1·3
Total hardness by soap-test	24·8	4·4
Carbonates, as carbonate of lime ...	22·2	1·8

Both were clear.

These results shew very high organic purity and that the softening process has been correctly carried out.

Coulsdon—*continued.*

1. East Surrey Water Co.—*continued.*

Bacteriological tests.

Ordinary gelatine plate cultures. Unsoftened ; 1 organism per cubic centimetre. Softened ; 1 organism per 3 c.c.

Agar-cultures at blood-heat. No colonies in either.

Special tests for organisms of the Coli group. In both waters negative results were obtained in over 100 c.c of water.

2. Both works. From the Water Works Directory 1909.
Repeated in the one of 1911.

Hardness before softening 18°, after softening 4° (water softened by Clark's process).

[The following analyses are obviously of the water after softening.]

		Parts per 100,000.	
		Kenley supply.	Purley supply.
Total solid matters		11·72	10·4
Organic carbon		·021	·025
„ nitrogen...		·005	·005
Ammonia		—	—
Nitrogen as nitrates and nitrites		·465	·546
Total combined nitrogen ...		·47	·551
Chlorine		1·7	1·3
Hardness.	Temporary	·2	—
	Permanent	4·4	—
	Total	4·6	4·9

Both were clear.

Cranleigh.

From a well 85 ft. deep in Mount Field.

By R. A. Cripps. June 1902.

	In grains per gallon.
Total solids	71
Chlorine	2·4
Ammonia	·00112
„ albuminoid	·0014
Nitrogen as nitrites	Nil.
„ „ nitrates	Mere trace.
Lead	Absent.

Total hardness (Clark's Scale) 4·6°

Microscopic examination, satisfactory.

Very turbid, owing to the presence of very finely divided clay. The turbidity not due to any organic impurity.

Croydon.

1. Empress Laundry, Dartnell Road. *See* p. 139.

By R. A. Cripps, 1904. Communicated by Messrs. Duke and Ockenden.

Total solids	26	grains per gallon.
Chlorine	1·05	„ „

Ammonia none ; Albuminoid ammonia mere trace.

No nitrogen as nitrites or nitrates.

Total hardness (Clark's Scale) 16·3°. Hardness after boiling 1°.

Microscopic examination. Traces of woollen fibres.

"This water is of excellent quality, free from any suspicion of organic pollution and well suited for drinking purposes. I have specially examined the water for iron and find only the merest trace, insufficient to cause any staining of clothes when used for laundry purposes" ; and there is no other impurity in the water to cause discoloration.

Croydon—*continued.*

2. PITLAKE. MESSRS. H. & G. MEASURES. *See* p. 141.

By R. A CRIPPS, May, 1902. In grains per gallon.

Total solids	28
Chlorine	·9
Ammonia	·0025
" albuminoid	·0004
Nitrogen as nitrites	Absent.
" nitrates	Traces.
Lead	Absent.
Total hardness (Clarke's Scale) 16°	
Microscopic examination	Very satisfactory.

Of excellent quality and may be safely used for drinking purposes. Free from metallic contamination and of great organic purity.

3. UPPER NORWOOD. Biggin Hill.

The well is thought to tap the same spring that used to come out at the bottom of the hill (*see* p. 54).

By F. B. BURLS, July, 1894. From Foord's "Springs . . . and Spas of London," 1910, pp. 228, 229.

Ammonia free	·033	parts per 100,000.
" albuminoid	·025	" "
Dissolved solids, inorganic	321·48	grains per gallon.
" " organic	19·94	" "
Total	341·42	" "
Chlorine	23·1	" "
Nitric acid (NO_3)	·2	" "
Sulphuric acid (SO_3)	140·25	" "
Alkalies (Sodium and trace of Potassium)	50·12	
Magnesia (MgO)	9·59	
Lime (CaO)...	97·4	
Sodium-chloride	38·1	
" nitrate	·3	
" sulphate	14·33	
Magnesium sulphate	28·77	
Calcium "	192·1	
" carbonate	32·57	

Faintly yellow and turbid ; contains a trace of iron, but no poisonous metals ; the microscopical residue consists of vegetable debris ; contains more mineral matter than is often found in mineral springs, and this mineral matter would make it permanently hard, only a little being removed by boiling.

In addition it is organically impure. Absolutely unfit for domestic purposes.

4. WATERWORKS. Surrey Street Pumping Station (*see* pp. 144, 145).

By PROF. WAY. From the Report on the Sanitary Works of Croydon, by B. LATHAM, 1868, p. 26.

	In grains per gallon. March, 1852.	Jan., 1853
Organic matters and combined water	1·09	·98
Silica	·93	·84
Sulphate of lime	·53	·74
Carbonate of lime	15·41	14·64
Chloride of sodium	1·51	1·34
Carbonate of magnesia	·61	·76
Sulphate of soda	·18	·2
Sulphate of potash	·85	·74
Residue in a gallon	21·11	20·24

Hardness in Clark's degrees before boiling 16° and 15½°, after 4½° and 4°.

The second of the above appears in a shorter form in *Trans. Soc. Eng.* for 1884, p. 235.

Croydon—*continued.*

4. Waterworks. Surrey Street—*continued.*

Two later analyses Nov., 1867 by Dr. Odling, from the same publication, p. 27.

	In grains per gallon. Old well.	New well.
Total solid matter... ...	21·609	21·945
Mineral matter	21·364	21·455
Volatile matter	·245	·49
Lime	9·625	9·765
Magnesia	·195	·187
Potash	·25	—
Soda	1·168	—
Silica	1·064	·959
Sulphuric acid	·658	·606
Chlorine	·988	·777
Carbonic acid	7·39	7·865
Ammonia	·028	·035
Nitrogen as ammonia ...	·023	·029
" oxides ...	·206	·28
" organic matter	·004	—

Hardness before boiling 15·2°, in both; after 3° and 3·4°.
Specific gravity, 1·00031 in both.

For general purposes, all that can be desired.
In Smee's "My Garden," p. 30, there are analyses of water from the old well and new well, also by Prof. Odling, differing slightly from the above.

By W. J. Dibdin, Feb., 1907. From the "Reports of the Borough Engineer on Water Supply and Purification and Medical Officer of Health on Filtration." Vol. xxv. No. 25.
Appearance, clear and bright.
Odour at 100° F., none.

Total solids	... Grains per gallon	25.
" " appearance on ignition, no blackening.		
Phosphoric acid	... Very slight trace	
Hardness. Permanent 4. Total 16·5 degrees.		
Ammonia Free	... Grains per gallon	·0032
" Albuminoid	" "	·0041
Chlorine	" "	1·
Oxygen absorbed from permanganate at 80° F. in 15 minutes	" "	·0011
Ditto in 4 hours	" "	·0029
Organic elements :—		
Carbon	... Parts per 100,000	·036
Nitrogen	" "	·009
	Total ...	·045
Nitrogen as nitrates, &c.	... Grains per gallon	·226

Bacteriologic :—
Cultivation on gelatine-plates, colonies per cc. 204.
Micro filter mm. per litre ·2.
Pathogenic organisms: No acid or gas forming organisms in less than 10 cc. No streptococci.
Microscopical examination: Hairs and fibres, some dyed. Starch cells. General debris.

Remarks—Shows a distinct increase in the organic constituents corresponding with a rise in the total number of bacteria.

The free ammonia is the highest since Jan., 1900 which preceded the objectionable conditions in No. 2 well-room, and an examination of that well is suggested by Mr. Dibdin.

Croydon—*continued.*

WATERWORKS. Waddon Well. (Chalk.) *See* p. 146.

Made by MESSRS. DIBDIN and THUDICHUM, June 1899.

Appearance, slightly turbid, due to the presence of finely divided particles of chalk with a little silica.

Odour, at 100° F., none.

Hardness—Total 17·9° ; Permanent 25°.

	Results in grains per gallon.
Total solids. No blackening on ignition	34·2
Free ammonia	·0006
Albuminoid ammonia	·0006
Chlorine...	·95
Oxygen absorbed from permanganate in 15 minutes	·0014
,, ,, in 4 hours (both at 80° F.) ...	·0041
Nitrogen as nitrates, &c.	·299

"This water is to all intents and purposes identical with that obtained from the Surrey Street Well . . . It is evidently an excellent water."

(? Mixture of water from various sources in use).

(1) 18 November, 1908. From the "Waterworks Directory," 1909.

(2) 15 February, 1911. ,, ,, ,, 1911.

	1.	2.
Appearance, clear and bright in both.		
Odour at 100° F., none in either.		
Total solids. Grains per gallon ...	24	22
,, ,, Appearance on ignition	No blackening.	No blackening.
Phosphoric acid	Very slight trace.	Nil.
Hardness. Permanent	4·3°	5·4°
,, Total	19·2°	17·1°
Ammonia, free. Grains per gallon ...	Trace.	·0003
,, albuminoid ,, ,, ...	Nil.	·0003
Chlorine ,, ,, ...	1·2	1·2
Oxygen absorbed from permanganate at 80° F. in 15 minutes. Grains per gallon	·007	0
Ditto, in 4 hours. ,, ,,	·0175	·007
Organic elements :—		
Carbon. Parts per 100,000 ...	·007	·016
Nitrogen ,, ,, ...	·011	·005
Total ,, ,, ...	·018	·021
Nitrogen as nitrates, &c. Grains per gallon	·288	·389

Bacteriologic :—

Cultivation on gelatine-plates. Colonies per cc.	22	7
Micro filter mm. per litre	Very slight trace.	·1

No coli-like organisms in 100 cc. No streptococci. Both.

Microscopic examination. Few fibres and little débris in 1. Mineral and vegetable débris in 2.

Remarks.—Quite normal samples and of excellent quality.

Dunsfold.

BLACKNEST. Deep boring, *see* p. 151.

By R. A. CRIPPS. July 1908. Communicated by MESSRS. DUKE and OCKENDEN.

Total solids	263
Chlorine	142
Ammonia	·105
Albuminoid ammonia	None.
Nitrogen as nitrates and nitrites	"
Lead	"
Total Hardness 11·4°	

Microscopic examination, some oxide of iron.

May be safely used for drinking purposes. Free from organic pollution and of moderate hardness. Owing to the presence of salt [*see* figure for chlorine] has a distinctly saline taste.

