**Reports to the Right Hon. William Cowper, M.P., president of the General Board of Health, on the metropolis water supply, under the provisions of the Metropolis Water Act.**

# GENERAL BOARD OF HEALTH.

# REPORTS

TO THE

## RIGHT HON. WILLIAM COWPER, M.P.,

PRESIDENT OF THE GENERAL BOARD OF HEALTH,

ON THE

# METROPOLIS WATER SUPPLY,

UNDER THE PROVISIONS
OF THE METROPOLIS WATER ACT.

Presented to both Houses of Parliament by Command of Her Majesty.

LONDON:
PRINTED BY GEORGE E. EYRE AND WILLIAM SPOTTISWOODE.
PRINTERS TO THE QUEEN'S MOST EXCELLENT MAJESTY.
FOR HER MAJESTY'S STATIONERY OFFICE.

1856.


METROPOLIS WATER SUPPLY.
Plan
DISTINGUISHING THE SITES OF THE WORKS
AND THE
DISTRICTS SEVERALLY SUPPLIED
BY THE
Water Companies.
1856.
NEW RIVER
HAMPSTEAD
WEST MIDDLESEX
GRAND JUNCTION
EAST LONDON
CHELSEA
LAMBETH
SOUTHWARK AND VAUXHALL
KENT
PLUMSTEAD
LAMBETH
REFERENCE.
SCALE

GENERAL BOARD OF HEALTH.

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# PART I.

## CHEMICAL.

REPORT on the CHEMICAL QUALITY of the SUPPLY of WATER to the METROPOLIS; by A. W. HOFMANN, Professor of Chemistry in the Metropolitan School of Science, and Chemist to the Museum of Practical Geology, F.R.S.; PH. D.; LL.D. &c., and LINDSEY BLYTH, Esq., Lecturer on Natural Philosophy at St. Mary's Hospital.

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LETTER from the Right Hon. WILLIAM COWPER, M.P., President of the General Board of Health.

General Board of Health,
Whitehall, Jan. 3, 1856.

GENTLEMEN,

I HAVE to request that you will examine and report upon the water now supplied to the metropolis by Water Companies, in pursuance of the Metropolis Water Act, 1852.

The object I have in view being to judge of the salubrity of the water delivered for the consumption of the inhabitants of London, I would suggest that your analyses should be directed to ascertain the degree of hardness, permanent and temporary, of the water, and the total admixture of matters foreign to its chemical composition, distinguishing the suspended from the dissolved, the mineral from the organic, and among the latter to specify, as far as may be practicable, those which are putrefiable.

I have, &c.

Professor Hofmann,
Lindsey Blyth, Esq.

WILLIAM COWPER.

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REPORT by Professor HOFMANN and Mr. BLYTH.

SIR,—WE have now the honour to report to you the results obtained in the analysis of the water-supply to the metropolis, which we have undertaken at your request.

The object of the inquiry being to obtain a view of the value of the waters in a sanitary respect and for domestic purposes, it was thought advisable to exclude from the investigation all details which did not directly affect this question.

In accordance with your instructions we have therefore confined ourselves in the analyses to:—

I. The determination of the hardness of the waters, *a.* before boiling (permanent and temporary hardness), and *b.* after boiling (permanent hardness).

II. The determination of the total amount of solid matter contained in the waters.

III. The determination of the organic matter contained in the waters.

It was, moreover, considered important to repeat these determinations from time to time, so as to obtain some insight into the variations of the waters during the several seasons.

Of the above three determinations, the examination of the organic matter which is present in waters is of an especial interest in a sanitary point of view. This examination is attended with very considerable difficulties. The accurate determination of the quantity of organic matter in a water is one of the most delicate operations in analytical chemistry. Still greater is the difficulty of examining into the nature of the organic matter; the total amount of organic matter is so small that immense quantities of water must be evaporated in order to obtain the material upon which to work, and few indeed are the data upon which a satisfactory examination of this kind can be founded at the present moment.

Very little is known of the nature of the ill-defined substances which constitute the organic matter generally found in water. Berzelius distinguishes two substances, crenic and apocrenic acids, which slightly differ in their chemical deportment; but these two bodies are as yet scarcely chemically examined, and much doubt still hangs over their individuality and even over their existence. The organic matter in water has been divided into *nitrogenous* and *non-*

*nitrogenous* matter; but all we know is, that certain varieties of the organic matter found in water contain nitrogen, which is readily shown by treating them with hydrate of potash, when abundance of ammonia is evolved.

The opinions of chemists are divided as to the manner in which organic matter in water is capable, under certain conditions, of producing a deleterious effect upon the animal economy. But it is now generally admitted, that the substances which constitute the organic matter of water act injuriously by no means in consequence of being poisonous themselves, but by undergoing those great processes of transformation, called decay and putrefaction, to which all vegetable and animal matter is subject, when no longer under the control of vitality, either in plants or animals. These putrefactive processes either give rise to the formation of poisonous bodies, or they act simply as ferments, generating similar processes of decomposition in the substances composing the animal organism. Now, with special reference to the last mode of action, it is well established by general experience that *nitrogenous* substances are infinitely more liable to undergo putrefaction than organic bodies from which nitrogen is absent. And hence the very general and correct opinion that the deleterious character of organic matter in water is proportionate to the amount of *nitrogen* which it contains. Could this nitrogen be estimated with any degree of accuracy, such an estimate would certainly afford the most satisfactory element in the examination of the organic matter. Unfortunately this estimate is attended with very considerable difficulties. The nitrogen of the organic matter which has undergone putrefaction and has therefore ceased to be deleterious, remains in the water, partly as ammonia, partly as nitric acid. It would therefore by no means be sufficient to evaporate the water and to determine the amount of nitrogen in the residue. It would be absolutely necessary to estimate also the nitrogen present in the form of nitric acid and of ammonia, and only after the deduction of their joint amount

from the total amount, numbers would be obtained, which, representing the quantity of still putrescible nitrogenous substances, would afford, within certain limits, the necessary data for a comparison of the organic matter present in different waters.

It is obvious that this mode of proceeding is very complicated, and not likely to furnish trustworthy results, unless carried out with the greatest circumspection, and with all the appliances which the modern progress of analytical chemistry can suggest. It was our intention to enter fully into this part of the inquiry, and a series of experiments were actually made by us with the view of fixing on the best method of conducting the inquiry. The illness of Mr. Blyth, which at this period deprived us of his assistance, has compelled us to abandon, for the present at least, this part of the examinations, and to confine ourselves to an accurate determination of the hardness (permanent and temporary), of the total amount of solid constituents, and of the organic matter.

## *Collection of the Waters.*

Before entering on the chemical examination of the waters, it will be desirable to say a few words on the mode of collecting the different samples submitted to analysis.

The first series of samples were taken at your desire from the mains of each Company, as near as possible to the houses supplied, so as to insure a fair estimate of the actual quality of the water used by the inhabitants of the Metropolis.

In accordance with these instructions, Mr. Blyth collected samples from each of the nine Water Companies mentioned in the Metropolis Water Act, and also from the works of the Woolwich and Plumstead Water Company which have been established since that Act was passed.

The samples were collected in clean-stoppered glass bottles. In some instances they were taken from stand-pipes established in connection with cab stands; in others the water was specially turned on from the main by a turncock. Where it was not

practicable to procure a supply by either of these modes, the water was taken from a service pipe through which it had been flowing for some time, without having previously been stored in tanks or cisterns, so that the samples could be considered as actually representing the water of the main.

The exact source of each sample, and the date of taking it, are stated in the tables giving the result of the examination.

In the second series of samples, taken at a later period of the year, it was desired to obtain some information as to the effects of filtration. To this end, samples were taken of the waters before and after filtration at the works of each Company, and with the co-operation of their officers, as well as from the mains within the district supplied. As in the first instance, the source of the waters and the date of taking them are stated in the Tables.

It may be well to remark, that at the period of taking the first set of samples, a great deal of rain had fallen, the rivers were swollen and turbid, and the filtration did not seem to be quite perfect; in fact, some of the samples exhibited an amount of matter in suspension which required several days to subside.

At the period of taking the second set of samples, with one exception, very little rain had fallen for nearly two months, the rivers were comparatively clear, and all the samples of filtered water were perfectly bright.

In the exceptional case, that of the Lambeth Water Company, some delay having occurred before samples could be procured, heavy rains had fallen a day or two previously, and the Thames was partially swollen and turbid.

The Lambeth Company have no subsiding reservoirs, the water passing directly from the river at Kingston on to the filtering beds. In order to obtain a specimen of unfiltered water it was necessary to draw directly from the Thames, as it passes into the Company's Works. It was very evident to the eye that the water of the Thames was not of an uniform

character, and therefore samples were taken from both sides of the river The Table No. 5. will show to what extent the two samples differed.

To obtain a definite knowledge of the influence of the several seasons upon the Metropolitan Water Supply, a much more extended series of analyses would be required.

However, the two sets of samples examined during the present inquiry may be considered as fairly representing the condition of the water in a wet and in a dry period.

### *Chemical examination of the Water.*

The following Tables exhibit the results obtained in the analysis of the ten waters submitted to examination. It may be stated that each number contained in the Table is, with one or two exceptions, the mean of two well concordant experiments, the details of which are united in the Appendix. The hardness was determined by the well-known elegant process of Professor Clark; the second determination (of the permanent hardness) being made after five minutes boiling. This deserves particularly to be mentioned, inasmuch as by protracted ebullition the hardness may be still further reduced. The total amount of solid constituents was determined by evaporating an exactly measured quantity of the water with a known amount of carbonate of soda in platinum capsules, and weighing the residue, dried at a temperature of 248° F., in the same capsules. This residue ignited, and subsequently, moistened repeatedly with solution of carbonate of ammonia (to replace the carbonic acid which lime and magnesia-salts might have lost during the ignition) and dried at a gentle heat until the weight had become constant, furnished the amount of saline, and, by calculation, the amount of organic matter.

For the sake of comparison we have added in each case the results obtained, in 1851, by the Government Commission (consisting of Professors Graham, Miller, and Hofmann).

## I.—Water supplied to the Metropolis by the Grand Junction Water Company.

*Results obtained in* 1856.

| Description of Water. | Date of Taking. | Hardness. | | | Solid Constituents, Grains per Gallon. | | |
|---|---|---|---|---|---|---|---|
| | | Total. | Permanent. | Temporary. | Total Solid Residue. | Organic Matter. | Inorgan. Matter. |
| From main in Grand Junction Road; filtered. | Jan. 18 | 15·95 | 9·05 | 6·90 | 23·35 | 1·98 | 21·37 |
| From stand pipe in Picadilly; filtered. | Mar. 29 | 14·10 | 6·50 | 7·60 | 21·21 | 1·015 | 20·195 |
| From pipe at works coming from Hampton; unfiltered. | Mar. 29 | 14·55 | 8·2 | 6·35 | 23·22 | 1·17 | 22·05 |

*Results obtained by the Government Commission in* 1851.

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Nearest accessible point to the works of the Company. | Between Jan. 29 and 31. | 14·00 | — | — | 21·72 | 3·07 | 18·65 |

## II.—Water supplied to the Metropolis by the West Middlesex Water Company.

*Results obtained in* 1856.

| Description of Water. | Date of Taking. | Hardness. | | | Solid Constituents, Grains per Gallon. | | |
|---|---|---|---|---|---|---|---|
| | | Total. | Permanent. | Temporary. | Total Solid Residue. | Organic Matter. | Inorgan. Matter. |
| Service pipe near Dorset Square; filtered | Jan. 18 | 13·65 | 9·4 | 4·25 | 21·16 | 0·819 | 20·341 |
| From cab-stand, Broadway, Hammersmith; filtered. | Mar. 31 | 14·4 | 7·4 | 7·0 | 19·897 | 1·015 | 18·882 |
| From Hampton; unfiltered. | Mar. 31 | 14·8 | 7·55 | 7·25 | 22·05 | 1·05 | 21·00 |

*Results obtained by the Government Commission in* 1851.

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Nearest accessible point to the works of the Company. | Between Jan. 29 and 31. | 14·6 | — | — | 22·67 | 2·75 | 19·92 |

## III.—Water supplied to the Metropolis by the Chelsea Water Company.*

*Results obtained in* 1856.

| Description of Water. | Date of Taking. | Hardness. | | | Solid Constituents, Grains per Gallon. | | |
|---|---|---|---|---|---|---|---|
| | | Total. | Permanent. | Temporary. | Total Solid Residue. | Organic Matter. | Inorgan. Matter. |
| From stand pipe at cab-stand in King Street; filtered. | Jan. 22 | 11·8 | 9·05 | 2·75 | 20·31 | lost. | lost. |
| From stand pipe at cab-stand, King Street; filtered. | April 2 | 14·8 | 8·25 | 6·55 | 23·397 | 1·207 | 22·19 |
| From works at Thames Bank; unfiltered. | April 2 | 14·8 | 8·6 | 6·2 | 24·675 | 1·645 | 23·03 |
| *Results obtained by the Government Commission in* 1851. | | | | | | | |
| Nearest accessible point to the works of the Company. | Between Jan. 29 and 31. | 14·44 | — | — | 21·28 | 2·38 | 18·90 |

## IV.—Water supplied to the Metropolis by the Southwark and Vauxhall Water Company.

*Results obtained in* 1856.

| Description of Water. | Date of Taking. | Hardness. | | | Solid Constituents, Grains per Gallon. | | |
|---|---|---|---|---|---|---|---|
| | | Total. | Permanent. | Temporary. | Total Solid Residue. | Organic Matter. | Inorganic Matter. |
| From cab stand near Church in Kennington Common; filtered. | Jan. 23 | 12·02 | 7.75 | 4·27 | 20·57 | 1·36 | 19·21 |
| From main at Kennington Church; filtered. | Mar. 27 | 14·5 | 9·85 | 4.65 | 21·105 | 1·33 | 19·775 |
| From pipe from Hampton Works; unfiltered. | Mar. 27 | 14·25 | 7·07 | 7·18 | 21·927 | 1·435 | 20·492 |
| *Results obtained by the Government Commission in* 1851. | | | | | | | |
| Nearest accessible point to the works of the Company. | Between Jan. 29 and 31. | 15·00 | — | — | 21·08 | 1·51 | 19·57 |

* Since these samples were taken, the Chelsea Water Company have altered the source of their supply. They now obtain their water at Thames Ditton, but samples from the new source had not been examined when this report was completed.