? Sample taken from between 1046 and 1070 feet down. This water shut out later.

Frensham.

WEY VALLEY WATERWORKS. Hindhead. *See* p. 164.

1. Made and communicated by DR. J. C. THRESH.

2. From the Waterworks Directory, 1909. Repeated in that of 1911. Date of sample, March 1906.

			(1)	(2)
Total solid matter dried at 180° C. (parts per 100,000)			13·5	19·6
Chlorine	"	"	1·7	1·6
Nitric nitrogen	"	"	·65	·36
Nitrites	"	"	None.	None.
Lead, copper, zinc, iron	"	"	"	"
Free ammonia	"	"	·0004	·0024
Organic ammonia...	"	"	·002	·0016
Oxygen absorbed at 80° F. in 3 hours	"	"	·005	·0171

(1) Hardness—Permanent 4°; Temporary, 1·5°. Total 5·5°
(2) " " 5·5°; " 3·5° " 9°

1. Turbidity, clear and bright; colour, faint green tint; odour, none.

2. Turbidity and odour, none; colour, normal. Of most exceptional purity; admirably adapted in every respect for public supply.

Bacteriologic examination of 2 :—

Number of organisms per cc. capable of growing on alkaline nutrient jelly at 20° C. in 14 days, counted by aid of pocket-lens, 68.

Smallest quantity of water in which growth occurred with production of acid and gas in bile-salt glucose broth (1, 5, 10, 20 cc.). No acid or gas in any. No objectionable bacteria in this growth.

Spores of bacillus enteritides sporogenes absent in 150, 350, and 500 cc.

Godalming.

WATERWORKS (*see* pp. 168–170). From the mains.

Made and communicated by DR. J. C. THRESH. May 1907.

	In parts per 100,000.
Total solid matter dried at 180° C. ...	31·8
Chlorine	2·8
Nitric nitrogen	·65
Nitrites	Nil.
Lead, copper, zinc, iron	...Very slight trace of iron.
Free ammonia	·0004
Organic ammonia	·0004
Oxygen absorbed at 98° F. in 3 hours	·048

Hardness—Permanent, 8°; Temporary, 10. Total 18.

Turbidity, slight trace of vegetable débris; colour, faint yellowish green; odour, none.

Godalming—*continued.*

WATERWORKS—*continued.*

(? Water as supplied, *i.e.*, a mixture from all sources).

1. From "Waterworks Directory," 1909. 2. From ditto, 1911.

	Grains per gallon. 1.	2.
Total solid matter	21·56	22·6
Loss on ignition	3·64	2·8
Combined chlorine	1·49	1·4
(Equal to common salt) ...	2·46	2·31
Nitrogen as nitrates, none as nitrites ...	·57	·47
Ammonia	·0003	·002
„ albuminoid or organic	·002	·0037
Oxygen required to oxidize organic matter	·011	·024
Hardness—Temporary	9·8°	9·1°
Permanent	4·9°	5·2°
Total	14·7°	14·3°

Experimental works for New Supply at Ockford. By MR. EDWARD HINKS; in grains per gallon.

	Excavation No. 3. 20 Nov., 1909.	Excavation No. 4. 20 Nov., 1909.	Boring A. 1 Oct., 1909.	Boring B. 4 Feb., 1910.
Odour and colour	None.	None.	None.	None.
Turbidity	Trace of suspended ferruginous sand.	Trace of suspended ferruginous sand.	None.	None.
Total solid matter	17·64	14·56	14·	15·54
Losing on ignition ...	1·54	1·26	·28	·52
Combined chlorine ...	·93	1	1·15	·85
(Equal to common salt)...	(1·53)	(1·65)	(1·9)	(1·4)
Nitrogen as nitrates ...	Trace.	·02	Trace.	Trace.
Nitrites	None.	None.	None.	None.
Iron	—	—	—	Trace.
Saline ammonia	·001	·001	·0035	·0025
Albuminoid ammonia ...	·0007	·0007	Trace.	·0005
Oxygen absorbed from permanganate in 4 hours at 80° F.	·022	·011	·0017	·007
Hardness —				
Temporary	11·5°	8·7°	9·7°	11·2°
Permanent	2·5°	3·3°	1·9°	1·7°
Total	14°	12°	11·6°	12·9°

Remarks.—Excavations Nos. 3 and 4. These are of very similar composition and similar also to the waters from Ockford excavations in April and June, 1908. The iron present is in suspension and not in solution and is probably temporary. The slight variation in mineral composition from the 1908 samples is favourable. Both are highly pure organically, of low salinity and of moderate hardness. An excellent pure supply may be expected. Boring A.: Of high degree of organic purity, low salinity and moderate hardness. Should prove an excellent drinking water. Boring B.: Very similar to that from other borings at Ockford. Organically and bacteriologically very satisfactory for a new boring. An excellent pure water may be expected, well fitted for public supply.

Guildford.

1. Old Waterworks. *See* p. 334.

By Prof. Miller. *Tenth Rep. Med. Off. Privy Council*, 1868, pp. 37, 38 ; also in *Royal Commission on Water Supply Minutes of Evidences*, p. 441. Fol. Lond. 1869.

1. Old Well. 2. New Well. September, 1867.

	1.	2.
Appearance, nearly bright in both.		
Colour	None.	None.
Taste and smell	None.	None.
Hardness (Clark's Scale) before boiling	15·1°	16·2°
After boiling 1 hour	4·8°	4·1°
Total solids, in grains per gallon ...	23·2	24
Fixed salts	22·7	23·2
Volatile and combustible matter ...	·5	·8
Nitric acid N_2O_5...	1·2	1·1
Ammonia...	·01	·02
Gas in cubic inches per gallon	16·3	19·49
Carbonic acid CO_2	7·74	8·18
Oxygen	2·85	1·17
Nitrogen	5·71	10·14
Ratio of oxygen to nitrogen	1 : 2·05	1 : 8·6

There is nothing remarkable in the amount or quality of the saline matter in either of these waters. A little ammonia and a small amount of nitrates are present, the ammonia probably from surface-drainage ; it is higher in the new well. Organic matter slight, but decidedly greater in the new well.

Aeration of 1, perfect ; of 2 *very defective.* (2 nearly recovered its proper proportion of aeration on standing in a reservoir). 2 appears to have contained some putrescible or rapidly alterable substance which has absorbed a large proportion of the dissolved oxygen.

2 had been in a condition of partial stagnation for two months and the defective aeration may be partially due to contact with cotton-waste, oil, and wood ; but the presence of ammonia points unmistakably to animal contamination.

Both had a scanty reddish sediment.

2. Newer Waterworks. *See* p. 172.

From well in Chalk ; 35 feet deep.

Made and communicated by Dr. J. C. Thresh. Sept., 1906.

In parts per 100,000.

Ca.	Mg.	—	CO_3	SO_4	Cl.	NO_3	Probable combinations.	
9·05	·1	—	12	·7	1·95	2·75		
8·	—	—	12	—	—	—	Calcium carbonate	20
·3	—	—	—	·7	—	—	„ sulphate	1
·75	—	—	—	—	1·35	—	„ chloride	2·1
—	·1	—	—	—	·3	—	Magnesium „	·4
—	—	·2	—	—	·3	—	Sodium „	·5
—	—	1	—	—	—	2·75	„ nitrate ...	3·75
							Silica, &c. ...	·65
							Total solid constituents dried at 180° C. ...	28·4

Free ammonia	·004
Organic „	·001
Oxygen absorbed in 4 hours at 27° C. ...	·02
Nitrites	Nil.

Hardness.—Temporary, 20° ; Permanent, 4° ; Total, 24°.

Guildford—*continued.*

2. Newer Waterworks—*continued.*

From a 15 inch boring.

Made and communicated by Dr. J. C. Thresh. Sept., 1906.

In parts per 100,000.

Ca.	Mg.	—	CO_3.	SO_4.	Cl.	NO_3.	Probable combinations.	
9·4	·3	—	12·5	1·1	2·	2·35		
8·35	—	—	12·5	—	—	—	Calcium carbonate	20·85
·45	—	—	—	1·1	—	—	„ sulphate	1·55
·6	—	—	—	—	1·	—	„ chloride	1·6
—	·25	—	—	—	1·	—	Magnesium chloride	1·25
—	—	·85	—	—	—	2·35	Sodium nitrate	3·2
							Silica, &c.	·85
							Total solid constituents dried at 180° C ...	29·3

Free Ammonia ... ... ·0006
Organic „ ... ... ·0004
Oxygen absorbed in 4 hours at 27° C. ·011
Nitrites ... ... Nil.

Hardness—Temporary, 20°; Permanent, 4°; Total, 24°.

3. Woking Waterworks. *See* p. 172.

Made and communicated by Dr. J. C. Thresh. Sept., 1906.

In parts per 100,000.

Ca.	Mg.	Na.	K.	CO_3.	SO_4.	Cl.	NO_3.	Probable combinations.	
8·9	·4	—	trace	13·2	·85	1·85	1·8		
8·8	—	—		13·2	—	—	—	Calcium carbonate	22
·1	—	—		—	·15	—	—	Calcium sulphate	·25
—	·2	—		—	·7	—	—	Magnesium sulphate	·9
—	·2	—		—	—	·6	—	„ chloride	·8
—	—	·8		—	—	1·25	—	Sodium chloride	2·05
—	—	·7		—	—	—	1·8	Sodium nitrate	2·5
								Silica, &c.	·7
								Total solid constituents dried at 180° C. ...	29·2

Lambeth.

1. Messrs. Beaufoy's, South Lambeth Road. *See* p. 184.

By J. Sadler; compiled by R. B. Hayward, *Geology of London*, 1889, vol. i, table opp. page 533.

	In parts per 100,000.
Total solid contents...	43·5
Calcium	3·0
Magnesium	1·3
Sodium	11·8
Potassium	·6
Carbonic acid (CO_3)	16·9
Sulphuric acid (SO_4)	4·0
Chlorine	4·9
Silica (SiO_2)	·5
Organic	·5

Lambeth—*continued.*

2. VAUXHALL. Burnett's Distillery. *See* p. 186.

By PROF. ODLING, "An Account of Guy's Hospital Well," 1860? Said to be sand-spring water. In grains per gallon.