## V.—Water supplied to the Metropolis by the Lambeth Water Company.

*Results obtained in* 1856.

| Description of Water. | Date of Taking. | Hardness. | | | Solid Constitutents, Grains per Gallon. | | |
|---|---|---|---|---|---|---|---|
| | | Total. | Permanent. | Temporary. | Total Solid Residue. | Organic Matter. | Inorganic Matter. |
| From stand pipe at cab-stand, Manor Place, Walworth Road; filtered, | Jan. 23 | 11·35 | 8·10 | 3·25 | 19·11 | 1·26 | 17·85 |
| From stand pipe, Borough Road; filtered. | April 5 | 12·05 | 7·6 | 4·45 | 20·195 | 0·80 | 19·395 |
| From south side of the River at Thames Ditton; unfiltered. | April 11 | 10·90 | 8·45 | 2·45 | 30·10 | 3·91 | 26·18 |
| From north side of the River at Thames Ditton; unfiltered, | April 11 | 12·55 | 7·75 | 4·80 | 20·205 | 1·925 | 18·28 |
| *Results obtained by the Government Commission in* 1851. | | | | | | | |
| Nearest accessible point to the works of the Company. | Between Jan. 29 and 31. | 14·16 | — | — | 20·40 | 2·59 | 17·81 |

## VI.—Water supplied to the Metropolis by the New River Water Company.

*Results obtained in* 1856.

| Description of Water. | Date of Taking. | Hardness. | | | Solid Constituents, Grains per Gallon. | | |
|---|---|---|---|---|---|---|---|
| | | Total. | Permanent. | Temporary. | Total Solid Residue. | Organic Matter. | Inorgan. Matter. |
| From stand pipe at cab-stand, Agar Street, Strand; filtered. | Jan. 25 | 14·6 | 7·75 | 6·85 | 22·36 | 0·910 | 21·45 |
| From Agar Street, Strand, filtered. | April 4 | 12·6 | 9·25 | 3·36 | 21·07 | 1·015 | 20·055 |
| From works, unfiltered | April 4 | 13·1 | 6·5 | 9.9 | 21·91 | 0·98 | 20·93 |
| *Results obtained by the Government Commission in* 1851. | | | | | | | |
| Nearest accessible point to the works of the Company. | Between Jan. 29 and 31 | 14·9 | — | — | 19·50 | 2·79 | 16·71 |

## VII.—Water supplied to the Metropolis by the East-London Water Company.

*Results obtained in* 1856.

| Description of Water. | Date of Taking. | Hardness. | | | Solid Constituents, Grains per Gallon. | | |
|---|---|---|---|---|---|---|---|
| | | Total. | Permanent. | Temporary. | Total Solid Residue. | Organic Matter. | Inorgan. Matter. |
| From stand pipe at cottages near Bow Common; filtered. | Jan. 22 | 13·98 | 8·05 | 5·93 | 22·17 | 1·28 | 20·89 |
| From service pipe at inspector's office; filtered. | April 1 | 14·65 | 8·25 | 6·40 | 20·685 | 1·00 | 19·365 |
| From works at Lea Bridge; unfiltered. | April 1 | 13·3 | 6·3 | 7·0 | 23·31 | 0·945 | 22·365 |
| *Results obtained by the Government Commission in* 1851. | | | | | | | |
| Nearest accessible point to the works of the Company. | Between Jan. 29 and 31 | 15·00 | — | — | 23·51 | 4·12 | 19·39 |

## VIII.—Water supplied to the Metropolis by the Kent Water Company.

*Results obtained in* 1856.

| Description of Water. | Date of Taking. | Hardness. | | | Solid Constituents, Grains per Gallon. | | |
|---|---|---|---|---|---|---|---|
| | | Total. | Permanent. | Temporary. | Total Solid Residue. | Organic Matter. | Inorgan. Matter. |
| From service pipe, New Cross; filtered. | Jan. 23 | 12·45 | 12·3 | 0·15 | 28·49 | 1·26 | 27·23 |
| From well at works, as being pumped into mains; filtered. | April 5 | 11·1 | 9·3 | 1·8 | 23·87 | 1·19 | 22·68 |
| From subsiding reservoir, at works, Deptford; unfiltered. | April 5 | 12·55 | 8·70 | 3·85 | 27·30 | 1·382 | 25·918 |
| *Results obtained by the Government Commission in* 1851. | | | | | | | |
| Nearest accessible point to the works of the Company. | Between Jan. 29 and 31. | 16.0 | — | — | 29.71 | 2.61 | 27.10 |

## IX.—Water supplied to the Metropolis by the Hampstead Water Company.

*Results obtained in* 1856.

| Description of Water. | Date of Taking. | Hardness. | | | Solid Constituents, Grains per Gallon. | | |
|---|---|---|---|---|---|---|---|
| | | Total. | Permanent. | Temporary. | Total Solid Residue. | Organic Matter. | Inorgan. Matter. |
| From service pipe at cottages, Highgate Hill; mixed. | Jan. 22 | 10·5 | 10·5 | 0·0 | 34·26 | 1·29 | 32·97 |
| From service pipe; mixed. | April 4 | 5·45 | 5·40 | 0·05 | 30·765 | 1·47 | 29·295 |
| From well at Hampstead; unfiltered. | April 4 | 4·7 | 3·9 | 0·8 | 57·101 | 2·24 | 54·861 |
| From the works at Highgate; unfiltered. | April 4 | 6·35 | 6·35 | 0·0 | 22·54 | 1·575 | 20·965 |
| *Results obtained by the Government Commission in* 1851. | | | | | | | |
| Nearest accessible point to the works of the Company. | Between Jan. 29 and 31. | 9·8 | — | — | 35·41 | 1·81 | 33·57 |

## X.—Water supplied to Woolwich by the Woolwich and Plumstead Water Company.

*Results obtained in* 1856.

| Description of Water. | Date of Taking. | Hardness. | | | Solid Constituents, Grains per Gallon. | | |
|---|---|---|---|---|---|---|---|
| | | Total. | Permanent. | Temporary. | Total Residue. | Organic Matter. | Inorgan. Matter. |
| From works at Plumstead; softened | Jan. 25 | 8·15 | 8·1 | 0·05 | 18·84 | 0·75 | 18·09 |
| From service tap at the cottages near the railway station, Woolwich Arsenal. | April 5 | 12·85 | 10·05 | 2·80 | 21·85 | 1·015 | 23·835 |
| From well at works; unsoftened. | April 5 | 22·65 | 10·25 | 12·40 | 33·163 | 1·05 | 32·113 |

The analytical results tabulated in the preceding pages demand but little interpretation. The number

of analytical determinations, although considerable, is not sufficient to furnish the data which are necessary for the elaboration of a definite view regarding the fluctuations in the composition of the waters supplied to the metropolis at different seasons. In fact, the elements which are capable of influencing the composition of the waters are so manifold and liable to such extraordinary variations, that it becomes obvious that the number of estimations has still to be considerably increased. Then only will it be possible to eliminate the influence of accidental disturbances upon the general features of the analysis. It would therefore be premature to enter into a comparative discussion of the results obtained in January and in April, and of the slight discrepancies exhibited by the analyses of the waters of the same Company taken at different localities and under circumstances otherwise different.

A most interesting fact, however, is elicited, if the average result obtained in 1856 be compared with the results of the analyses made in 1851 by the Government Commission.

In the following table these results are placed in juxtaposition :—

*Comparison of the average Results obtained in the Analysis of* 1856 *with those of the Analysis made in* 1851.

| Description of Water. | Date of Taking. | Hardness. | | | Solid Constituents, Grains per Gallon. | | |
|---|---|---|---|---|---|---|---|
| | | Total. | Permanent. | Temporary. | Total solid Residue. | Organic Matter. | Inorganic Matter. |
| Grand Junction Water Company. | 1851 | 11·00 | — | — | 21·72 | 3·07 | 18·65 |
| | 1856 | 14·87 | 7·92 | 6·95 | 22·59 | 1·38 | 21·21 |
| West Middlesex Water Company. | 1851 | 14·60 | — | — | 22·67 | 2·75 | 19·92 |
| | 1856 | 14·28 | 8·12 | 6·16 | 21·03 | 0·96 | 20·07 |
| Chelsea Water Company. | 1851 | 14·44 | — | — | 21·28 | 2·38 | 18·90 |
| | 1856 | 13·80 | 8·63 | 5·17 | 22·79 | 1·42 | 21·37 |
| Southwark and Vauxhall Water Company. | 1851 | 15·00 | — | — | 21·08 | 1·51 | 19·57 |
| | 1856 | 13·59 | 8·22 | 5·37 | 21·19 | 1·37 | 19·82 |
| Lambeth Water Company. | 1851 | 14·16 | — | — | 20·40 | 2·59 | 17·81 |
| | 1856 | 11·98 | 7·82 | 4·16 | 19·84 | 1·33 | 18·51 |
| New River Water Company. | 1851 | 14·9 | — | — | 19·50 | 2·79 | 16·71 |
| | 1856 | 13·4 | 7·8 | 5·6 | 21·78 | 0·968 | 20·812 |
| East London Water Company. | 1851 | 15·00 | — | — | 23·51 | 4·12 | 19·39 |
| | 1856 | 13·98 | 7·53 | 6·45 | 22·05 | 1·09 | 20·96 |
| Kent Water Company. | 1851 | 16·00 | — | — | 29·71 | 2·61 | 27·10 |
| | 1856 | 12·03 | 10·1 | 1·93 | 26·10 | 1·37 | 24·73 |
| Hampstead Water Company. | 1851 | 9·8 | — | — | 35·41 | 1·84 | 33·57 |
| | 1856 | 7·43 | 7·41 | 0·02 | 29·19 | 1·45 | 27·74 |

This table shows that the hardness of the waters in 1856, was, with one exception, somewhat less than in 1851; the diminution, however, with one or two exceptions, is only trifling. The total amount of solid matter in the two years likewise exhibits but unimportant fluctuations.

*A very considerable diminution, however, is observed in the amount of organic matter.*

In fact, in 1856, the waters supplied to the metropolis contained not more than one-half of the organic matter which was present in the year 1851.

This result is certainly not accidental. The diminution is not merely an average result, but uniformly observed throughout. The waters examined in 1851 were taken in January; those investigated in 1856, partly in January and partly in April. The diminution of the organic matter cannot therefore be due to the influence of the season. Nor can it be due to any difference in the mode of determining the organic matter in 1851 and 1856. These determinations were made by exactly the same method; for it so happens that the analytical part of the inquiry in 1851 which refers to the organic matter was likewise made in the laboratory of the Royal College of Chemistry. The diminution is obviously partly due to the alteration of the localities from which many of the Companies derive their supply. The Grand Junction, the West Middlesex, the Southwark and Vauxhall Companies, formerly supplied respectively at Kew, Barnes, and Battersea, derive their present water from Hampton; the Lambeth Water Company used to take their Water at Lambeth, but have now erected extensive works at Thames Ditton. The diminution of the organic matter in the London Water Supply, is however by no means confined to the Companies that have changed the locality of their source, and it must therefore be attributed in a great degree to the con-

siderable improvement which has taken place in the collection, filtration, and general management of the supply of water to the Metropolis.

A. W. Hofmann, F.R.S.
Lindsey Blyth.

# APPENDIX.

## Experimental Numbers from which the Results of the foregoing Report are deduced.

The amount of water employed in each case was 1 litre (0.22 gallons); the weights of the solid constituents and of the solid matter are expressed in grammes, one litre being the weight of 1000 grammes of water. The numbers given in the columns of the second half of the Tables represent the quantities of solid constituents and saline matter which are present in 1,000 parts of water.

## EXPERIMENTAL NUMBERS.

| Name of the Water. | Date of Taking. | Hardness. | | | | | | Solid Constituents. | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Temporary and Permanent. | | | Permanent. | | | Total solid Residue. | | | Saline Constituents. | | |
| | | I. | II. | Mean. | I. | II. | Mean. | I. | II. | Mean. | I. | II. | Mean. |
| *Grand Junction Water Company.* | | | | | | | | | | | | | |
| Main in Grand Junction Road. | Jan. 18 | 16·0 | 15·9 | 15·95 | 9·0 | 9·1 | 9·05 | 0·334 | — | 0·334 | 0·306 | — | 0·306 |
| From pipe at works coming from Hampton. | Mar. 29 | 14·6 | 14·5 | 14·55 | 8·2 | 8·2 | 8·2 | 0·331 | 0·332 | 0·315 | 0·314 | 0·316 | 0·315 |
| From stand pipe in Piccadilly. | Mar. 29 | 14·1 | 14·1 | 14·1 | 6·5 | 6·5 | 6·5 | 0·306 | 0·300 | 0·303 | 0·291 | 0·286 | 0·288 |
| *West Middlesex Water Company.* | | | | | | | | | | | | | |
| Service pipe near Dorset Square. | Jan. 18 | 13·5 | 13·7 | 13·6 | 9·3 | 9·5 | 9·4 | 0·291 | 0.313 | 0·302 | 0·279 | 0·301 | 0·290 |
| Unfiltered, from Hampton. | Mar. 31 | 14·8 | 14·8 | 14·8 | 7·6 | 7·5 | 7·55 | 0·319 | 0·311 | 0·315 | 0·304 | 0·296 | 0·300 |
| From cab stand, Broadway, Hammersmith, filtered. | Mar. 31 | 14·3 | 14·5 | 14·4 | 7·4 | 7·4 | 7·4 | 0·285 | 0·283 | 0·284 | 0·272 | 0·267 | 0·270 |
| *Chelsea Water Company.* | | | | | | | | | | | | | |
| From stand pipe at cab-stand, King Street. | Jan. 22 | 11·8 | 11.8 | 11·8 | 9·0 | 9·1 | 9·05 | 0·298 | 0·282 | 0·290 | Lost. | Lost. | Lost. |
| From works at Thames Bank ; unfiltered. | Apr. 2 | 14·8 | 14·8 | 14·8 | 8·6 | 8·6 | 8·6 | 0·352 | 0·353 | 0·352 | 0·328 | 0·330 | 0·329 |
| From stand pipe at cab stand, King Street ; filtered. | Apr. 2 | 14·8 | 14·8 | 14·8 | 8·2 | 8·3 | 8·25 | 0·334 | 0·334 | 0·334 | 0·316 | 0·318 | 0·317 |

Experimental Numbers—*continued.*

| Name of the Water. | Date of Taking. | Hardness. | | | | | | Solid Constituents. | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Temporary and Permanent. | | | Permanent. | | | Total solid Residue. | | | Saline Constituents. | | |
| | | I. | II. | Mean. | I. | II. | Mean. | I. | II. | Mean. | I. | II. | Mean. |
| *Southwark and Vauxhall Water Company.* | | | | | | | | | | | | | |
| From cab stand near church, in Kennington common. | Jan. 23 | 12·0 | 12·05 | 12·02 | 7·7 | 7·8 | 7·75 | 0·294 | 0·293 | 0·293 | 0·271 | 0·277 | 0·274 |
| From main at Kennington church | Mar. 27 | 14·5 | 14·5 | 14·5 | 9·8 | 9·9 | 9·85 | 0·300 | 0·303 | 0·301 | 0·282 | 0·283 | 0.282 |
| From pipe from Hampton at works. | Mar 27 | 14·3 | 14·2 | 14·25 | 7·05 | 7·1 | 7·07 | 0·311 | 0·315 | 0·313 | 0·291 | 0·295 | 0·293 |
| *Lambeth Water Company.* | | | | | | | | | | | | | |
| From stand pipe at cab stand, Manor Place, Walworth Road. | Jan. 23 | 11·5 | 11·2 | 11·35 | 8·1 | 8·1 | 8·1 | 0·272 | 0·274 | 0·273 | 0·257 | 0·253 | 0·255 |
| From stand pipe, Borough Road. | Apr. 5 | 12·05 | 12·05 | 12·05 | 7·6 | 7·6 | 7·6 | 0·290 | 0·287 | 0·288 | 0·278 | 0·276 | 0·277 |
| From South side of river at Thames Ditton opposite the works. | Apr. 11 | 10·9 | 10·9 | 10·9 | 8·5 | 8·4 | 8·45 | 0·433 | 0·428 | 0·430 | 0·375 | 0·373 | 0·374 |
| From Thames Ditton, north side of Lambeth works. | Apr. 11 | 12·5 | 12·6 | 12·55 | 7·7 | 7·8 | 7·75 | 0·290 | 0·287 | 0·288 | 0·262 | 0·260 | 0·261 |