Chloride of sodium ...	14·3	Total 47·83.
Carbonate of soda ...	6·73	
Sulphate of soda ...	15·69	
Sulphate of potash ...	1·92	
Carbonate of lime ...	5·39	
Carbonate of magnesia	3·2	
Silica	·6	

Phosphate of iron and alumina, traces.
Organic matter, traces.

3. In the same paper PROF. ODLING gives a table of results, by DR. DUPRÉ and himself, from waters of 28 shallow wells in the district of Lambeth, including Kennington, Vauxhall, Brixton, &c., and says that "in the shallow waters furnished by this limited area, the organic, or combustible, matter was found to vary from one to nearly eighteen grains, and the saline, or mineral, matter from twenty to one hundred and twelve grains per gallon. These waters not only vary much from one another, but also from time to time. They are almost always rich in organic matter, and contain obvious quantities of ammonia and nitric acid, products of animal decomposition. Many of them, when pumped down, furnish a liquid which is little else than filtered sewage. Moreover they are usually very hard waters, from the presence of sulphate and carbonate of lime."

Leatherhead.

LEATHERHEAD AND DISTRICT WATERWORKS. *See* p. 189.

By DR. P. F. FRANKLAND. November, 1883.

	In parts per 100,000.
Total solid matter	35·2
Organic carbon	·07
„ nitrogen	·035
Ammonia	0
Nitrogen as nitrates and nitrites	·502
Total combined nitrogen	·537
Chlorine	1 8

Hardness—Temporary, 19·9; Permanent, 3·6; Total, 23·5.
No poisonous metals.

Though turbid, owing to the unfinished state of the borehole, is palatable, and contains only a small proportion of organic matter. Of excellent quality for drinking.

A later Analysis. November, 1908.

Made and communicated by DR. J. C. THRESH.

	In parts per 100,000.
Total solid matter dried at 180° C.	34·6
Chlorine	2·
Nitric nitrogen	·62
Nitrites	None.
Lead, copper, zinc, iron	None.
Free ammonia	·0008
Organic „	·0016
Oxygen absorbed at 98° F. in 3 hours	·012

Hardness—Permanent, 3·5°; Temporary, 19·5°; Total, 23°.

Turbidity, clear and bright. Colour, faint green tint. Odour, none. Of the highest organic purity.

Merton.

SOUTHDOWN LAUNDRY. Kingston Road, Raynes Park. *See* p. 194.
Made by MR. E. L. CLAPHAM. May, 1906. Communicated by MESSRS. ISLER.

	In grains per gallon.
Silica	·11
Oxide of iron	·08
Carbonate of lime ...	4·89
" " magnesia ...	3·44
Sulphate of sodium ...	5·54
Bicarbonate of sodium ...	6·82
Chloride " " ...	4·09

Hardness, 8·84°.

Norwood.

NORWOOD BREWERY CO. Chapel Road, West Norwood. *See* pp. 202, 203.

	? In grains per gallon or parts per 100,000.
Total solid matter	25·9
Saline residue	24·9
Organic and volatile matter	·98
Carbonate of lime	14·11
Lime combined with acids other than carbonic	9·45
Magnesia	1·89
Sulphuric acid	1·97
Nitric acid	·35
Nitrous "	Nil.
Chlorine	1·12
Iron in solution	·02
Lead	Nil.
Oxygen absorbed in 3 hours	·14
Probably combined as follows :—	
Chloride of sodium	1·85
Nitrate of lime	·53
Sulphate "	3·34
Carbonate "	14·11
" magnesia...	3·97
Silica and alumina	·84
	In parts per million.
Free ammonia	·08
Albuminoid ammonia	·02

Peckham.

1. NEW PHŒNIX BREWERY. 37, Peckham Road. *See* p. 208.
Communicated by MR. C. BEADLE, from information given by the Company in 1904.

	In grains per gallon.
Free ammonia	·014
Albuminoid ammonia ...	·004
Oxygen absorbed in 1 hour	·106
" " " 3 hours	·113
Chlorine	7·3
Carbonic anhydride... ...	12·54
Sulphuric "	9·6
Lime	10·64
Magnesia	3·6
Sodium (no potassium) ...	4·75
Silica	1·26

Mineral constituents probably as follows :—

Sulphate of magnesia ...	14·4	Total 54·69.
Carbonate of lime	19·	
" " magnesia ...	7·98	
Chloride of sodium ...	12·05	
Silica	1·26	

Peckham—*continued.*

2. By W. W. Fisher, *Analyst*, August, 1901.

Depth of well 259 feet.

	Grains per gallon.
Total solids	35
Chlorine in chlorides ...	2·6
Nitrogen in nitrates ...	·014
Ammonia	·021
„ albuminoid ...	·004
Oxygen absorbed in 3 hours	·005
Hardness	29·6

The hardness of this water is notable.

Penge.

London and Provincial Steam Laundry. *See* pp. 210, 211.

Made by A. Wynter Blyth, July, 1892.

	In grains per gallon.
Chlorine	1·3
Nitrogen as nitrates	·0036
Free ammonia	Nil.
Albuminoid ammonia	·002
Organic nitrogen	·0049
Oxygen consumed in 15 minutes at 15° C. ...	·0045
„ „ 1 hour at 100° C. ...	·923
Hardness	17·
„ after boiling	5·5
Alkalinity calculated as carbonate of lime ...	14·
Total solid matter	26·25
Loss on ignition	5·25
„ „ from CO_2 (carbonic acid gas)	6·6
Lime (CaO)	7·52
Magnesia	9·2
Sulphuric acid in combinations...	2·7

Slightly turbid from the presence of finely divided ferruginous matter which was removable by filtration and contained no living organisms.

The hardness is about the same as that of the London waters, and diminishes on boiling to 5·5°. It may be softened to 2° by adding 1¼ lbs. of 90 per cent. lime and ⅓ lb. of good caustic soda to 1,000 gallons.

An excellent drinking water.

Reigate.

Old Waterworks. Wells in Lower Greensand. *See* p. 216.

Since absorbed by the East Surrey Co.

By Prof. C. M. Tidy, November, 1890.

Communicated by Messrs. Easton and Anderson.

	In grains per gallon. Well 1.	Well 2.
Total solid matter	23·8	17·6
Ammonia	·002	—
{ Nitrogen in nitrates and nitrites	·343	·375
{ Equal nitric acid	1·543	1·687
Oxygen required to oxidize the organic matter	·039	·015
Lime (CaO)	8·06	5·6
Magnesia (MgO)	·576	·504
Sulphuric anhydride (SO_3)	1·87	1·2
{ Chlorine	1·8	1·512
{ Equal common salt	2·95	2·478
Silica	·6	·6
Organic carbon, parts per 100,000	·124	·058
„ nitrogen „ „	·024	·022
Hardness, before boiling	18°	3·7°
„ after „	12·6°	3·6°

No. 1, turbid. No. 2, clear. Reaction very slightly alkaline in both.

Shere.

GOMSHALL TANNERY. Well in Lower Greensand. *See* pp. 224, 225.

By DR. A. ASHBY, October, 1888.

	In parts per 100,000
Chlorine	1·4
Nitrogen from nitrates (equal to nitric acid 1·16, no nitrous acid)	·3
Sulphuric acid	·12
Phosphoric acid	Very heavy traces.
Total solids (dried at 110° C.)	13·12
Loss on ignition of ditto	1·
Free ammonia	·0011
Albuminoid ammonia	·0036

Permanent hardness, 3·1 ; Temporary, 5· ; Total, 8·1.

Behaviour of residue on ignition ; scarcely changes.
Appearance in 2 foot tube ; clear ; pale blue.

The characteristics of this water are as follows :—It is very pure, being almost free from organic matter. It contains only a small quantity of mineral matter, and very little lime or magnesium-salts. It is soft. It contains a very small quantity of sulphuric acid, and of chlorine. It does not contain any iron or other metallic impurity, either in solution or as a deposit. The residue after evaporation and the water after being boiled are alkaline.

A partial analysis, of Sept. 1888, by MR. H. R. PROCTOR differs somewhat, being as follows :—

	Well.	Artesian Well.
Temporary hardness (carbonates)	16·5	6·5
Permanent hardness (sulphates)	9·52	3·4
Chlorine	2·13	1·59

The difference between the two waters is notable.

2. PUBLIC SUPPLY. ? From the boring alluded to on p. 224.
Made and communicated by DR. J. C. THRESH. June 1899.
In parts per 100,000.

Ca.	Mg.	Na.	CO_3.	SO_4.	Cl.	NO_3.		
4·2	·25	—	5·6	1·15	1·2	·9	Probable Combinations.	
3·7	—	—	5·6	—	—	—	Calcium carbonate	9·3
·5	—	—	—	1·15	—	—	„ sulphate	1·65
—	·25	—	—	—	·75	—	Magnesium chloride	1·0
—	—	·3	—	—	·45	—	Sodium „	·75
—	—	·35	—	—	—	·9	„ nitrate ...	1·25
							Silica, &c.	1·55

Total solid constituents dried at 180° C. ... | 15·5

Southwark.

1. BANKSIDE. Belfast and London Aerated Water Co., see p. 225.

By PROF. ATTFIELD.

From *Geology of London*, 1889, *vol.* 1, *table opp. p.* 533. Compiled by R. B. HAYWARD.

	In parts per 100,000.
Total solid contents	27·1
Chlorine	12·7

Hardness—Temporary 4·4° ; Permanent 8·6°. Total 13°.

Southwark—*continued.*

2. Guy's Hospital, see p. 229.

An account of Guy's Hospital Well, by Dr. W. Odling, 1860?. Also in *Chem. News*, vol. iii, pp. 35, 49. Sample taken May 1860.

"The water . . is bright and colourless . .. brisk and pleasant to the taste, and has a marked alkaline reaction . . Its temperature, when fresh from the well, was found to be 54°, that of the atmosphere being 65·5° F." The specific gravity at 60° F. is 1000·77.

The solid residue is composed of the following constituents, in grains per gallon :—

Chlorine	9·75	Total by summation 51·14 by direct experiment 51·69.
Sulphuric acid	9·24	
Carbonic acid	6·9	
Silicic acid	·79	
Lime	1·47	
Magnesia...	1·15	
Soda	13·87	
Sodium	6·32	
Potash	·66	
Phosphate of iron and Alumina	·05	
Organic matter	·94	

"A sufficient amount of sodium to combine with the whole of the chlorine was calculated as sodium, the remainder as soda."

"In the evaporated residue, the acid and basic constituents of the water seem to be combined with one another, somewhat in the manner indicated below":—

Chloride of sodium	16·05	Total residue 51·72.
Carbonate of soda	12·36	
Sulphate of soda	15·21	
Sulphate of potash	1·33	
Carbonate of lime	2·62	
Carbonate of magnesia ...	2·37	
Silica	·79	
Phosphate of iron and Alumina	·05	
Organic matter	·94	

Dr. Odling adds "that the mode in which the different constituents are combined in the residue, affords no information as to the mode in which they are combined in the water itself. It appears probable, indeed, that, in the water, every acid is united with every base . . Even the arrangement of the different constituents of the residue, to form definite salts, is to some extent a conventional affair." It was found indeed that "a portion of the silica existed in the state of silicate of soda."

The water is sparingly aerated, practically having no free carbonic acid (13·98 grains in a gallon, but not free). There were also 5·49 cubic inches of nitrogen, and ·91 of oxygen in a gallon of the water at mean temperature and pressure.

It is a soft water, the hardness, by Dr. Clark's soap-test, being only 5·5°, reduced by boiling to 1·5°.

3. The Exchange and Hop Warehouse Co., 24 Southwark Street.

Made and communicated by Messrs. Beadle and Stevens. November, 1904

Abyssinian well. Floor-level 16 feet above high water of the Thames. Water-level 23 feet down at high water and 29 at low water.

Through gravel and fine sand, about 34 feet, to London Clay.

Two samples (low level) gave 16·3 and 16·4 parts per 100,000 of chlorine. Two other samples (high level) gave 15·9 and 15·5 They conclude that the well derives from 10 to 14 *per cent.* of its water from the Thames.

In parts per 100,000.

	Sample 1.	Sample 3.
Saline ammonia	·011	—
Albuminoid ammonia	·01	—
Nitrates (no nitrites)	·081	—
Oxygen absorbed in ¼ hour	·067	·06
" " 4 hours	·128	·11
Total hardness (calculated as Ca CO_3)	24·2	23·6
Alkalinity	27	26

Southwark—*continued.*

3. The Exchange and Hop Warehouse Co.—*continued.*

These results indicate that the organic impurities, the saline constituents and the hardness are greater at the low than at the high level. This points to infiltration of impure Thames water, but this is largely filtered and purified by passing through sand and gravel, enough to make it suitable for flushing and washing purposes, but not for drinking.

Sutton.

Waterworks, see page 240.

By Dr. C. M. Tidy. January. 1890.

Communicated by Messrs. Easton and Anderson.

Eight samples taken from different parts of the works then in use, varied, as a rule slightly, and are fairly typified as regards 6 of them by No. 4 of the second set of analyses, which is also of a portion of the supply then in use. Two, however, shewed some marked variation, as follows.

A from large fissure 7 feet west of intermediate shaft in West Heading. From southern side of fissure.

B from large fissure 12 feet east of westermost shaft of heading; from northern side of fissure.

		A	B
Total solid matter	grains per gallon	23·6	33·24
Nitrogen in nitrates and nitrites	„ „	1·456	1·808
Lime (CaO)		10·08	12·26
Sulphuric anhydride	„ „	·8	1·53
Chlorine		1·44	2·376
Hardness before boiling ...		17·37°	21·22°

Four samples analysed by Dr. Tidy. July, 1890.

Communicated by Messrs. Easton and Anderson.

1, 2 and 3 are from a well then new which it was proposed to use as a new source of supply.

1. From vertical fissure 34 to 37 feet, 7 inches from engine-house floor-line. 2. From horizontal parting 45¼ feet from engine-house floor-line. 3. From horizontal parting 54 feet, 5 inches from engine-house floor-line. 4. From central shaft of old heading.

——		1	2	3	4
Total solid matter ...	... grains per gallon	31	30·6	35·6	28·8
Ammonia	„ „	None	None	None	None
Nitrogen in nitrates and nitrites	„ „	1·732	1·732	1·746	1·416
Oxygen consumed in oxidising the organic matter	„ „	·015	·018	·015	·015
Organic carbon	... parts per 100,000	·051	·052	·046	·048
„ nitrogen	„ „	·024	·03	·021	·021
Lime (CaO)	... grains per gallon	11·53	11·08	12·63	10·97
Magnesia (MgO)	„ „	Traces	Traces	Traces	Traces
Sulphuric anhydride (SO_3) ...	„ „	1·02	1·	1·33	1·05
Chlorine	„ „	1·8	1·94	2·088	1·534
Hardness. Degrees ...	... Before boiling	20·12	19·05	22·1	19·05
„ „ ...	... After „	5·9	4·9	5·5	4·9
Silica	... ...	·35	·28	·3	·35

All were clear, bright, and slightly alkaline.

In the 8 samples of Jan. 1890 (mentioned previously and six of which were very similar to 4) the oxygen consumed by organic matter was nil in all cases.

Sutton—*continued.*

WATERWORKS—*continued.*

Two samples analysed by DR. TIDY. Nov. 1890.

Communicated by MESSRS. EASTON & ANDERSON.

1. From the old heading. 2. From new well, from a fissure 109 feet below the surface.

		1	2
Total solid matter ...	... grains per gallon	27·2	23
Ammonia	" "	0	0
Nitrogen in nitrates and nitrites	" "	·52	·479
Oxygen required to oxidise the organic matter	" "	0	0
Organic carbon	... parts per 100,000	·038	·042
" nitrogen	" "	·02	·018
Lime (CaO)	... grains per gallon	10·3	9·63
Magnesia (MgO)	" "	Traces	Traces
Sulphuric anhydride (SO_3) ...	" "	1·2	1·09
Chlorine	" "	1·44	1·008
Hardness. Degrees	... Before boiling	18·63	16·95
" "	... After "	4·4	3·7
Silica	... ...	·6	·4

Both were clear and very slightly akaline.

DR. TIDY remarks in a letter to Messrs. Easton & Anderson on the low figure for nitrogen of the old supply (1), which had been condemned. The explanation of Messrs. Easton & Anderson was that the springs were then low and that as they rose the water deteriorated.

3 Samples. By DR. TIDY. Jan. 1891.

Communicated by MESSRS. EASTON & ANDERSON.

1. From Old Heading. 2. From New Well 180 feet down.
3. From New Well 129 feet down.

——		1	2	3
Total solid matter ...	... grains per gallon	28·2	24·	24·6
Ammonia	" "	0	0	0
Nitrogen as nitrates and nitrites	" "	·863	·552	·552
Oxygen required to oxidise organic matter	" "	0	0	0
Organic carbon	... parts per 100,000	·061	·046	·038
" nitrogen	" "	·022	·012	·01
Lime (CaO)	... grains per gallon	9·85	9·74	9·74
Magnesia (MgO)	" "	1·297	·324	·288
Sulphuric anhydride (SO_3) ...	" "	·533	·47	·47
Chlorine	" "	1·368	1·08	1·08
Hardness. Degrees...	... Before boiling	18·4	17·3	16·7
" " ...	... After "	4·8	3.7	3·7
Silica	... ...	·4	·4	·5

All three were clear and slightly alkaline. In all cases the total solids on evaporation were perfectly white. 2 and 3 are remarked on as peculiarly satisfactory.

Sutton—*continued.*

WATERWORKS—*continued.*

A later analysis of the Public Supply.

Made and communicated by DR. J. C. THRESH. April, 1899.

In parts per 100,000.

Ca.	Mg.	Na.	K.	CO_3	SO_4	Cl.	NO_3	PO_4		
12·4	·45	—	—	14·2	2·2	2·75	8·0	Trace	Probable combinations.	
9·5	—	—	—	14·2	—	—	—	—	Calcium Carbonate ...	23·7
·9	—	—	—	—	2·2	—	—	—	„ Sulphate ...	3·1
2·	—	—	—	—	—	—	6·2	—	„ Nitrate ...	8·2
—	·45	—	—	—	—	1·35	—	—	Magnesium Chloride ...	1·8
—	—	·9	—	—	—	1·35	—	—	Sodium „ ...	2·25
—	—	—	1·1	—	—	—	1·8	—	Potassium Nitrate ...	2·9
—	—	—	—	—	—	—	—	—	Silica, water of hydration, &c.	2·55
									Total solid constituents dried at 180° C.	44

Free ammonia	Nil.
Organic ammonia	·003
Oxygen absorbed in 4 hours at 27° C.	·066
Nitrites	Nil.

Thursley.

Boring at Cosford Mill. ? *see* p. 243.

Made and communicated by DR. J. C. THRESH. May, 1907.

	In parts per 100,000.
Total solid matter dried at 180° C. ...	22·2
Chlorine	3·
Nitric nitrogen	·013
Nitrites	Absent.
Lead, copper, zinc, iron...	Iron in suspension.
Free ammonia	·0022
Organic ammonia	·0006
Oxygen absorbed at 98° F. in 3 hours	·028

Hardness—Permanent, 5 ; Temporary, 6. Total, 11.

Turbidity : Reddish yellow sediment consisting of sand, iron and vegetable debris.

Colour : Yellowish. Odour : None.

Wandsworth.

WANDSWORTH ROAD, Lavender Hill. South Western Brewery.

By HASSALL.

From *Geology of London*, 1889, *vol i, table opposite p. 533.* Compiled by R. B. HAYWARD.

	In parts per 100,000.
Total solids ...	39·8
Calcium	2·4
Magnesium	2·3

Wandsworth—*continued.*

WANDSWORTH ROAD—*continued.*

	In parts per 100,000.
Sodium	6·2
Potassium	2·3
Carbonic acid (CO_3)	13·1
Sulphuric acid (SO_4)	7·2
Chlorine	2·
Silica (SiO_2) ...	1·7
Organic	1·7

Hardness—Temporary, 12·9° ; Permanent, 6·1°. Total, 19°.

West Clandon.

WOKING AND DISTRICT WATER CO. From the deep boring, *see* p. 251.

Made and communicated by DR. J. C. THRESH. April, 1899.

In parts per 100,000.