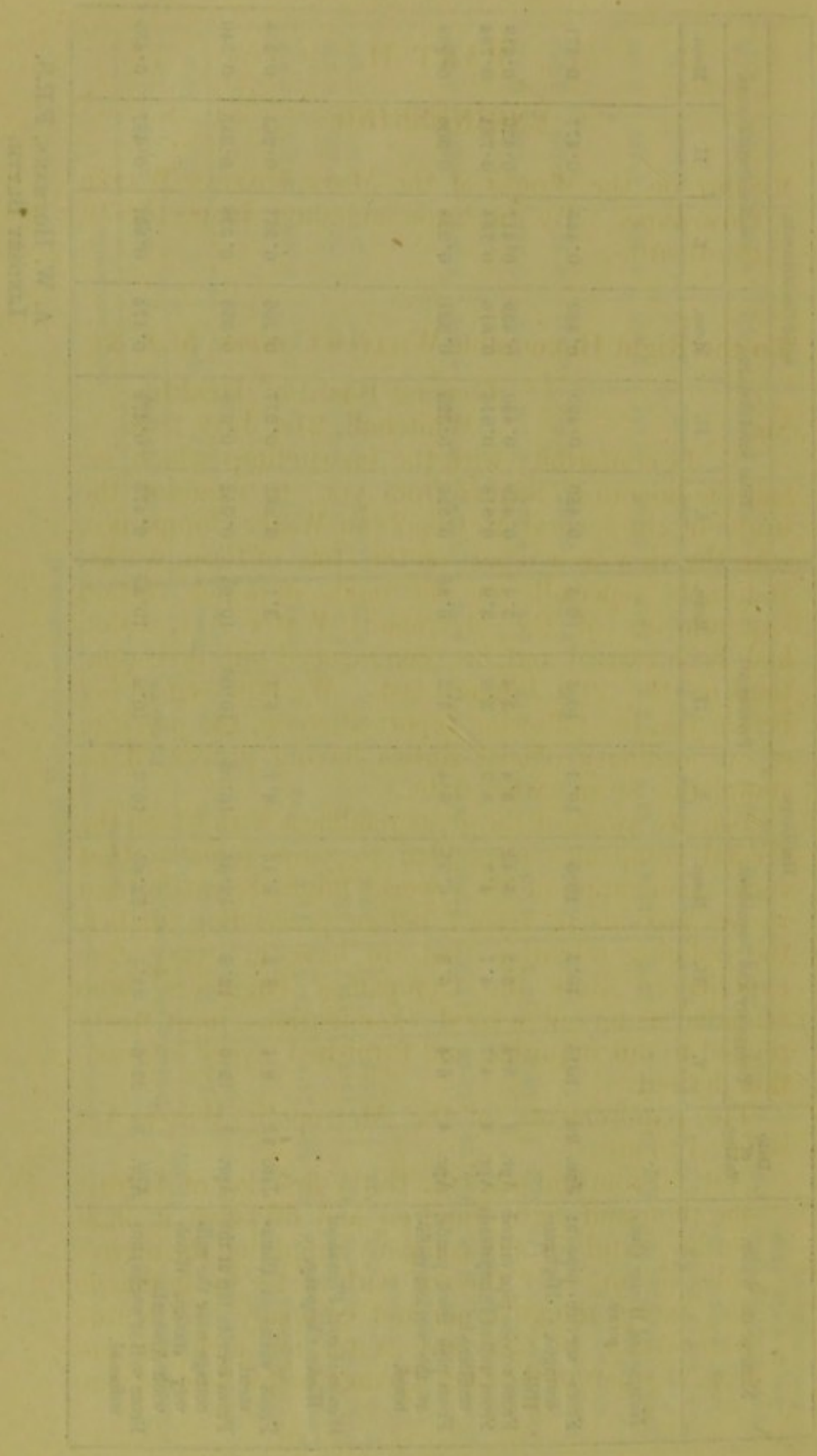
Experimental Numbers—*continued.*

| Name of the Water. | Date of Taking. | Hardness. | | | | | | Solid Constituents. | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Temporary and Permanent. | | | Permanent. | | | Total solid Residue. | | | Saline Constituents. | | |
| | | I. | II. | Mean. | I. | II. | Mean. | I. | II. | Mean. | I. | II. | Mean. |
| *New River Water Company.* | | | | | | | | | | | | | |
| From stand pipe at cab stand, Agar St., Strand. | Jan. 25 | 14·4 | 14·8 | 14·6 | 7·8 | 7·7 | 7.75 | 0·311 | 0·328 | 0·319 | 0·298 | 0·315 | 0·306 |
| From works; unfiltered | Apr. 4 | 13·1 | 13·1 | 13·1 | 6·5 | 6·5 | 6·5 | 0·310 | 0·316 | 0·313 | 0·296 | 0·302 | 0·299 |
| From Agar Street, Strand; filtered. | Apr. 4 | 12·6 | 12·6 | 12·6 | 9·2 | 9·3 | 9·25 | 0·300 | 0·302 | 0·301 | 0·286 | 0·287 | 0·286 |
| *East London Water Company.* | | | | | | | | | | | | | |
| From stand pipe at cottages near Bow Common. | Jan. 22 | 14·05 | 13·90 | 13·98 | 8·1 | 8·0 | 8·05 | 0·300 | 0·333 | 0·316 | 0·283 | 0·313 | 0·298 |
| From works at Lea Bridge; unfiltered. | Apr. 1 | 13·3 | 13·3 | 13·3 | 6·3 | 6·3 | 6·3 | 0·334 | 0·332 | 0·333 | 0·319 | 0·320 | 0·319 |
| From service pipe at inspector's office. | Apr. 1 | 14·7 | 14·6 | 14·65 | 8·2 | 8·3 | 8·25 | 0·297 | 0·294 | 0·295 | 0·281 | 0·280 | 0·280 |
| *Kent Water Company.* | | | | | | | | | | | | | |
| From service pipe, New Cross. | Jan. 23 | 12.6 | 12·3 | 12·45 | 12·6 | 12·0 | 12·3 | 0·393 | 0·421 | 0·407 | 0·374 | 0·403 | 0·388 |
| From well at works as being pumped into mains. | Apr. 5 | 11·1 | 11·1 | 11·1 | 9·3 | 9·3 | 9·3 | 0·344 | 0·339 | 0·341 | 0·326 | 0·323 | 0·324 |
| From subsiding reservoir, at works, Deptford; unfiltered. | Apr. 5 | 12·6 | 12·5 | 12·5 | 8·7 | 8·7 | 8·7 | 0·390 | 0·390 | 0·390 | 0·370 | 0·370 | 0·370 |

Experimental Numbers—*continued.*

| Name of the Water. | Date of Taking. | Hardness. | | | | | | Solid Constituents. | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Temporary and Permanent. | | | Permanent. | | | Total Solid Residue. | | | Saline Constituents. | | |
| | | I. | II. | Mean. | I. | II. | Mean. | I. | II. | Mean. | I. | II. | Mean. |
| *Hampstead Water Company.* | | | | | | | | | | | | | |
| From service pipe at cottages, Highgate Hill. | Jan. 22 | 10·5 | 10·5 | 10·5 | 10·5 | 10·5 | 10·5 | 0·480 | 0·499 | 0·489 | 0·465 | 0·477 | 0·471 |
| From service pipe mixed | Apr. 4 | 5·4 | 5·5 | 5·45 | 5·4 | 5·4 | 5·4 | 0·439 | 0·440 | 0·439 | 0·417 | 0·420 | 0·418 |
| From well at Hampstead; unfiltered. | Apr. 4 | 4·7 | 4·7 | 4·7 | 3·9 | 3·9 | 3·9 | 0·818 | 0·814 | 0·816 | 0·784 | 0·784 | 0·784 |
| From pipe from ponds at the works; unfiltered. | Apr. 4 | 6·4 | 6·3 | 6·35 | 6·4 | 6·3 | 6·35 | 0·320 | 0·323 | 0·321 | 0·298 | 0·300 | 0·299 |
| *Woolwich and Plumstead Water Company.* | | | | | | | | | | | | | |
| From works at Plumstead. | Jan. 25 | 8·1 | 8·2 | 8·15 | 8·1 | 8·1 | 8·1 | 0·261 | 0·277 | 0·269 | 0·251 | 0·265 | 0·258 |
| From service tap at the cottage near the railway station, Woolwich Arsenal. | Apr. 5 | 12·9 | 12·8 | 12·85 | 10·05 | 10·05 | 10·05 | 0·352 | 0·358 | 0·355 | 0·338 | 0·343 | 0·340 |
| From well at works; unsoftened. | Apr. 5 | 22·6 | 22·7 | 22·65 | 10·3 | 10·2 | 10·25 | 0·475 | 0·472 | 0·474 | 0·461 | 0·457 | 0·459 |

A. W. Hofmann, F.R.S.
Lindsey Blyth.



# PART II.

## ENGINEERING.

REPORT on the WORKS of the METROPOLITAN WATER COMPANIES. By the Superintending Inspectors of the Board.

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To the Right Honourable WILLIAM COWPER, M.P. &c.

General Board of Health,
Whitehall, 21st July 1856.

SIR,

IN conformity with the instructions which we had the honour to receive from you, to examine the works of the several Metropolitan Water Companies, with the view to a report on the state of those works, and more especially on the mode in which certain requirements of the Metropolis Water Act, 1852, had been carried out, we commenced our investigations on the 21st January last. We now beg to lay before you the following report thereon, the pressure of our ordinary official duties having prevented its completion at an earlier date.

You are aware of the great readiness with which the several companies responded to your request, that such examination of their works might be made, and we are anxious to record, before proceeding further, the obliging attention that we have in every case experienced from the Companies' engineers, who attended us on our several examinations, most freely replied to our inquiries, and furnished every information desired.

The requirements of the Metropolis Water Act referred to are—

1st. "From and after the thirty-first day of August one thousand eight hundred and fifty-five it shall not be lawful for any company supplying the metropolis or any part thereof with water for domestic use, except the governor and company of Chelsea waterworks, to take any water for such purpose from any part of the river Thames below Teddington

Lock, or from any part of any of the tributary rivers or streams of the river Thames below the highest point where the tide flows in such tributary rivers and streams respectively; and from and after the thirty-first day of August one thousand eight hundred and fifty-six it shall not be lawful for the said governor and company of Chelsea waterworks to take any water for domestic use from any part of the river Thames below Teddington Lock.

2d. "From and after the thirty-first day of August one thousand eight hundred and fifty-five every reservoir within a distance in a straight line from Saint Paul's Cathedral in the city of London of not more than five miles, in which water for the supply for domestic use of the metropolis or any part thereof is stored or kept by any company, shall be roofed in or otherwise covered over: provided always, that this provision shall not extend to any reservoir the water from which is subjected by the company to efficient filtration after it is discharged from such reservoir, and before it is passed into the mains or pipes of the company for distribution, or to any reservoir the whole of the water from which is distributed through distinct mains or pipes for other than domestic purposes, nor to any reservoir whatever the water stored in which shall be used exclusively for other than domestic purposes.

3d. "From and after the thirty-first day of December one thousand eight hundred and fifty-five, no water shall be brought or conducted within the metropolis by any company for the purpose of domestic use otherwise than through pipes or through covered aqueducts, unless the same shall be afterwards filtered before distribution.

4th. "From and after the thirty-first day of December one thousand eight hundred and fifty-five, every company shall effectually filter all water supplied by them within the metropolis for domestic use, before the same shall pass into the pipes for distribution, excepting any water which may be pumped from wells into a covered reservoir or aqueduct, without exposure to the atmosphere, and

which shall not be afterwards mixed with unfiltered water.

5th. "Every steam engine furnace, or other work in which coals which produce smoke during combustion shall be consumed by any company for the purpose of the waterworks shall be constructed on the most effectual principle for consuming its own smoke.

6th. "Every company shall, within one year after the passing of this Act, cause a map to be made of the district within which any mains or district mains shall have been laid down or formed by them on a scale not less than six inches to a mile, and shall cause to be marked thereon the course and situation of all existing mains and district mains, and shall, within six months from the making of any alterations or additions, cause the said maps to be from time to time corrected, and such additions made thereto as may show the line and situation of all such mains and district mains as may be laid down or formed by them from time to time after the passing of this Act; and such map, or a copy thereof, with the date expressed thereon of the last time when the same shall have been so corrected as aforesaid, shall be kept in the principal office of each company, and shall be open to the inspection of all persons interested in the same within the said district, who shall be at liberty to take copies of or extracts from the same."

There is a further requirement as to the provision of a constant supply of water to the several districts under certain conditions; but as this clause of the Act will not come into operation until after the expiration of five years from the date of the passing of the Act, we have not entered at any length upon its consideration.

We directed our attention chiefly to the above points; but in the course of our examinations it appeared to us that so much having been required of and accomplished by the several companies to remove from the supplies of water furnished to the metro-

polis the grave objections which attached to them, it was open for consideration whether any other steps might be adopted to render those supplies as perfect as circumstances would possibly admit.

Having regard to our experiences in many places under the Public Health Act, we were led to consider whether it might not be advisable to give early attention to the number of towns (containing in the aggregate a very considerable population) situated above the new sources of supply, and whose drainage may sooner or later seriously tend to the pollution of the water, and to some extent render nugatory the vast outlay which the Companies have been called upon to make.

As Dr. Clark's process also for softening water impregnated with bicarbonate of lime has been prominently brought forward as an important means of further improving the metropolitan supply, we have, in accordance with your directions, given special attention to the works executed for this purpose by the Plumstead, Woolwich, and Charlton Water Company.

Upon these questions therefore we shall beg to offer some remarks at the close of our report.

We have found that although our inquiries were chiefly directed to specific points connected with the metropolitan water supply, facilities offered for gaining a complete view of the works in the aggregate, as they at present exist. We had no doubt you would consider it desirable that we should avail ourselves of this opportunity, and we have therefore conducted our inquiries and framed our report accordingly.

An elaborate return having been made to the General Board of Health, in 1850, by the several water companies, we have abstracted from those documents the state of the works of each company at that time, and furnished in a separate return, compiled from our inquiries, the additional works executed since that period, in order that the extent of the recent improvements may be more apparent; and have then given a summary of the whole, exhibiting the complete works which together make up the entire Metropolitan Water Supply.

The old metropolitan water companies were nine in number, but as the Plumstead, Woolwich, and Charlton Water-works have been recently established for the supply of a district comprised within "the Act for the better local management of the metropolis," that company should be added to the number, and we have therefore included a description of the works executed by them.

Five of these ten companies take their supplies from the river Thames, namely:—

| | |
|---|---|
| The Chelsea | Company, |
| The Grand Junction | ,, |
| The Southwark and Vauxhall | ,, |
| The Lambeth | ,, |
| The West Middlesex | ,, |

The other five companies have the following sources of supply:—

The New River Company's sources remain unaltered. The supply is obtained partly from certain wells and springs in various places, but chiefly from the river Lea, near Hertford.

The East London Company derive their water wholly from the river Lea, but it is now taken from a point considerably higher up the river than formerly.

The Kent Company have for their source the river Ravensbourne, the point from which the supply is drawn being unaltered.

The Hampstead Company, from the first, obtained their small supply from certain ponds and wells, but have more recently been assisted by supplies from the New River and the West Middlesex Companies.

The Plumstead, Woolwich, and Charlton Consumers' Pure Water Company derive their supply from a well and boring sunk into the chalk, above the town of Woolwich.

We have appended a general plan of the metropolis, distinguishing in different colours the areas of the districts now severally supplied by these Companies, and showing in the same colours the sites of their works

and reservoirs, and the connecting mains between the sources of supply and the districts.

The Lambeth Company, in deference to the great complaints which were made of the foul state of the water supplied by them, anticipated the general Act of 1852, and obtained powers in 1847 for the alteration of the source of their supply.

The Chelsea Company were allowed by the Act of 1852 a longer period of time than the other companies, namely, until the 31st of August of the present year, for the completion of the arrangements necessary for obtaining their supply from above the tidal influence. We were apprehensive therefore that we should not have the opportunity, by the time our report must be presented, of seeing these works sufficiently advanced to enable us to include a full description of the arrangements for furnishing the new supply to the district; but we are happy to state that such rapid progress has been made with the works as to allow of the supply being furnished from the new source before the expiration of the time allowed by the Act. The Company have selected a site for their works called "Seething Wells," adjoining the works of the Lambeth Company at Thames Ditton.

The Grand Junction, the Southwark and Vauxhall, and the West Middlesex Companies, have established their new works on three contiguous plots of land, on the banks of the river Thames, at Hampton, and have erected buildings of similar design, which combine to produce an important effect. The mains of these three Companies from Hampton to their several establishments in London run in parallel direction, as shown on the plan, as far as Twickenham, and at the point of divergence from each other, means of communication between the three have been formed for mutual aid in case of accident or repair.

We commenced our examinations at the Hampton works.

## THE WORKS OF THE GRAND JUNCTION WATER COMPANY IN 1850,

Described chiefly from the Return of the Company to the General Board of Health at that date.

The Company's Acts of Parliament were respectively,—51 Geo. III. c. 169.; 56 Geo. III. c. 4.; 59 Geo. III. c. 111.; 7 Geo. IV. c. 140.; 5 & 6 Will. IV. c. 95.; 7 & 8 Vict. c. 30.

*Source of Supply.*—The Company was incorporated to exercise powers of water supply originally granted to the Grand Junction Canal Company, and at first distributed water taken from that canal. In 1821–22 they changed their source of supply to the River Thames. In effecting this alteration, the mouth of the intake culvert-pipe was placed in close proximity to the outlet of the Ranelagh sewer in the river. In 1834 a further change was made, and a point higher up, on the Surrey side of the Thames, 360 yards above Kew-bridge, was selected, where the stream is separated from the Brentford or Middlesex side of the river by an ait commencing about 150 yards above Kew-bridge, and extending in length nearly half a mile. The water, after passing through an iron pipe, laid down in the bed of the river, was received into a well eight feet diameter, and about 22 feet in depth, whence it was pumped into a depositing reservoir.

*Reservoirs.*—The total capacity of the reservoirs and filter beds (five in number) was 17,900,000 gallons, arranged as follows:—

| | |
|---|---|
| Depositing reservoirs at Kew-bridge, | 5,000,000 |
| Filter beds at ditto - | - 3,500,000 |
| Store reservoir at Campden-hill | - 6,000,000 |
| Store reservoir at Paddington | - 3,400,000 |

The reservoir at Paddington, which is about 89 feet above the level of Trinity high-water mark, was lined with brick, and the bottom coated with gravel.

*Filtration.*—The filter beds adjoining the depositing reservoirs at Kew-bridge contained an area of 70,078 superficial feet. The water in the filter beds varied in depth from three to seven feet, as it was required; but all the water passed through the filter before it was pumped into the service reservoirs and mains for distribution. The filtering medium consisted of layers of gravel and sand arranged in the following order, viz.:

| | Ft. | In. | |
|---|---|---|---|
| 1. Rough gravel that will not pass through a screen of 2-inch mesh | 0 | 7½ | thick. |
| 2. Gravel that will not pass through a screen of 1-inch mesh - - | 0 | 6 | „ |
| 3. Gravel that has passed through the screen of 1-inch mesh - - | 0 | 9 | „ |
| 4. Small shells - - - | 0 | 1½ | „ |
| 5. Coarse sharp sand . - - | 0 | 6 | „ |
| 6. Fine sharp sand - - - | 1 | 6 | „ |
| Total thickness of filtering medium | 4 | 0 | |

*Engine Power.*—The total amount of steam power was equal to about 840 horses, comprised in seven engines, as follows:—

1. Grand Junction engine, 300 horse power.
2. Maudslay's do. 130 „
3. East Cornish do. 130 „
4. West Cornish do. 130 „
5. Paddington do. 70 „
6. North filter do. 40 „
7. South filter do. 40 „

*Mains and Branches.*—The length of the iron mains and branches was about 80 miles one furlong and 17 yards, and the sizes varied from 30 inches diameter to three inches.

*Quantity of water pumped.*—The total quantity of water pumped for supplying the district from the 1st October 1848 to 29th September 1849 was 1,289,184,930 gallons. The daily quantity delivered

per house, including all purposes, appears to have been nearly 255 gallons.

*Tenements supplied.*—The number of tenements supplied with water, including those on the high service, and trades and large consumers, was 14,058; of these no less a number than 11,485 were rated under 5*l.* per annum, and about 200 were large consumers.

The supply was given every day, except Sunday, throughout the whole of the Company's district.

The highest service afforded by the Company, was about 150 feet above Trinity high-water mark, and the lowest 12 feet above that level.

*Cost of the works.*—The total expenditure, up to December 1849, amounted to 522,295*l.* 4*s.* 9*d.*

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ALTERATIONS and ADDITIONS under the following Acts:

The Metropolis Water Act, 15 & 16 Vict. c. 84.
The Grand Junction Waterworks Act, 15 & 16 Vict. c. 157.

*New source of supply.*—The river Thames at Hampton, at the point whence the Southwark and Vauxhall Company and the West Middlesex Company draw their supplies, a quarter of a mile above Hampton village, six miles above Teddington Lock, and 26 miles above London Bridge. The water was first supplied from the new source by the Grand Junction Company on the 7th August 1855.

*Works at Hampton.*—The intake from the river is two feet six inches below the maximum summer level. It is not in the main channel, there being an ait opposite the works which somewhat protects the water from the disturbance of barges and other traffic. The water has to pass three sets of galvanized iron strainers of different sized mesh before entering two subsiding reservoirs, of 45,000 superficial feet each, and capable of holding from six to ten million gallons, the actual quantity contained in them varying

with the height of the stream. The water flows from these reservoirs to the pumping well.

The engine-power consists of two Cornish engines of 110 horse-power each. The cylinders are 60 inches in diameter with a 10-feet stroke. The poles are 42 inches in diameter with a 10-feet stroke. There is a stand pipe 90 feet high, to the top of which the engines are calculated to raise twenty-two million gallons of water in twenty-four hours.

These works are connected with the Company's distributing works at Kew Bridge by a main of 33 inches in diameter, and about 13,500 yards in length. It passes through Twickenham, Isleworth, and Brentford.

*Works at Kew and Kensington.*—The reservoirs and filter beds at Kew remain the same in number as before, but they have been enlarged. The two reservoirs cover an area of 245,000 superficial feet, affording about three days' subsidence, and the three filter beds comprise 225,000 superficial feet. The filtering medium now consists of

1. Harwich sand, . from 3 to 4 feet thick.
2. Fine gravel - - - 1 foot thick.
3. Fine screened gravel - 9 inches thick.
4. Rough screened gravel - 9 inches thick.
5. Coarse gravel - - 1 foot thick.

The bottom layer is formed to a current each way to the lines of drains on a concrete floor.

The Company possess, at Kew, a large area of spare land for additional works when required.

The open service reservoir at Campden Hill, Kensington, is now being covered (in compliance with the provisions of the Metropolis Water Act, 1852), it being within a distance of five miles from St. Paul's Cathedral. The covering consists of perforated brick arches nine inches in thickness, 20 feet span, springing from girders supported on iron columns. The arches are covered with asphalte, upon which a thickness of soil will be laid and sown with grass. This reservoir has now an area of 46,800 square feet, with 22 feet depth of water. The cost of the covering will be 8,000*l.*

Two engines, with 70 inch cylinders, and of the aggregate power of 300 horses, with nine boilers, and stand pipe of 150 feet high, are in course of erection at Campden Hill, and there will be space in the engine-house for a third similar engine. The height of service from the stand pipe will be 250 feet above Trinity high-water mark. It is expected that the whole of the works at Campden Hill will be completed by Midsummer next year.

One additional engine, of 150 horse-power, and four additional boilers, are in progress of erection at Kew, making a total engine-power of 920 horses, and 11 boilers, at that spot.

The reservoir and engine at Paddington have been abolished.

*Mains and Branches.*—The mains and branch pipes of this Company now measure about 117 miles; 37 miles having been laid since the previous return.

The plan of the mains and district mains, required by the 17th section of the Metropolis Water Act, 1852, is complete. It is laid down to a scale of 12 inches to the mile.

"*Consumption of smoke.*"—No apparatus has been adopted at Kew for the "consumption" of the smoke of the furnaces. Very perceptible smoke was emitted from the chimney while we were present, but it was not dense.

*Quantity of water supplied.*—The mean supply to the district during last year was 6,714,292 gallons, per day, distributed throughout the whole of the district daily, and the number of tenements now supplied amounts to 17,221.

The district to which the supply is given, and the positions of the works, are distinguished by brown colour on the accompanying plan.

*Total cost of the works.*—The cost of the additional works executed since the passing of the Acts of 1852 had amounted, on the 31st March 1856, to the sum of 166,128*l.* To this amount, however, should be added the contracts in actual execution, amounting to 45,000*l.*, which will make with the previous outlay, a total expenditure of 733,423*l.*

## General Remarks.

The new buildings of this Company at Hampton, as well as of the Southwark and Vauxhall, and the West Middlesex Companies, are of Italian design, executed in white brick with stone dressings. They consist of engine and boiler-houses, cottages for the workmen, and a square tower which contains the chimney and a stand-pipe, 90 feet high, 4 feet 6 inches in diameter.

It is proposed to burn Welsh coal in the furnaces, but Newcastle coal having hitherto been used, the ornamental tower is already somewhat disfigured by smoke.

The most noticeable part of the works at Hampton, are the direct acting engines, erected by Harvey and West, which are working steadily and well. They are nominally of 100 horse-power, but work up to 110. It is proposed to pump 11 hours per day, 12 strokes per minute in ordinary work, 14 strokes in full work.

The water was turbid at the time of our inspection at Hampton, owing to recent rains. The filtered water at Kew was however bright, and pleasant to drink.

The time of cleansing the filter beds varies from a few days to eight weeks, according to the state of the river. Considerable attention is paid to the washing of the sand for filtration. The operation costs $8\frac{1}{2}d.$ per cubic yard.

With two feet head of water on the filter beds, about three gallons per hour pass through each square foot when in good working order.

The reservoir at Campden Hill, Kensington, is at present the only reservoir of this Company for filtered water. The works at this place, described in the return, were not complete at the time of our visit, but were in rapid progress. In the mean time the supply for the whole of the district is pumped directly into the distributing mains.

The Company has purchased land at Shoot-up-Hill, near Hampstead Heath, at an elevation of 260 feet above the Thames, for the formation of another large reservoir.

The whole of the new works of this Company appear to be most efficiently carried out with a due regard to economy.

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## THE WORKS OF THE SOUTHWARK AND VAUXHALL COMPANY IN 1850,

Described chiefly from the Return of the Company to the General Board of Health at that date.

The Vauxhall Company was constituted by 45 Geo. III. c. 119., 53 Geo. III. c. 155., and 4 & 5 Will. IV. c. 78.
The Southwark Company was constituted by 4&5 Will. IV. c. 79.
The two Companies were incorporated by 8 Vict. c. 69.

*Source of supply.*—The Company took its supply of water from the river Thames, near the Red House, Battersea, by means of a galvanized iron pipe 4 feet in diameter, laid to the full current of the river, considerably below low-water mark. The water was admitted first into a subsiding reservoir, from which it passed into a second, and thence into two filter beds, from which a 4-feet iron culvert conducted it to the pumps at the engines. It was then forced over stand pipes to a height of 185 feet above Trinity high-water mark, into the mains for distribution.

*Reservoirs.*—The capacity of the two depositing reservoirs and two filter beds at Battersea was equal to 43,000,000 gallons, the depositing reservoirs being capable of holding 32,000,000 gallons, and the filter beds 11,000,000 gallons. The area of the reservoirs and filter beds amounted to 491,000 superficial feet, the depositing reservoirs having a surface of 370,000 feet, and the filter beds 121,000 feet.

*Filtration.*—The only parliamentary obligation to which the Company was subjected as to the quality of the water supplied was, that it should be filtered. They, however, made arrangements for securing the

best supply practicable from that source by taking water only during the ebb tide.

The filtering medium was 5 ft. 6 inches thick, and consisted of

1st. A layer of clean sharp *river* sand, 2 ft. thick.
2d. A layer of fine gravel, 1 ft. thick.
3d. A layer of fine screened gravel, 9 inches thick.
4th. A layer of rough screened gravel, 9 inches thick.
5th. A layer of coarse gravel, 1 foot thick. This bottom layer was formed to a current each way to the lines of drains on a concrete floor.

*Engine power.*—The steam power of the four engines employed amounted nominally to about 355 horses :—

No. 1. engine, cylinder 64 inches. diameter, stroke 10 feet 6 inches.
„ pumps, 32 inches diameter, stroke 10 feet.
No. 2. engine, cylinder 64 inches diameter, stroke 11 feet 8 inches.
„ pumps, 33¼ inches diameter, stroke 10 feet 6 inches.
No. 3. engine, cylinder 31 inches diameter, stroke 6 feet 3 inches.
„ pumps 21½ inches diameter, stroke 3 feet 7½ inches.
No. 4. engine, combined cylinders 24 and 40 inches diameter, with an 8 feet stroke.
„ pumps 60 inches diameter, stroke 8 feet.

*Mains and Branches.*—The length of mains, branches, and services amounted to about 380 miles.

*Quantity of water pumped.*—The total quantity of water pumped during the year 1849 was 2,195,006,370 gallons.