Ca.	Mg.	—	CO_3	SO_4	Cl.	NO_3		
8·2	·25	—	10·9	2·7	1·7	2·5	Probable combinations.	
7·25	—	—	10·9	—	—	—	Calcium Carbonate...	18·15
·95	—	—	—	2·3	—	—	„ Sulphate ...	3·25
—	·1	—	—	·4	—	—	Magnesium „ ...	·5
—	·15	—	—	—	·45	—	„ Chloride	·6
—	—	·8	—	—	1·25	—	Sodium Chloride ...	2·05
—	—	·9	—	—	—	2·5	„ Nitrate ...	3·4
—	—	—	—	—	—	—	Silica, &c.	·05
							Total solid constituents dried at 180° C.	28

Free ammonia	None.
Organic ammonia ...	·002
Nitrites	Nil.

Hardness—Temporary, 16° ; Permanent, 6°. Total, 22°.

Wimbledon.

1. By CAMPBELL.

From *Geology of London*, 1889, *vol. i, table opposite p. 533.* Compiled by R. B. HAYWARD.

	In parts per 100,000.
Total solid contents	32·6
Calcium	4·2
Magnesium	1·2
Sodium	5·3
Potassium	1·1
Carbonic acid (CO_3)...	13·7
Sulphuric acid (SO_4)	3·4
Chlorine	2·
Silica (SiO_2)	1·

Hardness—Temporary, 5·2° ; Permanent, 7·7°. Total, 12·9°.

Wimbledon—*continued.*

2. Cæsar's Well, Wimbledon Common [gravel-water].

By Miss Whiteley. 1899 ?

	In parts per 100,000.
Total solids ...	14·32
Chlorine	1·527
Inorganic ammonia	·00375
Organic ammonia	·028
Nitrogen as nitrite	trace
„ „ nitrate	·769

Temporary hardness, 0. Permanent, 5·29.

The mineral matter in the solids consisted of iron, aluminium, magnesium, calcium, and sodium, in the form of sulphate, chloride, and nitrate.

The water contains a large quantity of dissolved gases.

Witley.

King Edward Schools. Two well-waters.

Made and communicated by Dr. J. C. Thresh. May, 1907.

	In parts per 100,000.	
Total solid matter dried at 180° C. ...	16·4	9
Chlorine	3·2	3·2
Nitric nitrogen	·024	·24
Nitrites	Nil.	Nil.
Lead, copper, zinc, iron	Iron present in suspension.	Nil.
Free ammonia	·0012	·0004
Organic ammonia	·0022	·0026
Oxygen absorbed at 98° F. in 3 hours	·009	·064
Hardness—Permanent	6·	2·5
„ Temporary	·5	·5
„ Total	6·5	3·
Turbidity...	Iron present in suspension.	Slight deposit of vegetable debris.
Colour	Slight yellow.	Slight yellow.
Odour	None.	None.

Woking.

1. Brookwood Asylum. Upper shallow well (No. 2) on the estate.

Three analysis of the same water (1) by Dr. Stevenson, (2) by Mr. Wanklyn, (3) by Dr. [Sir E.] Frankland. 4 May, 1878.

From a report by the Medical Superintendent.

The samples were taken on the same day (? at the same time).

——	In grains per gallon.		
	1	2	3
Total solid matters	15·12	11·9	13·97
Chlorine	1·54	1·8	1·61
Equal to common salt	2·54	3	2·65
Nitrogen as nitrates and nitrites	·544	·4	·394
Iron	·001	none	n.s.
Ammonia, free	none	·0007	·001
„ organic or albuminoid	·003	·0028	—
Total ammonia	·003	·0035	—
Organic carbon	—	—	·76
„ nitrogen	—	—	·023
Total combined nitrogen	—	—	·418
Previous sewage contamination	—	—	3·724

Woking—*continued.*

1. Brookwood Asylum—*continued.*

Dr. Stevenson and Mr. Wanklyn agree that their samples are organically pure and fit for dietetic purposes.

Dr. Frankland says of his sample that it contains a small though well marked proportion of animal organic matter and is not safe for dietetic purposes.

Mr. Wanklyn states for purposes of comparison that the average drinking water of this country yields ·0056 grains per gallon of albuminoid ammonia.

(It is not clear whether the three samples analysed above were identical, though it would appear so from the table from which this is taken; but the analytical results seem strangely at variance.)

2. Sutton Place, between Woking and Guildford. *See* p. 257.

Made and communicated by Dr. J. C. Thresh. July, 1901.

In parts per 100,000.

Ca.	Mg.	—	CO_3	SO_4	Cl.	NO_3		
4·9	2·1	—	13·9	3·2	2·7	·13	Probable combinations.	
4·9	—	—	7·35	—	—	—	Calcium carbonate	12·25
—	2·1	—	5·25	—	—	—	Magnesium ,,	7·35
—	—	1·	1·3	—	—	—	Sodium ,,	2·3
—	—	1·5	—	3·2	—	—	,, sulphate	4·7
—	—	1·75	—	—	2·7	—	,, chloride	4·45
—	—	—	—	—	—	—	,, nitrate	·15
							Total solid constituents dried at 180° C. ...	31·2

Wonersh.

Chilworth. Springs [really shallow wells] in the north-eastern part of Brook's Wood, about half a mile S.S.W. of railway-station, for Chilworth and Wonersh water supply. *See* p. 259.

Made by Dr. S. Rideal, 1901.

	Parts per 100,000.
Total solid residue	17·4
Chlorine	1·64
Nitric nitrogen	·404
Nitrous ,, faint trace.	
Albumenised ammonia	·0026
Free ammonia...	nil
Oxygen consumed	·041

Bacterial examination. Organisms per c.c. at 20 C. 17; at 37·5 C., 2. No indol-producing organisms were isolated from 5 c.c. of the water.

"The water supply from these springs is suitable for a public supply in this district without filtration . . . it would be desirable for the wells to be protected in a more permanent manner" [than at present]. This has been done.

"The chemical examination shows that the soluble [organic ?] matter present is small in quantity and of vegetable origin. The nitrogen present . . is characteristic of the natural waters of this neighbourhood, and affords a good measure of the natural purification which is effected throughout this district."

"The bacterial examination shows that the total number of organisms present . . is small, and that they are of a harmless type."

From the RIVERS POLLUTION COMMISSION, SIXTH REPORT, 1874.

By Sir E. Frankland.

Source and Date.	In Parts per 100,000.											Remarks.
	Temperature. C.	Total Solid Impurity.	Organic Carbon.	Organic Nitrogen.	Ammonia.	Nitrogen as Nitrates and Nitrites.	Total combined Nitrogen.	Previous Sewage or Animal Contamination.	Chlorine.	Hardness. Temporary.	Hardness. Permanent.	Hardness. Total.	
Caterham Waterworks—													
12 May, 1868	11·	31·08	·02	·006	0	·027	·033	0	1·35	14·4	9·	23·4	Clear and palatable.
14 Feb., 1873	11·2	27·68	·028	·009	0	·021	·03	0	1·55	15·2	6·	21·2	Clear and palatable.
Clapham—													
Pump in Wandsworth Road 8 Sept. 1873... ...	—	133·32	·453	·133	·013	6·757	6·901	67,360	15·	8·2	48·5	56·7	Clear and palatable.
Pump corner of Clifton Street, Larkhall Lane, 8 Sept., 1873 ...	—	122·2	·287	·051	·51	5·793	6·264	61,810	8·4	9·	48·5	57·5	Turbid. Palatable.
Pump Larkhall Lane, near Wandsworth Road Railway Station, 8 Sept., 1873 ...	—	144·28	·435	·129	·019	4·383	4·528	43,670	12·2	·7	44·3	45·	Palatable.
Pump in Manor Street, 8 Sept., 1873 ...	—	138·08	·112	·04	·07	9·353	9·451	93,790	23·5	1·5	51·5	53·	Very turbid; slight saline taste.
Croydon Waterworks, 11 May, 1868. ...	13·5	32·	·04	·007	·001	·551	·559	5,280	—	12·9	9·1	22·	Clear and palatable.
Dorking, Burford Lodge, 12 Aug., 1873 ...	—	29·16	·057	·032	0	1·294	1·326	12,620	6·4	30·2	7·1	37·3	Clear and palatable.

Great Bookham— Well in sand 12 ft. deep ...	—	76·64	·145	·061	·001	3·53	3·592	34,990	4·1	12·	37·3	49·3	Slightly turbid. Palatable.
Well in sand 18 ft. deep ...	—	83·96	·772	·151	·012	2·282	2·443	22,600	10·75	21·1	28·2	49·3	Very turbid. Palatable.
Both 24 Jan., 1872. Mr. Wood's. 23 Jan., 1872	—	35·9	·094	·037	·003	·698	·737	6,680	1·75	19·7	6·6	26·3	Very turbid. Palatable.
Well in Eastwick Lane ...	—	41·36	·548	·155	·003	1·534	1·691	15,040	3·15	22·8	10·	32·8	Turbid. Dangerous; ought to be closed.
Well in Tanner Lane, Both 23 Jan., 1872 ...	—	32·16	·821	·131	·011	·518	·658	4,950	1·75	20·8	6·1	26·9	Slightly turbid. Palatable. Dangerous; ought to be closed.
Guildford Waterworks. 4 Oct., 1873	—	28·58	·06	·017	0	·413	·43	3,810	1·8	14·5	7·	21·5	Clear and palatable.
Pepherharrow—Old well at Rectory, August, 1869 ...	—	71·4	·014	·012	·001	6·722	6·735	66,910	14·3	3·2	19·2	22·4	An instance of sewage oxidised in passage through greensand.
Redhill Railway Station— Overflowing well, 14 Feb., 1873 ...	11	33·52	·054	·006	·001	0	·007	0	2·4	20·6	5·1	25·7	Slightly turbid. Palatable.
Southwark, Barclay's Brewery Old well, 9 July, 1869 ...	12·1°	73·3	·085	·008	·06	0	·057	170	14·08	4·5	2 8	7·3	From well 367 feet deep.
Newer well, 14 July, 1869	—	71·56	·055	·01	·075	·035	·107	650	12·9	4·	3·9	7·9	From well 143 feet deep.
Surbiton— Knowle's Cottage, Surbiton Hill. 18 March, 1870.	—	74·88	·504	·081	·001	4·086	4·168	40,550	6·4	6·7	25·6	32·3	———
Wandsworth— Lavender Sweep, March, 1871 ...	—	106·94	·281	·039	0	1·391	1·430	13,590	6·63	15·7	45·7	61·4	Clear.