The highest service afforded by the Company, was about 150 feet above Trinity high-water mark, and the lowest service below high water.

*Tenements supplied.*—The number of tenements supplied was 34,864, of which about 1,000 were on

the main, and had nearly a constant supply. The number of large consumers was 647.

The average quantity delivered to each dwelling house, for seven days in the week, was 143 gallons per diem.

The supply of water was given daily throughout the whole of the Company's district.

*Cost of Works.*—The total expenditure on the Works up to December 1849 was 435,247*l.*

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ALTERATIONS and ADDITIONS under the following Acts :

The Metropolis Water Act, 15 & 16 Vict. c. 84.
The Southwark and Vauxhall Water works Act, 15 & 16 Vict. c. 158.

*Source of Supply.*—The river Thames at Hampton, at the point whence the Grand Junction and the West Middlesex Companies draw their supplies. The water was first supplied by the Southwark and Vauxhall Company from this source on the 19th July 1855.

*Works at Hampton.*—The intake from the river adjoins that of the Grand Junction Company, and the water passes through three sets of strainers, as before described, into two subsiding reservoirs of 45,000 superficial feet each, and capable of holding from six to ten million gallons, the actual quantity varying with the height of the stream.

The engine power at Hampton consists of two Cornish engines, built by Harvey and West, of 110 horse-power each. The cylinders are 60 inches in diameter, with 10-feet stroke. The poles are 42 inches in diameter, with 10-feet stroke. There is a stand pipe 90 feet high, to the top of which the engines are calculated to raise 22 million gallons of water in 24 hours. Four cottages have been erected for enginemen, &c. The main to Battersea is 36 inches in diameter, and about 23,000 yards in length. It passes through Twickenham, under the Thames, and then through Richmond, Putney and Wandsworth to

Battersea. It is connected with the Grand Junction Company's main at Hampton, and with the West Middlesex Company's main at Mortlake, for mutual aid in case of accidents.

*Filter Beds and Works of Distribution at Battersea.*—The two reservoirs of deposit and subsidence at Battersea are of the aggregate capacity of twenty million gallons. One circular filter bed of 75,000 superficial feet, has been added to the works. The whole of the filtering beds are now capable of filtering an aggregate of 18 million gallons per diem.

From one to two feet of sharp sand have been added to the former thickness of the filtering medium already described. Harwich sand is now chiefly used.

A Cornish engine of 170 horse-power has been substituted at Battersea for the old lifting engine of 30 horse-power, formerly used for raising the water directly from the river, which is no longer required. Two new boilers have been added, making a total of 11.

An engine-house is built, and ready to receive an additional engine of 350 horse-power, with 112-inch cylinder, and 50-inch pump.

*Mains and Branches.*—The total length of pipeage now amounts to about 432 miles. The plan of the mains and district mains, required by the 17th section of the Metropolis Water Act, 1852, is complete. It is drawn to a scale of 100 feet to the inch.

"*Consumption of Smoke.*"—No apparatus has been adopted for the "consumption" of smoke of the furnaces. Welsh coal is now used.

*Quantity of Water supplied.*—The mean supply of water to the district during the year 1855, was 10,331,122 gallons per day. The supply is given daily, for six days in the week, and two million gallons are furnished on Sundays.

The number of tenements now supplied amounts to 41,529, including 641 large consumers.

The area of the district at present supplied by this Company and the sites of the works are shown in pink

colour on the accompanying plan. The middle portion of the district, where the two colours on the plan are intermixed, is also supplied by the Lambeth Company.

*Total Cost of the Works.*—The cost of the additional works executed under the Acts of 1852 has amounted to £186,510. To this sum should be added the contracts in actual execution, which amount to £27,500, making, with the previous outlay, a total expenditure of £649,257.

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## General Remarks.

It will be seen from the foregoing returns that the works of this Company at Hampton are precisely similar to those of the Grand Junction Company; with the exception of the size of the mains for conveying the water thence to the works at Kew and Battersea.

The new direct-acting engine of 170 horse-power, erected at Battersea, is contained in the building which formerly held the 30-horse engine used for lifting the water from the river to the contiguous reservoirs. The new engine occupies less space than the former one, although of such increased power. The whole of the new works appear to have been well and economically carried out.

The filtered water at the Battersea Works was bright and pleasant to drink, notwithstanding the turbid state of the river. This Company has no reservoir of filtered water. The supply is pumped direct over the stand pipes into the mains for the service of the district. Land has been purchased, however, for reservoirs at Nunhead, Peckham, at a level of 210 feet above high-water mark.

The connection between the river and the reservoirs at the Battersea works, by which the supply was formerly obtained, has not yet been actually removed, but a dam has been put across to prevent the use of this intake.

The Company not having taken sufficient precautions to prevent the issue of dense smoke from the furnaces at Battersea, were, on one occasion, fined 5*l.* for offending in this respect. Welsh coal is now used. A greater body of smoke than is usually due to Welsh coal was emitted during our visit, but it could not be called dense.

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## THE WORKS OF THE WEST MIDDLESEX WATER COMPANY IN 1850,

Described chiefly from the Return of the Company to the General Board of Health at that date.

The Acts obtained by the West Middlesex Company prior to 1850 were three in number, viz.,—

46 Geo. III. c. 119.
50 Geo. III. c. 132., and
53 Geo. III. c. 159.

*Source of supply.*—The Company obtained their supply of water from the river Thames, near Barnes-terrace, in the parish of Barnes, about ten miles above London-bridge.

*Reservoirs.*—The water passed into two subsiding reservoirs, comprising an area of about 16 acres. It was led through a duct from the Thames first into the western and thence into the eastern reservoir.

These reservoirs were also partially supplied with water through the gravelly beds of the district. From the lower reservoir the water was conveyed by means of a 36-inch iron pipe across the bed of the river to the pumping-well on the Middlesex side.

In addition to these subsiding reservoirs the Company had in use two service reservoirs, situate at Kensington, and at Barrow-hill,—that at Kensington being capable of containing 3,450,000 gallons, and that at Barrow-hill 4,752,000 gallons.

The Kensington reservoir is 111 feet above the level of Trinity high-water mark. The Barrow-hill reservoir is 177 feet 6 inches above the same level.

The highest service afforded by the Company, was 207 feet above Trinity high-water mark, and the lowest about 20 feet.

*Filtration.*—The water was not filtered. Its freedom from matter in suspension was dependent solely on subsidence in the reservoirs.

*Engine Power.*—The nominal power of the three engines at Hammersmith was 245 horses.

No. 1. 54-inch cylinder, 8 feet stroke; pump, 20 inches diameter, 8 feet stroke.

No. 2. 54-inch cylinder, 8 feet stroke; pump, 20 inches diameter, 8 feet stroke.

No. 3. 64-inch cylinder, 8 feet stroke; pump, 23 inches diameter, 8 feet stroke.

*Mains, Branches, &c.*—The total length of mains, branches, and service pipes was about 150½ miles; they varied in diameter from 30 inches to 3 inches.

*Quantity of Water pumped.*—The total quantity of water pumped in the year 1849 was 1,216,929,812 gallons; about 144 gallons having been delivered to each house per diem.

*Tenements supplied.*—The number of houses supplied by the Company was 24,480. The instances in which parties had pipes on the mains were very rare, and there were very few large consumers. The district is almost exclusively one of houses.

The supply was given in all cases three times a week, and more frequently in parts of the district where it was required.

*Cost of the Works.*—The total cost of the works to the end of the year 1849 was 648,560*l.* 6*s.* 1*d.*

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Alterations and Additions under the following Acts:

The Metropolis Water Act, 15 & 16 Vict. c. 84.
The West Middlesex Waterworks Act, 15 & 16 Vict. c. 159.

*Source of Supply.*—The river Thames at Hampton, near the point whence the Southwark and Vauxhall, and Grand Junction Companies draw their supplies.

Water was first supplied to the Company's district from this source on the 19th July 1855.

*Works at Hampton.*—The intake from the river is separate from those of the other two Companies. It is provided with a double set of wire screens, and is further protected at the mouth by a line of sheet piling in the river, which keeps off all floating substances. There is no subsiding reservoir in connexion with these works, as with the contiguous works of the two other Companies. The water flows direct from the river to the engine well, through a pipe four feet in diameter. The supply can be stopped by means of sluices. The water is pumped direct to Barnes, a distance of about $8\frac{3}{4}$ miles. The diameter of the main is 36 inches. It runs parallel with the Southwark and Vauxhall main as far as Mortlake, whence it diverges to Barnes.

The engine-power consists of two Cornish engines, direct action, with 64-inch cylinders and 10 feet stroke. The poles are 45 inches in diameter with 10 feet stroke.

*Filter Beds, &c., at Barnes.*—The water from Hampton is delivered into the two subsiding reservoirs at Barnes, which were previously used for the subsidence of the water drawn from the Thames at that point. These contain about six days' supply.

Three filter beds have been constructed at Barnes, each comprising $1\frac{1}{2}$ acres in superficial area (sand surface.)

The filtering medium is 4 feet 6 inches in depth, and is thus composed :—

| Feet. | Inches. | |
|---|---|---|
| 2 | 9 | Thames sand |
| 1 | 9 | Hoggin and gravel of various sizes. |
| 4 | 6 | |

The water passes from the filter beds into a pure water well, whence it is conducted as before to the engines on the other side of the river. Filtered water was first supplied on the 27th March 1854.

*Service Reservoirs.*—It is proposed to abandon the service reservoir at Kensington, in order to save the cost of covering it, it being within the five-mile radius limited by the Metropolis Water Act, 1852.

The service reservoir at Barrow Hill, Regent's Park, which comprises an area of $1\frac{3}{4}$ acres, has been covered with a series of hollow brick arches, six inches thick, of 20 feet span, and 3 feet rise, springing from cross arches constructed on brick piers.

The depth of the reservoir is 20 feet.

The lower portion of the district is supplied direct from the distributing mains, without the intervention of any reservoir. The higher portion is supplied from the service reservoir at Barrow Hill, which is filled from the main by night.

*Engine-power.*—In addition to the new engines at Hampton already described, a new engine has been erected at Hammersmith, with 72-inch cylinder, 10-feet stroke, and double action pump, 23 inches diameter. Two new boilers have also been added.

A new engine has also been erected at Barrow Hill, 16 inch cylinder, 5-feet stroke, for the purpose of supplying a part of the district above this reservoir.

The total of the engines of this Company may now be taken at 480 nominal horse-power.

*Mains, Branches, &c.*—The total length of pipeage now laid is about 178 miles; about 28 miles have been laid since the return made in 1850.

A plan of the Company's under-ground works, to a scale of 5 feet to the mile, has been prepared in accordance with the Metropolis Water Act, 1852, and is now in course of correction to Midsummer last.

"*Consumption of Smoke.*"—No apparatus has been attached to the furnaces of this Company for the "consumption" of smoke. Welsh coal and screenings are used for the fires. The screenings being used in front, the smoke passes over the live Welsh coal and is converted into flame.

*Quantity of Water supplied.*—The average quantity of water distributed daily, for the week of 7 days, ending the 4th July, was 6,895,368 gallons.

The number of tenements now supplied, exclusive of stables, is 25,732.

The water is furnished to all parts of the district daily, Sundays excepted, and to some parts twice a day.

The area of the district at present supplied by this Company, and the works and reservoirs, are coloured blue on the accompanying plan.

*Cost of Works.*—The total cost of the additional works executed since the passing of the Company's Act of 1852, to the 30th March last, has amounted to 157,399*l.* 14*s.* 7*d.*, making with the previous outlay, a total expenditure of 805,950*l.* 0*s.* 8*d.*

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## General Remarks.

The buildings and engines of this Company at Hampton are similar to those of the Grand Junction, and of the Southwark and Vauxhall Companies, except that the engines are of somewhat larger dimensions, as described in the return.

The air vessel is here of wrought iron, 5 feet in diameter and 18 feet high.

Thirty feet height of water in the stand pipe is sufficient pressure to command its delivery at Barnes.

Working with 4 feet head of water, about six gallons per hour are stated to pass through each square foot of surface of the filter beds. They are cleansed at intervals varying from 10 days to 7 or 8 weeks, according to the state of the river. The river was turbid at the time of our inspection.

The water is conducted across the river to the engines at Hammersmith by the same main in the bed of the river which previously took the supply from the subsiding reservoirs. The direct connexion of this main with the subsiding reservoirs still remains. It is stated to be maintained in case of accident to the filter beds,

but as the filter beds are arranged in three distinct divisions, this precaution appears to be wholly unnecessary, and it would be more satisfactory that the connexion with unfiltered water should be destroyed. The filtered water was bright and pleasant to the taste, very different to the water taken from the reservoirs. Even after the subsidence which the water undergoes in passing through the reservoirs, it is by no means fit for domestic use.

At Hammersmith the water is pumped direct into the distributing mains without any stand pipe, the air vessel being similar to that at Hampton.

The covering of the Barrow Hill reservoir appears to have been an economical as well as an efficient work. The cost was about £5,000. The arches have a slight covering of cement, but no soil is laid over them, the ventilation through the hollow brickwork of which they are composed being found sufficient to keep the water cool. The temperature of the water in the reservoir has been found to be raised only 3 degrees during summer.

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## THE WORKS OF THE LAMBETH WATER COMPANY IN 1850,

Described chiefly from the Return of the Company to the General Board of Health at that date.

The Lambeth Water Company was incorporated by 25 Geo. III. c. 89., and they obtained further legislative powers by 4 Will. IV. c. 7., and 11 Vict. c. 7.

*Sources of supply.*— The Company's authorized source of supply, until the passing of the Act 11 Vict. c. 7., was the River Thames at Lambeth. The latter Act enabled the Company to obtain their supply of water from the same river, above the tidal influence, at Thames Ditton.

*Reservoirs.*—The available capacity of the Company's reservoirs, three in number, was 15,900,000 gallons. Two at Brixton, formed with brick walls and paved bottom, comprised about three acres in extent, and were calculated to contain, when full, 12,150,000 gallons; the third, $1\frac{1}{4}$ acres in extent, having brick walls and earth bottom, was capable of holding 3,750,000 gallons.

*Filtration.*—The whole of the water supplied was passed through a vertical filtering medium of gravel and sand about seven feet thick.

*Steam power.*—The amount of steam power employed was stated nominally at 252 horses; the engines, five in number, being of the following dimensions:—

No. 1. Engine cylinder, $64\frac{3}{8}$ inches diameter; stroke, 8 feet.
No. 2. Engine cylinder, $46\frac{1}{2}$ inches diameter; stroke, $8\frac{1}{2}$ feet.
No. 3. Engine cylinder, $20\frac{1}{2}$ inches diameter; stroke, 3 feet.
No. 4. Engine cylinder, $16\frac{1}{4}$ inches diameter; stroke, 3 feet.
No. 5. Engine cylinder, 11 inches diameter; stroke, $2\frac{2}{3}$ feet.

*Mains, Branches, &c.*—The length of mains, branch mains, side services, and services for small streets, was about 135 miles, varying in size from 23 inches in diameter to two inches.

*Quantity of water pumped.*—The total quantity of water pumped for supplying the district during the year 1849 was 1,123,200,000 gallons. The quantity supplied for all purposes gave an average of 154 gallons per house per diem.

*Tenements supplied.*—The number of dwelling-houses supplied amounted to 23,396; and large consumers (from the mains), 147.

The highest service afforded by the Company was about 350 feet above high-water, and the lowest, 4 and 5 feet *below* high-water mark.

The supply was given daily to the district lying below St. Matthew's Church, Brixton, forming nine-tenths of the entire district. The more distant and elevated localities received their supply of water three and four days per week.

*Cost of the works.*—The total expenditure on the works amounted to 307,352*l.* 8*s.* 1*d.*

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ALTERATIONS and ADDITIONS under the following Acts:

Lambeth Waterworks Act, 11 Vict. c. 7., 1847.
The Metropolis Water Act, 15 & 16 Vict. c. 84.

*Source of Supply.*—The river Thames, between Kingston and Thames Ditton, whence the supply has been drawn since January 1852.

*Filter Beds and Reservoirs.*—The water is let in direct from the river to the filter beds, and after filtration is pumped to the reservoirs at Brixton. There are four double filter beds at Thames Ditton, but they comprise only altogether an area of 32,000 superficial feet, which will be found a very small extent of filtering surface in comparison with that of the other Companies. These filter beds, constructed with brick retaining walls, immediately adjoin the river. The filtering medium is about 6 feet in thickness, and consists of Thames and Harwich sand, and fine and coarse gravel in layers.

The two reservoirs at Brixton, comprising an area of 3 acres, have now been covered. They were each originally divided lengthwise by a wall, to effect a circulation of the water, and this arrangement is still retained. The covering consists of brick arches 9 inches thick, springing from walls 1½ bricks thick, and 20 feet from centre to centre. These walls have large openings in them, with buttresses between.

The Streatham reservoir remains uncovered, it being situated beyond the five miles radius from St. Paul's Cathedral prescribed by the Act for covered reservoirs.

*Engine power.*—The aggregate nominal engine power of the Lambeth Water Company is now equal to 680 horses. Two pair of W. Simpson's engines of similar construction, and of excellent and substantial design, have been erected at Kingston. One pair is sufficient for the ordinary duty.

The new engines are of the combined high pressure and condensing description. The high pressure cylinders have 28 inches diameter, length of stroke 5 feet 6½ inches. The low pressure cylinders have 46 inches diameter, and 8 feet length of stroke. They are worked from cylindrical boilers with central furnaces and flues.

A small engine is also erected here for draining the filter beds when cleansing is required.

A pair of small engines at Brixton raise the water thence to the higher reservoir at Streatham.

The old engines described in the previous return have been disposed of.

*Mains, Branches, &c.*—The main from Thames Ditton to the Brixton reservoirs for the supply of the district is 30 inches in diameter, and 10⅓ miles in length. With the view to future extensions, three lines of main have been laid at all the crossings; and wherever the main passes through private property sufficient width of land has been purchased for laying three parallel lines.

The total length of pipeage now laid is 206 miles. The additional length laid in the district since the previous return being 71 miles.

The plan of the Company's mains and district mains, required by the Metropolis Water Act, is complete, having been corrected to June last. It is on a scale of 16 inches to the mile.

"*Consumption of Smoke.*"—No apparatus is employed for the consumption of smoke of the furnaces. Welsh coal is used.

*Quantity of Water supplied.*—The average supply of water in 1855 was 6,109,000 gallons per diem and during this summer it has amounted to nearly seven million gallons.

The number of tenements supplied is 28,541. Nine-tenths of the district is supplied daily, and the remainder on the high land in the country districts four times per week.

The area of the district at present supplied by this Company, and the positions of the works, are coloured blue on the accompanying plan. It will be observed that a considerable portion of the district is supplied also by the Southwark and Vauxhall Company.

The total expenditure under the new Acts of 1847 and 1852, to the present time, has amounted to 301,633*l.*, making with the previous outlay a total expenditure of 608,985*l.* 8*s.*

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## General Remarks.

The whole of the works of this Company at Thames Ditton were executed under the powers obtained in 1847; but as they were merely anticipatory of the General Act of 1852, being precisely of the character that would have been carried out under the provisions of that Act, which require that the sources of supply from the Thames should be above the tidal influence, we have thought it right to include them as new additions.

These works are situated on a strip of land partly embanked from the river to an uniform line. There is sufficient area of land for a considerable extension of the works, which have been laid out on a comprehensive scale, and have been efficiently executed.

The substantial brick buildings consist of engine and boiler houses, chimney in form of a square castellated tower, workshops, offices, extensive coal shed, and a range of baths and other sanitary arrangements for the workmen.

The river was turbid at the time of our visit to Kingston, but the filtered water was bright and pleasant as the samples of the other Companies. When the river is so charged with matter in suspension, a filter bed is said to run freely only for about three days.

The drainage of Thames Ditton formerly discharged into the river above the site of these works. An intercepting sewer, 3 feet 6 inches by 2 feet 6 inches in diameter, has been laid down by the Company, extending for about a mile and a half above the intake of their supply of water, and for about half a mile below, for discharge of this drainage. Power has been taken in the Company's Act to carry the sewer as far up as Moulsey for the same purpose.

The pumps are of double action; the water being raised by the up-stroke as well as the down, and driven forward direct into the mains. No stand-pipe is employed, but in addition to the ordinary air-vessel, there is an air-chamber formed above the pump-valves, into which air is constantly pumped.

The covering of the two reservoirs at Brixton, comprising an area of about three acres, cost about 13,500*l*. The whole surface of the arches is covered with soil, and laid down in grass.

The accident which occurred here from the fall of some of the arches arose from no deficiency of construction, for the work is of the most solid description, but from the too early removal of the centreing. Only four sets of centres were employed by the contractor. The engineer afterwards required that the whole of each line should be put in at one time. One of these reservoirs was completed and at work before the 31st August 1855. The other was in course of completion at the time of our visit.

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## THE WORKS OF THE CHELSEA WATER COMPANY IN 1850,

Described chiefly from the Return of the Company to the General Board of Health at that date.

The Company was incorporated by Act of Parliament 8 Geo. I. c. 26., under the style of the "Governor and Company of Chelsea Water Works,"

Further powers were conferred upon them by Royal Charter dated 8th March, 9 Geo. I.; letters patent dated 11th October, 7 Geo. II.; and Act of Parliament 49 Geo. III. c. 157.

*Source of Supply.*—The water was procured from the Thames by means of a conduit pipe laid across the bed of the river beyond mid-stream, near the Red House, Battersea.

*Reservoirs and Filter Beds.*—The Company had four subsiding reservoirs, comprising together an area of 3½ acres. They were 15 feet deep, constructed with sloping sides and bottoms, paved with bricks on edge laid on concrete.

The whole of the water was filtered. The filter beds comprised an area of 90,000 superficial feet, and the filtering medium consisted of gravel, shells, and sand, 8 feet thick.

Two open service reservoirs received the filtered water from the Chelsea Works. One in the Green Park comprised an area of 1½ acres, was 10 feet deep, and was constructed with brick walls and paved bottom. One in Hyde Park was ¾ of an acre in extent, and 7 feet deep, constructed with brick walls and concrete bottom.

*Engine Power.*—The steam engines of the Chelsea Company amounted to 310 horses power. They were situated at Chelsea.

*Mains and Branches.*—The length of the mains and service pipes was about 134 miles. The large mains were 18, 12, and 10 inches in diameter, the auxiliary mains 7 and 6 inches in diameter, and the services 5, 4, and 3 inches.

*Quantity of Water pumped.*—The total quantity of water pumped into the mains supplying the district in 1848 was 1,248,115,000 imperial gallons. The average daily quantity per house, including trade and other purposes, was 219 gallons; excluding those purposes, the daily supply per house was 187 gallons.

There were from 200,000 to 300,000 gallons delivered per day to large consumers.

*Tenements supplied.*—The number of tenements supplied in 1849 was 20,996, and the supply was given daily throughout the district.

The highest service afforded by the Company was 157 feet above high-water mark, and the lowest 4 feet above the same level.

*Cost of the Works.*—The total expenditure upon the works, including an outlay of 35,000*l.* which was being incurred at the time of the Return, amounted to the sum of 455,712*l.*

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ALTERATIONS and ADDITIONS under the following Acts :

The Metropolis Water Act, 15 & 16 Vict. c. 84.
The Chelsea Waterworks Act, 15 & 16 Vict. c. 156.

*Source of Supply.*—The river Thames at Seething Wells, near Thames Ditton, immediately contiguous to the point whence the Lambeth Company's supply is taken, and about two miles above Teddington Lock.

The filtered water was first supplied from this source to about half the Company's district on the 2d July inst., and it has now been extended to the remainder.

*Reservoirs and Filter Beds.*—Two new subsiding reservoirs, with slopes of 1 to 1, lined with brick on edge laid on concrete, have been formed at Seething Wells. They comprise an area of 3 acres, and are each capable of containing 10 million gallons of water. Two filter beds adjoin them, which comprise an area of 2 acres, and are each capable of filtering 10 million gallons in 24 hours, at the rate of two gallons per hour per foot.

The filtering medium is eight feet in thickness, and consists of the following layers :—

| | ft. | in. |
|---|---|---|
| Fine sand - - - | 2 | 9 |
| Coarse sand - - - | 0 | 7 |
| Shells - - - | 0 | 2 |
| Fine gravel - - - | 1 | 6 |
| Coarse gravel - - - | 3 | 0 |

The several layers are formed undulating, with the view to better drainage and greater facilities of cleansing.

Two covered reservoirs adjoining each other have been constructed on Putney Heath. They are 2½ acres in extent, and hold 20 feet depth of water. These reservoirs command a maximum height of service of 170 feet above Trinity high water. They have sloping sides, paved with brick on edge, laid on concrete. The covering consists of brick arches, springing from 14-inch walls, of similar construction to that of the Lambeth Company's reservoirs at Brixton. A third (open) reservoir adjoins these, which is formed for a supply of unfiltered water for road and street watering, flushing, &c. It is half an acre in extent.

A convenient cottage is in course of erection here for the reservoir keeper.

*Engine Power.*—The aggregate nominal engine power of the Chelsea Company is now 700 horses. It is comprised in, first, two pair of W. Simpson's double cylinder or compound engines, similar to those of the Lambeth Company; small cylinders 28 inches diameter, large cylinders 46 inches diameter, and 8 feet stroke. The nominal power of these engines is 650 horses. Secondly, two engines with single cylinders 20 inches diameter, and 3 feet stroke. The nominal power of these engines is 50 horses.

The pumps worked by the larger engines are of the united plunger and bucket construction, with buckets 24 inches diameter, plungers 17½ inches diameter, and 7 feet length of stroke. Thirteen boilers have been erected for the supply of these engines.

The pumps worked by the smaller engines are of the same construction, with buckets 11¼ inches diameter, plungers 8 inches diameter, and length of stroke 2 feet 7 inches.

The whole of these engines have been erected at Seething Wells, and it is the Company's intention to

pull down and sell the pumping machinery of the old works at Chelsea.

Four double cottages have been erected at Seething Wells for the enginemen and workmen of the Company.

*Mains, Branches, &c.*—The total length of pipeage is now 198½ miles, the additional length laid since the previous return being 64½ miles. Two mains have been laid complete from Seething Wells to the Putney Heath reservoirs, one of 30 inches diameter, for filtered water, for the supply of the district, and one of 15 inches diameter for unfiltered water, for the supply of the parks, for street watering, &c. At all crossings and difficult places on the line, a second length of 30-inch main has been laid, and sufficient land has been purchased for laying four 30-inch mains. The mains from Putney Heath to the district consist of two of 24 inches diameter, and one of 12 inches.

The plan of the mains and district mains required by the Metropolis Water Act, 1852, is in progress, and it will include all the pipes of the new works recently constructed by the Company. The scale of the plan is 40 inches to the mile.

"*Consumption of Smoke.*"—No apparatus is employed for this purpose. The engines are worked with boilers of double capacity, and air is admitted into the furnaces for a few minutes after the supply of fresh fuel. If this is properly attended to, the arrangement will suffice for a compliance with the provisions of the Metropolis Water Act in this respect.

*Quantity of Water supplied.*—The average quantity of water pumped daily in 1855 was 5,323,000 gallons, and during the present summer it has reached 6,914,000 gallons per diem. The number of tenements supplied is now 25,030. The supply is furnished to all parts of the district daily.

The area of the district at present supplied by the Chelsea Water Company is coloured yellow on the accompanying plan. The site of the works and the line of mains thence to Putney Heath are also shown in the same colour.

*Cost of the Works.*—The total expenditure upon the works under the Acts of 1852 has amounted to 472,324*l.*, which sum, added to the previous outlay, makes the total cost of the Chelsea Company's Works 928,036*l.*

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## General Remarks.

The new works of the Chelsea Company above described are of the most substantial and excellent kind. The buildings are of plain although handsome character; but the engine chimney, in the style of an Italian campanile tower, is more ornate, and forms a striking feature in the landscape.

The river wall, built to an uniform line of considerable length, is constructed of concrete, and forms a handsome terrace.

The Company have acquired a sufficient area of land at Seething Wells for a very great extension of their works, and the buildings have been so designed as to admit of their being doubled or ultimately quadrupled on an uniform plan, when the necessity for such increased arrangements may arise.

The mains from the new reservoirs at Putney Heath to the district are carried over the River Thames by a bridge of wrought-iron plate girders, resting on iron columns upon screw piles. The bridge has nine openings, the centre span being 90 feet, and 20 feet in clear height above Trinity high water. This work occupied only 15 months in construction.

It has been before stated, that the Chelsea Water Company were allowed by the Metropolis Water Act, 1852, until the end of August of the present year for the alteration of their source of supply, but the state of the river within tidal influence, already bad, has become latterly so seriously worse, that the Company were anxious to effect the alterations with all possible speed, and great credit is due for the energetic manner in which the works have been

carried out and the change accomplished before the expiration of the time allowed.

The works at Chelsea are now altogether disused, but the connections have not yet been severed.

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## THE WORKS OF THE NEW RIVER COMPANY IN 1850,

Described chiefly from the Return of the Company to the General Board of Health at that date.

The Governor and Company of the New River were incorporated 21 June, 17 Jas. I. They have obtained at various subsequent times legislative powers: the Acts being, 3 Jas. I. c. 18.; 4 Jas. I. c. 12.; 4 Geo. II. c. 14. (private Act); 12 Geo. II. c. 32.; 3 Geo. IV. c. 109.

*Sources of Supply.*—The sources of supply were, the Chadwell spring, near Ware, in Hertfordshire; the river Lea, Spitalbrook; small springs taken into the river in its course; also the water-shed of the North-hall district, and four deep wells sunk into the chalk in Middlesex and Hertfordshire.