RIVERS POLLUTION COMMISSION—*continued.*

Source and Date.	Temperature. C.	Total Solid Impurity.	Organic Carbon.	Organic Nitrogen.	Ammonia.	Nitrogen as Nitrates and Nitrites.	Total combined Nitrogen.	Previous Sewage or Animal Contamination.	Chlorine.	Hardness. Temporary.	Hardness. Permanent.	Hardness. Total.	Remarks.
	In Parts per 100,000.												
Wandsworth—*cont.* St. Ann's Hill ... ... March, 1871.	—	76·	·479	·109	·002	4·875	4·968	48,270	6·28	5	27·9	32·9	Clear.
Wimbledon— Well 25 ft. deep at Sunnyside. March, 1871 ...	—	46·	·223	·035	0	·633	·668	6,010	4·2	12·1	18·6	30·7	Clear.
New Wimbledon— Borehole on Common 7 July, 1868 ...	12·5	33·38	·063	·038	·004	·047	·088	182	2·38	6·3	7·	13·3	Clear and palatable. (Well 200 ft. deep.)
Woking— Tube-well near Prison ... 7 Nov., 1868.	—	23·18	·228	·098	·004	0	·101	0	2·48	7·5	5·6	13·1	——
In Woking Prison ...	—	31·66	·224	·026	·004	·064	·093	350	3·57	4·9	7·8	12·7	Clear and palatable. (Well 100 ft. deep.)

MISCELLANEOUS.

There are a few subjects which do not readily find a place under any of the headings that have gone before, but which should not be neglected, for some of them are of considerable interest. It seems better, therefore, to put them together here.

Relation of Ground-water to Disease.

This subject has been under notice for many years, and is alluded to in two Reports on Croydon, published in 1853, in which the prevalence of fever was attributed to some extent to dampness of the soil, after a wet season, and to the occurrence of the Bourne[1]. Mr. Baldwin Latham, nearly 40 years later took up the question systematically, also with special reference to the Croydon district, and extracts from his paper will now be given.[2]

Speaking generally he says, " when the ground waters . . . have arrived at a considerable degree of lowness, as evidenced by the failure of springs and the drying up of rivers . . . such periods have always been accompanied or followed by epidemic disease."

" It will be found, in all probability, that ground water in itself, except under conditions where it is liable to pollution, has no material effect in producing or spreading disease. As a rule it is only in those places in which there has been a considerable amount of impurity stored in the soil that diseases become manifest, and the most common mode by which diseases are disseminated, is by means of the water supplies drawn from the ground, or by the introduction of contaminated ground air into the habitations of the people. It will also be found that the periods of low and high ground-water mark those epochs when certain organic changes take place in the impurities stored in the earth, and which ultimately become the cause, and lead to the spread of disease."

His definition of ground-water is:—" All water which is found in the surface soil, except such as may be in combination with the materials forming the crust of the earth," and this definition is important as the term is sometimes used for all such water, from the surface to considerable depths.

" The study of underground water shows that certain diseases are more rife when the water is high in the ground, and others when the water is low. The conditions that bring about and accompany low water, however, have by far the most potential influence on health, as all low water years are . . . unhealthy. As a rule the years of high water are usually healthy, except that it often happens when high water follows immediately upon marked low water that on the rise of the water an unhealthy period follows."

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[1] Statement . . . on the Epidemic at Croydon; together with Reports . . . to the General Board of Health . . . 8° *London*, pp. 4, 12, 13, 33, 47.

Reports (to the Home Office) . . . relative to the Prevalence of Disease at Croydon . . . Fol. *London*, p. 5.

[2] *Quart. Journ. R. Micr. Soc.*, 1891, n. ser., vol. xvii., pages referred to, 2, 6, 9, 12–14, 16, 17.

Small-pox seems to have occurred only (as an epidemic) after a long period of dryness of the ground.

"Typhoid fever is always more rife while the waters are rising in the ground than when they begin to diminish." He alludes to "the first great epidemic of fever in Croydon," in the autumn of 1852, "which occurred with a very rapid rise of the subsoil water," and which was the subject of the two Reports above noted. But this was preceded by very low water, the River Wandle suffering from deficiency. "In 1865 and 1866 there was a further epidemic of typhoid. Preceding this epidemic the Croydon branch of the River Wandle was . . . dry." In "1875 and 1876 was the last great epidemic, when again it was reported that the Croydon branch of the River Wandle was again dry."

"The figures of 1875 show that there was two periods . . . when the disease was at its maximum . . . in April—a most unusual period—and in October, the disease occurring in the spring of 1875 at a much later period than that at which the ground waters ordinarily commence to rise," and the cause of this was that the rise of the ground-water was delayed to the time in question.

Diphtheria requires the opposite conditions for its development to those for typhoid fever and small-pox. "During the whole of the last 5 years (= 1886-1890) the ground at Croydon has been in a continual state of dampness, as indicated by the records of the percolation gauges, and during the whole of that period diphtheria has been more or less rife."

Scarlet fever, however, goes with dryness of the ground, and the conditions that precede those for small-pox are those favourable for its development. It is most rife, therefore, in the years preceding small-pox, that is in low-water years.

Measles in Croydon apparently follows the opposite law to typhoid fever: as a rule this disease "is most rife in a low water year, especially following another low water year."

Whooping cough depends on dampness of the ground for its development, "and has been particularly rife during the past five years (=1886-1890), during which time there has been a marked dampness of the ground."

Diarrhœa depends largely on high temperature, but it is generally more prevalent in a low water year than at other times.

The general death-rate of a district is affected by the state of the ground-water. Years of drought and low water are the most unhealthy.

Gases in Wells and Well-waters.

Dr. J. Mitchell notes fatal effects due to the occurrence of carbonic acid gas "in a well near the race-course at Epsom, where it was met with at the depth of 200 feet; and in Norbury Park, near Dorking, at the depth of 400 feet "(?) These are both in Chalk.

Of sulphuretted hydrogen he says, "At Ash, 3 miles from Farnham, a well was dug in sand to the depth of 36 feet, and one of the workmen on descending into it was instantly suffocated."[1]

[1] *Proc. Geol. Soc.*, 1839, vol. iii., no. 65, p. 151.

"Noxious air" is recorded from the London Clay in an old well at Manor House, Wimbledon (*see* p. 254), and "a very offensive odour" from wells at Windlesham (*see* p. 256).

The nitrogen and oxygen in the water of the well at Guy's Hospital have been noted by Dr. Odling (*see* p. 307).

Dr. H. M'Leod has recorded experiments made for the determination of the gases in solution in well-waters.[1] The few results obtained made it "impossible to do more than point out the small quantity of oxygen in the waters from deep wells as compared with those from shallow ones, and with rain- and river-waters. The quantity of nitrogen is also very remarkable, as being in all cases . . . in excess of the amount absorbable by distilled water."

Of the six well-waters experimented on, two were from Surrey, from two wells at Messrs. Barclay's Brewery, Southwark (*see* p. 226). The older well reached into the Chalk and the newer one, which was in course of construction, did not, being only 143½ feet deep when the sample of water was taken. The following are his results:—

		Newer Well.	Older Well.
Temperature at time of collection ...		12·1° C.	12° C.
Results are the mean of		2 experiments.	4 experiments.
Volumes of gases in 100 volumes of water.	Nitrogen ...	2·03	1·973
	Oxygen ...	·029	018
	Carbonic Anhydride	5·765	3·814
	Total ...	7·824	5·805

The solubility of Nitrogen in 100 volumes of distilled water at 12° C. is, according to Bunsen, 1·549.

The Law of Underground Water.

In this matter Surrey is well to the front, the most notable case, as for the most part settling the law of the question, being one connected with Croydon. There is no need to go to the original reports of this case, as that eminent authority Mr. J. Shiress Will, Q.C., has given an account of it from which I will now give quotations.[2]

"The law with regard to the question of ownership in underground water first became definitely settled in the year 1859 by the case of *Chasemore* v. *Richards* . . . The plaintiff was the occupier of an ancient mill on the River Wandle, and for more than sixty years he and the preceding occupiers of the mill had used and enjoyed as of right the flow of the river for the purpose of working their mill. The defendant represented the members of the Local Board of Health of Croydon . . . who, for the purposes of supplying the town of Croydon with water, sank a well to the depth of 74 feet in their own land in the town of Croydon and about a quarter of a mile from the River Wandle, and pumped up large quantities of water from their well." Thus the Local Board "diverted, abstracted, and intercepted underground water (but underground water only) that otherwise would

[1] *Rep. Brit. Assoc.* for 1869, pp. 55–57 (1870).

[2] Surveyor's Institution. Trans. 1900, vol. xxxii., pt. viii., pp. 255, 256, 260, 266, 267.

have flowed . . . into the River Wandle, and so to the plaintiff's mill. The quantity so diverted . . . was sufficient to be of sensible value towards the working of the plaintiff's mill. The water so diverted was underground water flowing in no defined channel. . . . The judgment of the House of Lords was unanimous. They held that the principles which regulate the rights of owners of land in respect to water flowing in known and defined channels, whether upon or below the surface of the ground, do not apply to underground water which percolates through the strata in no known channels."

He then quotes from the judgment of LORD CRANWORTH, one of the five lords who took part in the case, as follows:—"The right to running water has always been properly described as a natural right, just like the right to the air we breathe; they are the gifts of nature, and no one has a right to appropriate them. [How about the land we live on?] There is no difficulty in enforcing that right, because running water is something visible, and no one can interrupt it without knowing whether he does or does not do injury to those who are above or below him. But if the doctrine could be applied to water merely percolating . . . through the soil and eventually reaching some stream, it would always be a matter that would require the evidence of scientific men to state whether or not there had been interruption, and whether or not there had been injury. It is a process of nature not apparent, and therefore such percolating water has not received the protection which water running in a natural channel on the surface has always received."

For two previous cases the reader is referred to MR. WILL's paper. Since the above decision, however, "the evidence of scientific men" has been largely used to prove or disprove interruption and injury; but as MR. WILL continues:—"The principles laid down in the case of *Chasemore* v. *Richards* have never been shaken or departed from. In every case that has arisen since then the difficulty has been not whether the decision . . . was right, but rather its application to the facts of the particular case," and this he illustrates by a notice of seven cases, none of which refer to Surrey.

Then comes the question: What is a known and defined channel? And here we are given the words of LORD CHELMSFORD, one of the five lords referred to, which are as follows:—"a certain and defined course, whether in an open visible stream or in a known subterranean channel," as contrasted with "water percolating through underground strata, which has no certain course, no defined limits, but which oozes through the soil in every direction in which the rain penetrates." And again he distinguishes "between water flowing in a definite channel and water, whether above or under ground, not flowing in a stream at all, but either draining off the surface of the land or oozing through the underground soil in varying quantities and in uncertain directions." But he agrees with Lord Chief Baron Pollock (in another case) that "if the course of a subterranean stream were *well known*, . . . as is the case with many which sink underground, pursue for a short space a subterraneous course, and then emerge again, it never could be contended that the owner of the soil under which the stream flowed could not maintain an action for the diversion of it if it took place under such circumstances as would have enabled him to recover had the stream been wholly above ground."

MR. WILL then cites a case of an underground channel held to be *defined*, but not therefore *known*. Naturally this is an Irish case; but it is followed by another, from the same part of the kingdom, in which a defined and known underground channel settled the question. But these and other matters do not refer to Surrey.

In replying to the discussion on his paper, in which suggestions as to the advisability of altering the law were made, MR. WILL said, "Underground water was something which one could neither see nor follow. How was it possible to attach rights of ownership to that which could neither be seen nor followed."

The practice of Parliament, however, differs somewhat from that of the Law, and is not bound by the latter. Consequently, in the discussion of private bills before Committees Parliament has been able to redress various risks of damage that are hardly provided for by the Law, and two cases of this sort in our county may be noticed. I well remember both, having been engaged in them.

The first has been described by that eminent engineer, MR. J. MANSERGH,[1] who says:—"The Croydon Corporation sought power to sink two wells and drive headings in the chalk, one at (or rather in the parish of) Beddington and the other at Addington. The latter was not opposed, but the Beddington one was very strongly by the millowners and riparian owners on the River Wandle." It was thought that this opposition might fail to get a *locus standi;* but it did, "and satisfied the Committee that the volume of water in the Wandle would be diminished (though the proposed site was a long way from the river) if water were pumped as proposed. They had also been told that under the law no compensation could be claimed, and, on fully realising the position, they sanctioned the unopposed well and struck out the opposed. This, it appears to me, was equivalent to saying that under the law an injustice might be done, and they preferred to prevent that injustice by stopping the sinking of the well."

The Corporation of Croydon, however, is limited as to the amount to be pumped at Addington, which is not to exceed what is equivalent to about a million gallons a day.

The other case refers to the neighbouring town of Sutton and has already been alluded to, but not from the legal point of view (*see* p. 80). It has been described by MR. W. V. GRAHAM and MR. H. F. BIDDER, from whose paper the following remarks are taken.[2]

"The water company own a well sunk in the chalk at Sutton. The railway company own a field alongside their railway, about

[1] The Law and Allocation of Underground Water. Read to the Engineering Conference of Inst. Civ. Eng. in 1897.

[2] Underground Water. A Discussion on certain recent Enactments affecting Water Rights. *Trans. Surv. Inst.*, 1907, vol. xxxix., pt ix., p. 307 (pp. 326–332).

half a mile from this well. In this field the railway company sank a two-foot boring to a depth of 350 feet, and erected a powerful pump, with the intention of conveying the water they obtained along their line to a considerable distance and using it. This boring was within half a mile of the Carshalton springs of the Wandle, and (so those interested in the river asserted) directly in the line of flow of the underground water to those springs . . ."

A railway-company has an exceptional property, a strip of land very many miles long, and for the most part only some yards broad, "which can incidentally be used for the distribution of water," not for sale, but for the company's use "up and down their line for stations, hotels, carriage washing, and other purposes," a use "different to that of any other owner (of land) except established water companies," and this use of the land belonging to the railway was probably not thought of when the company was created.

"The Sutton Water Company were alarmed at the proximity of this boring to their wells, and feared that the extensive use that would no doubt be made of the water obtainable would affect their own supply. They were advised that nothing illegal was being done or proposed by the railway company. They therefore made common cause with the local authorities and other persons interested . . . and, as a last resort, promoted a Bill in Parliament, prohibiting any person (without the express authority of Parliament) from conveying water from any well or water-course within the area of supply of the water company for sale or use outside that area."

"The Bill, though in form of general application, was avowedly aimed at the railway company."

"As a preliminary measure, a Bill which the railway company were then promoting (and which did not deal with this scheme) was opposed in the House of Commons on second reading, on the ground that the company were making an oppressive use of their position. In the debate that followed, the Secretary for the Board of Trade said that for a railway company to take water at Carshalton and bring it to London was, in the opinion of the Board, an enlargement of their powers for which they should not press. It was constituting themselves a *quasi* water company. He had represented this to the railway company, who had undertaken to restrict the use of the water to places within six miles of the well," and the bill was then passed. The six miles however "included large carriage-washing sidings . . . and 43 stations" and therefore the promotion of the Water Company's bill was continued.

"The whole strength of the case for such an unprecedented measure depended upon its being possible to show that extensive pumping at a well located where the boring of the railway was, would, in fact, seriously affect the River Wandle and the well of the water company. The contention of the railway company was that, as they would pump from a depth of 350 feet, . . . they would draw upon . . . the deep chalk, without affecting . . . the surface springs or the comparatively shallow wells."

It was proved by a three days' pumping test at the boring that springs were affected, as described above (pp. 80, 81), and the Bill became law.

In a later paper[1] Messrs. Graham and Bidder refer to another Surrey case, again one in which I was concerned, and may therefore describe to some extent myself.

"The Corporation of Croydon in 1897, seeking additional sources of supply . . . applied to the Local Government Board for sanction to a loan for the purpose of sinking a well at Waddon near the head water of the Wandle" (Croydon branch). "An inquiry was . . . held, at which the riparian owners were heard; and the application was refused," but not on account of the opposition as to the Wandle.

The Corporation, however, being in need of a further supply, made borings, and afterwards a well and pumping station, paying for the whole out of the rates, as they could do without sanction from any body, the ground being within the borough and the property of the Corporation.

From this it followed that "in 1908 those interested in the Wandle found themselves faced with the prospect of having large quantities of water abstracted underground above the springs of their river. . . . In these circumstances they promoted a late Bill, which eventually became the River Wandle Protection Act, 1908, the object of which was to restrict the power of the Corporation to sink or use wells that had not been specifically authorised by Parliament. The rules of both Houses were suspended to enable their Bill to be brought forward, and in the end a compromise was arrived at under which the Corporation were deprived of their power in the future to sink wells that would affect the Wandle, but were enabled to use their Waddon well, subject to a limitation as to quantity." That limitation was not more than 50 million gallons in 30 days, and the Corporation agreed to this rather than enter on what would have been a costly struggle. The Borough Engineer, Mr. G. F. Carter, has told me that without this pumping station the town might have been in serious straits for some days in 1911; but there has been no occasion as yet to pump to the full amount.

From the above it will be seen that short and small as it is the River Wandle has played a most important part in the law of underground water and in legislation connected therewith. No river-basin, I believe, has been more in evidence before Parliament during a long course of years. It was also specially referred to by Mr. C. H. Cooper in a paper on "Ownership of Underground Water,"[2] in connection with the effect of the pumping from the Streatham well of the Southwark and Vauxhall Company (*see* above, p. 80) and the probable effect of pumping from the same Company's wells at Mitcham.

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[1] Judicial and Parliamentary Decisions with regard to Rights in Underground Water since 1907. *Trans. Surv. Inst.*, 1911, vol. xliii., pt. viii. Discussion continued in pt. x. Pages noted, 379, 380.

[2] Journ. San. Inst., 1896, vol. xvii., pt. iv, p. 385.

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Index Maps.—Scale 4 miles to the inch

Sheet 12. Includes the whole county. 1890.

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Horizontal Sections.

1867. (Revisions 1882). Sheet 75. Section from the Chalk, west of Worthing, across the Weald, the Lower Greensand of Leith Hill, the Upper Cretaceous Beds near Dorking and Leatherhead, the Eocene Formations between Fetcham and Esher, and the Gravel and Alluvium of the Valley of the Thames. (Surrey part by W. Topley).

——. Sheet 76. Section from the Coast of Sussex . . across . . the Wealds of West Sussex and Surrey to the Chalk of the North Downs N.E. of Merstham, Surrey. H. W. Bristow, W. Whitaker, and W. Topley.

1868. Sheet 73. Section from the middle Eocene Strata at Selsea Bill, Sussex, to the Bagshot Sands of Chobham Ridges, Surrey; across the Wealds of West Sussex and Surrey . . . . (Surrey part by W. Whitaker, C. Le N. Foster, and W. Topley.)

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ADDENDA.

The following information has come to hand too late for insertion in the proper places.

Wells.

Epsom.

Waterworks.

Trial-boring 1903, 13 yards north of the Garden Well.
Communicated by Mr. W. V. Graham (and by H. Dewey).

		Thickness. Feet.	Depth Feet.
	Sand and flints	8	8
(Reading Beds.)	Mottled clay	4	12
	Red clay	5	17
	Blue clay	2	19
	Brown clay	3	22
	Green sand	11	33
	Sand and shell (*ostrea bellovacina*)	4	37
	Black sand...	7	44
(Thanet Sand.)	Grey sand	20	64
	Sand and flints, to chalk and flints	1	65

Guildford.

Waterworks.

From C. G. Mason's paper. (*See* p. 333.)

In 1701 a grant was made by the Corporation to W. Yarnold for the erection of a water-wheel and pumps to supply the town with water from a well adjoining the town-mills. This venture developed into a Company, of which the Corporation held 3½ out of the 8 shares. In 1865 the Corporation acquired the undertaking.

The supply was taken from wells under an old power-house now used as the Public Mortuary. This is the Old Waterworks alluded to above, pp. 85, 86, 301. The site is but a very short way, hardly 100 feet, eastward of the Millmead Works.