The quantity obtained from these sources was as follows:—

| | | | |
|---|---|---|---|
| From Chadwell springs | - | 500 | cubic ft. p. minute |
| „ River Lea - | - | 1,340 | „ „ |
| „ Amwell well - | - | 196 | „ „ |
| „ Amwell-hill well | - | 285 | „ „ |
| „ Cheshunt well | - | 50 | „ „ |
| „ Hampstead-road well | | 70 | „ „ |
| Total | - | 2,441 | cubic ft. p. minute |

*Reservoirs.*—There were six reservoirs, situate at the following places:

At Cheshunt two reservoirs, comprising an area of 18 acres 2 roods;

| | A. | R. | P. |
|---|---|---|---|
| No. 1 - | 11 | 0 | 0 |
| No 2 - | 7 | 2 | 0 |

At Stoke Newington two reservoirs, of an area of 42 acres 2 roods.

| | A. | R. | P. |
|---|---|---|---|
| No. 1 - | 22 | 0 | 0 |
| No. 2 - | 20 | 2 | 0 |

At the New River Head one reservoir, comprising an area of 5 acres.

The sixth and last reservoir, situated in the Hampstead road, was about 200 feet in diameter, built with brick sides.

*Filtration.*—No description of filter was used. The water generally had a period of seven days for subsidence in the store reservoirs. The Company stated further that, "In the reservoirs at Cheshunt "where the water is taken from the water-shed of the "district north of the same, it was generally retained "*a month*, and in the New River where the current is "gentle, as also at five enlarged portions of the same, "there was much time for the deposit of any alluvial "matter which it may contain."

*Engine Power.*—The effective engine power possessed by the Company amounted to 720 horses; the amount of steam power exerted during the summer was equal to about 360 horses working 16 hours each day; in the winter it may be taken at 260. The *nominal* engine power of the Company was 442 horses.

*Mains, Branches, &c.*—The length of pipeage was not given in the return of this Company, the details having never been kept.

*Quantity of Water pumped.*—The quantity of water delivered in the year 1849 was 18,000,000 gallons per day during the summer drought. In the previous year 918,517 gallons per day (Sundays excepted) were delivered to large consumers. The quantity supplied for all purposes amounted to about 170 gallons per house per day.

*Tenements supplied.*—The total number of tenements supplied was 83,206, and 444 large consumers; about 230 houses had a constant supply.

The highest service afforded by the Company, was 430 feet above high-water mark, and the lowest five feet above the same datum.

In the principal and more populated part of the Company's district, the supply was furnished daily; in the country district, north of the Regent's Canal, it was given only four days in the week.

*Cost of the Works.*—The total expenditure upon the works, to the end of the year 1848, was 1,421,717*l.*

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ALTERATIONS and ADDITIONS under the following Acts:

The Metropolis Water Act, 15 & 16 Vict. 84.
The New River Company's Act, 15 & 16 Vict. c. 160.
The New River Company's Act, 17 Vict. c. 39.
The New River Company's Act, 17 Vict. c. 72.

*Sources of Supply.*—The sources of supply remain unaltered; but considerable change has been effected in the course of the New River. Many of the bends have been cut off and straightened, and the length of the channel has been thereby greatly reduced. An Act has been obtained for the diversion of the Hertford sewerage from above the Company's intake from the River Lea; but nothing has yet been done towards carrying out this improvement.

*Reservoirs and Filter beds.*— The reservoirs at Stoke Newington and Cheshunt are still used as subsiding reservoirs. Those at Stoke Newington have been cleaned out and deepened, which has added about 40 per cent. to their capacity.

The old reservoir at the New River Head receives the surplus water of the river which passes the Stoke Newington works. The reservoir near the Brecknock Arms is now intended only for the supply of the New Cattle Market; and that at the Hampstead-road for the supply only of the contiguous baths and washhouses.

Filter beds have been constructed, both at Stoke Newington and the New River Head. Those at Stoke Newington, five in number, cover an area of 6½ acres, and space is reserved for two more. Those at the New River Head are three in number, covering an area of 2½ acres. The supply of filtered water to part of the district was commenced at Christmas 1855, and was subsequently extended over the whole district, with few exceptions, for the completion of which further pipeage is required, and will speedily be supplied.

The filtering medium is five feet in thickness, two of which consist of sand, and the rest of gravel in layers increasing in coarseness towards the bottom.

The Claremont-square reservoir, which receives the filtered water from the New River Head, has been covered over in accordance with the provisions of the Metropolis Water Act, 1852. The covering consists of brick arches springing from cross arches on brick piers. This reservoir has an area of 31,000 square feet, and is capable of holding 3½ million gallons.

Two new covered service reservoirs have been constructed at the top of Maiden-lane, 220 feet above high-water mark. The covering of these is of the same description as of that at Claremont-square. The area of each is 56,784 feet. With 22 feet depth of water they are capable of containing 7½ million gallons. They receive the filtered water direct from the Stoke Newington works. The arching of these reservoirs, as well as of that at Claremont-square, is covered with soil. Another covered reservoir for filtered water is situated at Stoke Newington, of different construction to the others. The water, 22 feet in depth, is wholly below the surface level of the ground, and the reservoir is enclosed by brick walls above ground, spanned with an iron roof covered with slates. Its area is 19,440 superficial feet, and it is capable of holding 1¾ million gallons.

*Engine-power.*—Six new engines have been erected at Stoke Newington of 1,000 nominal horse power. Two pairs are by W. Simpson, and are copies

of those at the Lambeth and Chelsea Works, on the combined high pressure and condensing principle. The high pressure cylinders are 28 inches in diameter, the length of stroke being 5 feet 6½ inches. The low pressure cylinders are 46 inches in diameter, and the length of stroke 8 feet. Each of these engines has one pump 27 inches in diameter, 6 feet 11 inches stroke.

One pair of engines has been supplied by Boulton and Watt. The cylinders are 60 inches in diameter, the length of stroke is 8 feet. Each engine works two pumps, one of 43$\frac{1}{11}$ inches diameter, and 4 feet 9 inches stroke, the other of 31⅓ inches diameter, and 7 feet length of stroke. There are 18 boilers for the supply of the six engines.

"*Consumption of Smoke.*"—No apparatus has been attached to the furnaces for the consumption of smoke; the best "Resolven" Welsh coal only is used.

*Mains, branches, &c.*—The entire length of pipeage possessed by this Company is not exactly known. No quantity was named in the return of 1850; but it is stated to be now somewhere between 400 and 500 miles.

A plan of the mains and district mains, as required by the Metropolis Water Act, has been laid down on the Ordnance engraved sheets 5 feet to the mile.

*Quantity of Water pumped.*—The daily quantity of water now pumped for distribution is 25 million gallons. The number of tenements supplied is 95,083.

The supply is given daily, Sundays excepted, to all parts of the district; and where necessary, in the poorer localities, in consequence of insufficient cisternage, on Sundays also.

The area of the district at present supplied by the New River Company is coloured pink on the accompanying plan. The sites of the reservoirs and other works are distinguished by the same colour.

*Cost of the Works.*—The total sum expended since the passing of the Company's Act, 1852, for new works and extensions, inclusive of purchase of

lands, &c. for further operations, was 566,084*l.* to the end of the year 1855, making with the previous outlay a total expenditure of 1,987,801*l.*

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## General Remarks.

It will be observed by the above statement that the new works of the New River Company are of a most extensive description. The New River Head is not a very desirable locality for filter beds, but otherwise the works have been carried out in a liberal spirit, and no expense has been spared that could render them substantial and efficient.

The engine buildings at Stoke Newington partake of the character of a Scotch castle, and form a prominent feature in the landscape for a considerable distance.

The large subsiding reservoirs at the same place were formerly equal to 10 days' supply, but, owing to the rapidly increased demand for water, are now only capable of 5 days' storage. When lately cleared out and deepened, only 10 inches of deposit were said to have been found, although the reservoirs have been in use for 20 years. The heavier particles in suspension would, no doubt, have been deposited along the course of the New River and in the other reservoirs before reaching those at Newington ; but it would appear to be impracticable to separate the finer matter entirely by rest. As stated in the return, no means of filtration were employed by this Company previous to the Act of 1852.

The filtering medium alone has cost the Company £35,000.

The cost of covering the Claremont-square reservoir was 21,000*l.* The expense was much increased by the necessity of supplying the tenants from the reservoir at the same time that the works were in progress, which required the construction of cross dams.

The pipe from the tank at the New River Head, which formerly supplied the unfiltered water to

the district, it is proposed to retain for the supply of unfiltered water in the same way during periods of frost. The Company's engineer considers that means of supply, independent of the filter beds, should be maintained, because 6 or 7 inches of snow may, in heavy falls, pass through the water on to the surface of the sand, and obstruct the filtering action. From all experience on this subject that has come to our knowledge, we have reason to believe that there would be no possible danger of this if the ordinary depth of water is kept on the filter beds, while it would certainly be more satisfactory that the means of supplying unfiltered water to the district should be removed.

The old engines at the subsiding reservoirs at Newington, for the supply of the Highgate district, will remain as they were, as well as that erected at Highgate for the higher lift.

The extensive works in progress in deepening and improving the channel of the New River, and in cutting off many of its windings, will, as we have said, have the effect of shortening its length very materially. We examined its course from the commencement at the Chadwell spring, near Ware, to the reservoirs at Cheshunt, which is as far as the alterations have yet proceeded.

The Chadwell spring, the original source of supply of the New River Company, yields about 500 cubic feet of water per minute; 274 cubic feet are derived from the wells at Great Amwell, and some small additions are obtained from other wells and from tributaries to the New River, but the main source of the Company's supply is now the river Lea, from which 1,840 cubic feet of water per minute are taken, with power reserved to extend the quantity to 2,500 feet. Under these circumstances it does seem important that the drainage of Hertford, which discharges immediately above this source of supply, should be diverted from it, and it is to be hoped that the powers obtained by the Company to effect this object will soon be put in operation.

## THE WORKS OF THE EAST LONDON WATER COMPANY IN 1850,

Described chiefly from the return of the Company to the General Board of Health at that date.

The several Acts obtained by the East London Water Company bear date as follows:—47 Geo. III. cap. 72.; 48 Geo. III. cap. 8.; 10 Geo. IV. cap. 117.

*Sources of supply.*—The river Lea, *i.e.* about 87 per cent. of the water supplied by this Company, was brought to Old Ford from the river Lea (at Lea-bridge), upwards of six miles from its mouth, by an open canal, nearly two miles in length; about 12 per cent. was taken into the reservoir near Lea-bridge; and about one per cent. was taken from a branch of the Lea, called the water-works stream.

*Reservoirs.*—This Company had six open reservoirs, their capacity, including the canal, was about equal to 35,000,000 gallons. They were situated as follows:

Two at Old Ford,
Two on the eastern side of the river Lea,
One at Lea-bridge,
And one at Stamford-hill.

These reservoirs, for the most part, were lined with Kentish rag-stone.

*Filtration.*—The water was not filtered. It was received into two large reservoirs of deposit, previously to flowing into smaller reservoirs, whence it was pumped into the district supplied by the Company.

*Engine-power.*—The total nominal engine-power was 516·8 horses by steam, 34·5 do. by water-wheels.

The total number of steam engines was five, as follows:

| | | |
|---|---|---|
| No. 1. engine, | cylinder 90 in. diameter, | stroke 10 ft. |
| | pumps - 44 in. diameter, | stroke 11 ft. |
| No. 2. ,, | cylinder 80 in. diameter, | stroke 10 ft. |
| | pumps - 41 in. diameter, | stroke 9 ft. |

No. 3. engine, cylinder 60 in. diameter, stroke 8 ft.
pumps - 27 in. diameter, stroke 8 ft.
No. 4. „ cylinder 60 in. diameter, stroke 8 ft.
pumps - 27 in. diameter, stroke 8 ft.
No. 5. „ cylinder 36 in. diameter, stroke 8 ft.
pumps - 17¾ in. diameter, stroke 8 ft.

The water power possessed by the Company consisted of—

The Lea-bridge water-wheel, with two pumps, one having 20½ inches diameter, stroke seven feet, and the other 11 inches diameter, stroke three feet.

The Stratford water-wheel, with two pumps, one having 11 inches diameter, stroke three feet, and the other nine inches diameter, stroke three feet.

*Mains, Branches, &c.*—The total length of mains was stated to be at least 88 miles, the sizes varying in diameter from 42 inches to five inches. These were always charged with water, under pressure. There were besides, 140 miles of service pipes of 4 and 3 inches diameter, making a total length of pipeage of 228 miles.

*Quantity of Water pumped.*—The quantity of water delivered in the year ending Christmas 1849 was 3,222,753,876 gallons. This was a somewhat smaller supply than was pumped in the previous year, the decrease having been due, it was considered, to the introduction of the system of daily instead of alternate supply, and the saving of waste consequent thereon. The average supply to each house, exclusive of large consumers, watering roads, &c., was, for seven days per week, 140 gallons per diem.

*Tenements supplied.*—The total number of private houses supplied was 56,673, and 264 large consumers.

The highest service afforded was about 120 feet above high-water mark, and the lowest about three feet above the same level.

The supply was given six days in the week, or oftener if required, throughout the Company's district.

*Cost of works.*—The total expenditure upon the works up to Midsummer 1849 amounted to 745,781*l.*

ALTERATIONS and ADDITIONS under the following Acts:

Metropolis Water Act, 15 & 16 Vict. c. 84.
East London Waterworks Act, 15 Vict. c. 7.
East London Waterworks Act, (No. 2.) 15 & 16 Vict. c. 164.
East London Waterworks Act, 16 & 17 Vict. c. 166.
East London Waterworks Act, 17 Vict. c. 65.

*Source of supply.*—The river Lea, above Tottenham. For the conveyance of the water from Tottenham to Lea Bridge, a new open channel has been cut of 100 square feet sectional area. From above this new intake, a large and expensive intercepting drain has been executed, four and a half miles in length, which cuts off from the river the refuse of dye-works, and the drainage of neighbouring places, which are stated to have a population of about 35,000 inhabitants, so that the water is now obtained of the same purity as above Chingford Mills.

*Filter beds, Reservoirs, &c.*—At Lea Bridge the water is received direct from the river on to 13 new filter beds, which cover an area of 12 acres. These have been constructed in two circles, each with a pure-water well in the centre. There are seven filter beds arranged in one circle and six in the other. The filtering medium is three feet six inches in thickness, composed entirely of sand.

From the filter beds the main body of water is conveyed by a four-feet iron pipe to the two oval reservoirs at Old Ford, which were formerly subsiding reservoirs. They have now been connected and covered with brick arches, springing from cross arches resting on piers, the surface of the arches being covered with soil. These reservoirs are $2\frac{1}{2}$ acres in extent.

The other reservoirs of the Company near Old Ford and that at Stamford Hill are now thrown out of use.

*Engine-power.*—In addition to the engine-power described in the former return, a new engine, with 100-inch cylinder and 11-feet stroke, has been erected at Lea Bridge for the supply of the upper northern district. There are six boilers to this engine. It is

capable of lifting 150 cubic feet of water each stroke. A new Cornish engine, 70-inch cylinder, is also in course of erection at Old Ford. The aggregate nominal engine power of the Company is now 840 horses, equal to 40 million gallons of water per day lifted 100 feet high.

"*Consumption of smoke.*"—Some apparatus has been employed at Old Ford for the prevention of dense smoke from the furnaces, but "smokeless" fuel is now used.