In 1871 the present site was purchased and the well 36 feet deep and of 8 feet diameter was sunk, with cylinders about 8 feet into the Chalk (below Alluvium, etc.). This supplies about 800,000 gallons in 24 hours.

In 1893 the adjoining flour-mills were purchased, the Corporation thus acquiring the whole of the water-power at this part of the Wey.

The boring described above, pp. 172, 173, is No. 1, and is lined to the depth of 100 feet below the engine-room floor (from which the measurements are made). Borehole No. 2, made in 1910, is 18 inches in diameter and lined to the depth of 102 feet below the ground-level, which is 2 feet 7½ inches below the engine-room floor. Only a small quantity of water is taken from it.

Its section is as follows, from plate 4 of the paper.

		Thickness. Ft.	Thickness. Ins.	Depth. Ft.	Depth. Ins.
Engine-room floor to ground-level		2	7½	2	7½
Made ground...		6	10½	9	6
[River Gravel.]	Loamy sand ...	9	—	18	6
	Sandy ballast ...	9	—	27	6
[Upper and Middle Chalk.]	Chalk and flints ...	85	3	112	9
	Chalk rock ...	15	3	128	—
	Chalk and flints (4,000 gallons of water an hour at 174 feet)...	65	9	193	9
	Hard grey chalk ...	26	9	220	6
	Chalk rock (layer of flints at 315 feet)	116	1½	336	7½

Tooting.

Burmester Road. Holland House Laundry. 1912.

? 35 feet above Ordnance Datum.

Communicated by Mr. W. Piper and the New England Boring Co.

Lined with 5-inch tubes to 280 feet down.

Water overflowed. Pumping at 2,200 gallons an hour reduced the level to 50 feet down.

	Thickness. Feet.	Depth. Feet.
Sand and gravel	12	12
Gravel...	3	15
London Clay...	155	170
Sand	9	179
Woolwich and Reading Beds	60	239
Thanet Sand	33	272
Chalk	58	330

Witley.

Waterworks. Brook Street, about 1¼ miles west of Witley Station.

Made and communicated by Messrs. Duke and Ockenden. 1911.

Dug well 62 feet, bored to 105 feet.

Water-level 40 feet down. No fresh water.

	Thickness. Feet.	Depth. Feet.
Dug well	—	62
Sand [? Hythe Beds]	36	98
Clay [? Atherfield]...	7	105

Analyses.

Farnham.

Tilford, from a well about 30 feet deep, in Lower Greensand.

Made and communicated by W. T. Burgess. April, 1910.

In parts per 100,000.

Practically clear.	
Total solid residue	10·52
Organic carbon	·115
,, nitrogen	·013
Ammonia, free and saline	·001
,, albuminoid	·0035
Nitrogen as nitrates	Trace
,, ,, nitrites	0
Total combined nitrogen	·013
Oxygen consumed (4 hours at 26·7° C.)	·055
Combined chlorine...	1·
Hardness—Total	5·7
,, Temporary	1·8
,, Permanent	3·9

Horley.

RAILWAY STATION. *See* p. 176.

By DR. E. L. JACOB, Medical Officer of the Surrey United Sanitary District, 1879.

Communicated by C. E. HAWKINS.

Colour, none. Transparency, clear. Odour, when warmed to 98° F., none. Appearance of residue, before, during and after ignition, good. Hardness, 2°.

Total solids (grains per gallon)	38·36
Loss on ignition (grains per gallon)	2·52
Chlorine (grains per gallon)	1·2
Free ammonia (parts per million)	·26
Albuminoid ammonia (parts per million)... ...	·05
Nitrites	None
Lead or iron	None
Oxygen absorbed from potassium-permanganate in 3 hours, acting in the cold (grains per gallon)	·136
Sulphates	A mere trace

Streatham.

DEEP WELL of the Metrop. Water Board. *See* pp. 234–238.

From Report on . . . the Chemical and Bacteriological Examination of the London Waters for the Twelve Months ended 31st March, 1911, p. 45. By DR. A. C. HOUSTON.

In parts per 100,000.

Alkalinity as calcium-carbonate	22·93
Temporary hardness, 16·63. Permanent, 6·37.	
Total lime	12·2
,, magnesia	1·39
Sesquioxides of iron and alumina	·06
Silica	1·22
Sulphates as SO_3	2·47
Combined chlorine	1·45
Oxidised nitrogen	·06
Total solids	30·82
Probably combined as follows :—	
Calcium-carbonate	21·79
Magnesium ,, ...	·96
,, sulphate	2·78
Sodium ,, ...	1·1
Chlorine as NaCl (+ a little KCl)	2·4
Sodium-nitrate	·36
Sesquioxides of iron and alumina	·06
Silica	1·22
	30·67
Difference	·15

Woking.

WATER COMPANY.

Made and communicated by DR. R. W. C. PIERCE.

1. Dapdune Well, Stoke, Guildford, Dec. 1904. 2. West Clandon Well, Jan, 1905. 3. West Horsley Well.

The average of several samples.

———		1	2	3
Total hardness	grains per gallon	17	15	15
Permanent hardness	" "	4	4	4
Total solids	" "	21·7	21	21
Chlorine...	" "	1·1	1	1
Nitrites	" "	0	0	0
Nitrogen as nitrates	" "	·23	·35	·45
Free ammonia	parts per million	Traces	0	0
Albuminoid ammonia	" "	·015	Traces	·015

All three have only traces of organic matter.

Camberwell.

HONOR OAK PUMPING STATION, Metropolitan Water Board. *See* p. 125.

Made by SIR W. CROOKES. Dec. 31, 1901.

Communicated by MR. J. W. RESTLER.

	Grains per gallon.
Total solid matter	25·3
Colour of residue, white.	
Chlorine (equal to chloride of sodium, 1·77)	1·08
Nitrogen as nitrates and nitrites	0
Nitrogen as ammonia	·007
Oxygen required to oxidise organic matter	·012
Organic carbon	·035
Organic nitrogen	·008

Hardness, 22·79 ; after boiling for a quarter of an hour, 6·79.

Appearance, clear ; colour, 4·20 ; odour, none ; reaction slightly alkaline.

The analysis confirms the excellent quality of the water, showing this sample to be somewhat better than one taken on Dec. 12, 1901.

BOURNE.

In the *Croydon Advertiser* of February 3rd, 1912, MR. B. LATHAM announced that the Wandle Bourne would rise below the 'Rose and Crown' on the 7th or 8th, the Editor adding that he "has certainly a justification for his prophecy, seeing that he has successfully foretold the flow on 14 previous occasions between 1877 and 1910." The water promptly appeared and was soon followed in the other branch of the valley, at Smitham Bottom, where I saw a small flow on February 14th.

On the 19th I saw the main stream, which had then reached down to over half way between the 'Rose and Crown' and Garston House, when the water gradually sank again into the earth. It continued to extend in its downward course and by the end of the month had got down to Purley. At this time the amount flowing, presumably at the part where it was highest, had reached a million gallons a day, as MR. LATHAM told me.

In the first week of March it had flooded the old gravel-pit on the south of the Tramway Depôt and some ten chains N.E. of Purley Church; but its ordinary course was then blocked, at Christchurch Road, and the flow was diverted into the Croydon surface-water-drain. At the end of March the stream had spread further upward, and though it did not flow through the grounds of the 'Rose and Crown,' it appeared again just across the road, the water being round great part of the gasholder, above which there was a flow for some way.

MR. LATHAM tells me that on April 19th the flow amounted to over 3,880,000 gallons a day, a little below the Rose and Crown, and that afterwards it began to decrease, ceasing about June 25th.

The following analysis of the water was made by MR. W. T. BURGESS, who says that the sample was taken about 100 yards above the footpath across the valley, at Garstone Farm, on 14th March, when the stream was flowing there at the rate of about 750,000 gallons a day :—

	Parts per 100,000.
Total solid residue	36·56
Ammonia, free	·001
,, albuminoid	·0035
Oxygen consumed in 4 hours at 26·7° C. ...	·034
Nitrogen as nitrates	·814
,, ,, nitrites	0
Chlorine	1·55
Hardness, total (by soap-test)	28·1
Carbonates, calculated as carbonate of lime	24·

Slightly turbid.

It is notable that the solid residue and the hardness are a good deal higher than with the water of the Kenley Works, but little lower down the valley, *see* p. 294.

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RAINFALL MAP

OF

SURREY.

By H. R. Mill, D.Sc., LL.D.

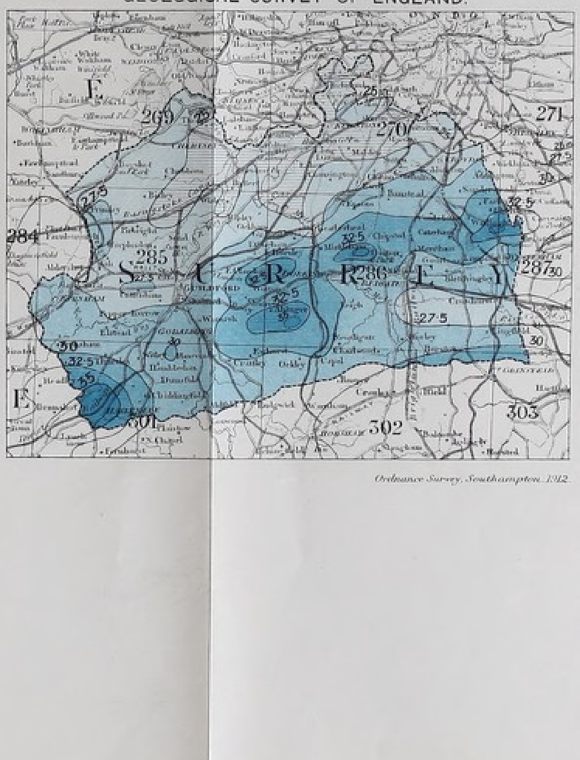
REFERENCE.

Rainfall below 25 inches
,, between 25 & 27·5 inches
,, ,, 27·5 & 30 ,,
,, ,, 30 & 32·5 ,,
,, ,, 32·5 & 35 ,,
,, above 35 ,,

Scale—1 Inch = 10 Miles.

NOTE.—The larger numerals indicate the Nos. of the New Series One Inch Ordnance Survey Maps.

GEOLOGICAL SURVEY OF ENGLAND.



Ordnance Survey, Southampton. 1912.