*Quantity of water pumped.*—The quantity of water now pumped is 16 million gallons per day, and the number of tenements supplied is 70,000. The supply is furnished six days per week.

*Mains, Branches, &c.*—The total length of pipeage laid, up to Christmas 1855, was 331 miles.

The plan of the Company's mains and district mains, required by the Metropolis Water Act, 1852, is complete up to Christmas last. It is drawn to the scale of 12 inches to the mile.

The area of the district supplied by the Company and the sites of the works are coloured purple on the accompanying plan.

*Cost of the works.*—The cost of the new works executed since the Acts of 1852, has been 250,000*l.*, making, with the previous outlay, a total expenditure of 995,781*l.* upon the works of this Company.

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## General Remarks.

The new works of the East London Water Company most worthy of note, are the 100-inch cylinder engine, the filtering arrangements at Lea Bridge, and the intercepting drainage.

This engine at Lea Bridge is said to be the largest yet erected for waterworks, although it will be seen that the Southwark and Vauxhall Company have one of still larger dimensions now in course of construction.

The filter beds are the most extensive works of the kind appertaining to the metropolitan supply, and they are admirably arranged. They were commenced

in 1852; the first half was completed in June 1854; and the whole by the 5th November 1855, when filtered water only was delivered to the Company's district.

The water of the Lea was quite as turbid as that of the Thames at the time of our visit, owing to the recent rains; but, although the filtering medium employed by this Company is of less thickness than that of any other, the filtered water certainly appeared to us to be the brightest.

The East London Water Company, as stated in the return, employed no means of filtration before the Act of 1852. The large depositing reservoirs upon which they had to rely for clearness of the water have now been abandoned, and all communication between them and the mains has been cut off. The cocks are now used in the main which brings the filtered water from Lea Bridge to the covered reservoirs at Old Ford.

This Company has no high-service reservoir for the supply of their tenants; the water is pumped direct into the district for distribution.

The new buildings at Lea Bridge are of brick; they are substantial, and of handsome elevation. The chimney, and stand-pipe for the supply of the northern high-level district, are enclosed in a square tower 148 feet in height. Fifty-two inch cocks are fixed between the pump and stand-pipe, and between the stand-pipe and main.

No expense has been spared in making these works as complete as possible.

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## THE WORKS OF THE KENT WATER COMPANY IN 1850,

Described chiefly from the Return of the Company to the General Board of Health at that date.

The Acts under which the powers of the Kent Company have been obtained are, 49 Geo. III. c. 189., 51 Geo. III. c. 145.

*Source of Supply.*—The water supplied by this Company was, and is still, taken from the river Ravensbourne, at Deptford.

*Reservoirs.*—The total capacity of the Company's reservoirs and filter beds amounted to 8,710,754 gallons. Two of these were impounding reservoirs situated at Deptford; the water was conveyed from them to two filter beds, and then pumped to the service reservoirs in Greenwich Park, on Woolwich Common, and near the Marine Barracks at Woolwich. From these reservoirs fire mains were also laid to command the Government establishments at Deptford, Greenwich, and Woolwich.

*Filtration.*—The sand surface of the two filters employed by the Company was $1\frac{1}{4}$ acres. Upon these the water was admitted and passed through direct to the engine pumps, all the water supplied having been filtered.

The filtering medium was clean washed gravel at the bottom, with a layer of shells on the gravel, and sand on the shells.

*Engine power.*—The steam-engines employed consisted of two Bolton and Watt engines, 38 inch cylinders, 8 feet stroke. Pumps, $14\frac{1}{2}$ inches diameter, 6 feet 3 inches stroke; and

One Cornish engine, 70-inch cylinder, 10-feet stroke. Pumps, double acting, $20\frac{1}{2}$ inches diameter, 10 feet stroke.

*Mains, Branches, &c.*—The total length of mains, branch mains, side services, and services for small streets, was 85 miles, 3 furlongs, and 165 yards, the sizes varying from 24 inches to $1\frac{1}{2}$ inches in diameter.

*Quantity of Water pumped.*—The total quantity of water pumped during the year 1849 was 393,948,750 gallons. The average supply to each dwelling house, reckoning seven days per week, was nearly 92 gallons per diem.

*Tenements supplied.*—The number of tenements supplied was 9,632, and thirteen large consumers, The supply was given six days a week to private consumers, and to the Government establishment at Woolwich and to the railways, seven days a week.

The highest service afforded by the Company, was 220 feet above high-water mark, and the lowest at high-water mark.

*Cost of the Works.*—The total expenditure upon the works was not stated, as the Company's books do not contain any account showing this result, but the capital raised amounted to 202,104*l.* 13*s.* 6*d.* The cost of the works was said to have exceeded this sum, as for many years a large proportion of the earnings was laid out in purchase of pipes and other works, properly chargeable to capital.

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ALTERATIONS and ADDITIONS under the following Act:
(13 & 14 Vict. c. 59.)

No new works have been executed by this Company under the Metropolis Water Act, 1852, but an Act was obtained in 1850, which empowered the Company to raise a further sum of one hundred thousand pounds, certain new works have been executed and alterations made since the return to the General Board of Health in 1850.

*Filter Beds, Reservoirs, &c.*—One new filter bed has been added at Deptford, making a total surface for filtration of 12,820 square yards. The filtering medium consists of two feet of gravel, six inches of shells, and two feet of sand. The subsiding reservoirs at Deptford, described in the former return, comprise an area of 25,157 square yards, and are capable of holding 1,358,298 cubic feet of water.

The service reservoir in Greenwich Park covers an area of 3,122 square yards, and contains 168,370 cubic feet of water. That on Woolwich Common covers an area of 4,378 square yards, and contains 277,890 cubic feet of water.

*Engine-power.*—One new Cornish engine has been erected at Deptford, 70-inch cylinder, 10-feet stroke. Double acting pump, 18 inches diameter. It is contained in the same building as the similar engine before described. The aggregate nominal engine power of the Company is now 500 horses.

"*Consumption of Smoke.*"—No apparatus for consumption of smoke is employed. Welsh coal is always used, and no dense smoke is formed.

*Quantity of Water pumped.*—The quantity of water pumped in 1855 was 862,760,566 gallons. The number of tenements to which the supply is now furnished is 16,077.

For the high service the water is now raised to a maximum height of 300 feet, and for the low service, 170 feet. The works for the high and low service are quite distinct.

The maximum daily supply to the district in 1855 was $3\frac{1}{2}$ million gallons.

The supply is either constant or is given daily to all parts of the district.

*Mains, Branches &c.*—The total length of pipeage now laid down is stated to be 124 miles. A plan of the mains and district mains, as required by the Metropolis Water Act, is in a forward state, laid down on the Ordnance engraved outline sheets, five feet to the mile, but it is not yet complete.

The area of the district supplied by the Kent Water Company, and the positions of the works and reservoirs, are coloured yellow on the accompanying plan.

*Cost of the Works.*—The cost of the new works executed since 1852 has been 27,022*l.*, and taking the amount before given as the cost of the previous works, the total expenditure has amounted to 229,126*l.* 13*s.* 6*d.*

## General Remarks.

The new works executed by the Kent Water Company since the previous return, call for no particular observation, except that they have been well carried out, and that the engines and buildings are a model of cleanliness and order.

No stand-pipe is used, but a larger air vessel than usual is connected with the main, it being six feet in diameter, and 30 feet high.

With double action pumps, the water being always in motion, no risk is incurred in pumping directly into the mains, either for supply, or for delivery into the high-level reservoirs.

The service reservoirs for the filtered water remain open as before, being situated beyond the limits prescribed by the Act of 1852; but, it should be added that they are chiefly of use as reserves in case of fire, a separate fire-main being carried from each to the Government buildings. The supply to the district is given for the most part direct from the mains, independently of the reservoirs. The lower reservoir, however, near the Marine Barracks at Woolwich, being in an objectionable locality, is now abandoned and disconnected from the works.

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## THE WORKS OF THE HAMPSTEAD WATER COMPANY IN 1850,

Described chiefly from the Return of the Company to the General Board of Health at that date.

The Hampstead Water Company's Act dates the 35th Henry VIII. c. 10.

*Sources of supply.*—The sources of supply were described in the return of 1850 as "springs at Hampstead and Ken Wood, two artesian wells, and temporarily the New River." The wells were situated respectively at Hampstead and Kentish Town.

*Reservoirs.*—The total superficial area of water in the reservoirs, when full, was stated to be about 35 acres; the depths of the reservoirs were said to vary considerably, and the bottoms to be so irregular that no estimate has ever been made of their total capacity that could be depended on.

*Filtration.*—The water was not filtered.

*Engine-power.*—The two steam engines amounted to about 72 horses-power nominally. They consisted of a Cornish engine, at Kentish Town, 60-horse

power, 44-inch cylinder, 10-feet stroke; and a high pressure non-condensing engine at Hampstead, of 12-horse power, cylinder 12 inches, 3 feet stroke.

*Mains, Branches, &c.*—The total length of the mains, branch mains, side services, and services for small streets, amounted to about 26 miles, 1 furlong, 131 yards, and varied in size from 12 inches to 3 inches internal diameter.

*Quantity of Water pumped.*—The quantity of water pumped during *six months* ending 1st December, 1849, including a temporary supply from the New River Company, was 78,013,000 gallons. The estimated quantity delivered to each house for domestic supply was 86 gallons per diem.

The supply was given *three* days a week throughout the district.

*Tenements supplied.*—The total number of houses supplied during the year 1849 was 4,490, empty houses inclusive; one large consumer of 500 gallons per diem, for 6 days a week, and two ditto 1,500 gallons per diem, for 6 days a week.

The highest service afforded by the Company, was about 215 feet above high-water mark, and the lowest 60 feet above that level.

*Cost of the works.*—The total capital invested in the works of this Company, as they existed in 1850, was estimated to be £81,231.

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ALTERATIONS and ADDITIONS under the following Act:

The Metropolis Water Act, 15 & 16 Vict. c. 84.

*Source of supply.*—There is no fresh source of supply for this Company. The artesian well at Kentish-town, from which part of the supply was formerly obtained, has since been continued to a depth of 1,302 feet from the surface by a bore hole commencing with 12 inches diameter, and reduced

first to 10 and then to 8 inches. After passing through the chalk in full expectation of obtaining water from the sands supposed to lie beneath it, a stratum of what is considered to be the New Red Sandstone has been penetrated without tapping the springs.

*Reservoirs and Filter Beds.*—The reservoirs remain as before. One small filter bed, comprising an area of 6,309 square feet, divided in the middle for cleansing purposes, has been constructed within the reservoir at Kentish-town, to filter the water obtained from the Hampstead and Highgate ponds. The filtering medium is 3 ft. 3 in. in depth, and is composed of the following layers:

1 ft. 0 in. large washed pebbles.
0 „ 6 „ small washed pebbles.
0 „ 6 „ fine shingle and gravel.
1 „ 3 „ sand.

The filtered water was first supplied at Christmas, 1855.

"*Consumption of Smoke.*"—No apparatus has been adopted for this purpose. Welsh coal is used for firing.

*Mains, Branches, &c.*—The total length of pipeage now laid extends to about 33½ miles.

The mains of this Company have been subject to such frequent alterations for the purpose of making connections at different points with the pipes of the New River and West Middlesex Companies, to meet the constantly increasing requirements, that it is said to have been impossible to prepare a satisfactory plan of the underground works as required by the Metropolis Water Act.

*Quantity of Water pumped.*—There appear to be no data for determining the gross quantity latterly supplied per day to the tenants of this Company, as the charge for the supply in aid by the New River and West Middlesex Companies, has been founded on the amount of the water rents of the houses supplied, and not on the quantity. Assuming, however, the same

average quantity per house as in the former return, the gross daily supply would amount to 603,060 gallons, the number of houses supplied being 6,348.

The area of the district supplied by this Company, and the sites of the reservoirs and works, are coloured brown on the accompanying plan.

*Cost of the Works.*—The cost of the additional works executed by this Company since the former return, has been 33,224*l.* 5*s.* 3*d.*, making with the previous outlay a total expenditure of 114,455*l.* 5*s.* 3*d.*

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## General Remarks.

The only new work of this Company strictly consequent upon the Act of 1852, is the small filtering apparatus above described.

The new boring at Kentish Town was commenced in June, 1853, from the bottom of the old well, which had been sunk 540 feet deep. The work was abandoned at the end of 1855, under the circumstances above stated, a depth of 1,302 feet having been obtained, and an expenditure of 7,500*l.* having been incurred.

The result of the undertaking was most unexpected. Considerable discussion has arisen among geologists as to the nature of the strata which have been met with, and much interest attaches to the subject. We are enabled by the courtesy of the engineer to append an entire section of the strata. It would be of importance to the cause of science if any means could be found for the continuance of the work.

A very small district is now supplied by this Company. Supplies of water have been obtained in aid for some time from the New River Company; and before the filter bed was ready, the water was also obtained for the supply of part of the district from the West Middlesex Company.

The water from the well at Hampstead, from which about 70 gallons per minute are raised, we found to be clear and bright, and of better colour than the filtered reservoir water.

The means of supply of the Hampstead Company, owing to the sacrifice of their previous well, and the failure and abandonment of the new one, are now less than before. It is understood that terms have been agreed, whereby the affairs of the Company will be merged in those of the New River; and the Hampstead Water Company, which originated in the time of Henry VIII., will then cease to exist.

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## Section of the Boring at Kentish Town.

| | | | ft. | in. | Depth. ft. in. |
|---|---|---|---|---|---|
| Tertiary Strata, 324 ft. 6 in. | *London Clay* (236 ft.). | 1. Yellow clay | 30 | 6 | |
| | | 2. Blue clay, with *Septaria* | 205 | 6 | |
| | *Woolwich and Reading Series* (61 ft. 6 in.). | 3. Mottled (red, yellow, and blue) clay | 37 | 6 | |
| | | 4. White sand, with flint-pebbles | 0 | 6 | |
| | | 5. Black sands; *passing into* | 2 | 0 | |
| | | 6. Mottled green and red clay | 1 | 0 | |
| | | 7. Clayey sands | 3 | 0 | |
| | | 8. Dark-grey sands with seams of clay | 9 | 6 | |
| | | 9. Quick-sands, ash-colrd. | 6 | 6 | |
| | | 10. Flint-pebbles | 1 | 6 | |
| | *Thanet Sands* (27 ft.). | 11. Ash-coloured sands | 10 | 0 | |
| | | 12. Argillaceous sands | 4 | 0 | |
| | | 13. Dark-grey clayey sands | 11 | 0 | |
| | | 14. Bed of angular green-coated flints | 2 | 0— | 324 6 |
| Chalk, 586 feet. | *Middle Chalk with flints* (244 ft. 6 in.). | 15. Chalk with flints | 119 | 6 | |
| | | 16. Hard chalk without flints | 8 | 0 | |
| | | 17. Chalk, less hard with few flints | 31 | 6 | |
| | | 18. Nodular chalk, with three beds of tabular flints | 13 | 6 | |
| | | 19. Chalk, with seams of tabular flint and a few nodular flints | 32 | 6 | |
| | | 20. Chalk, with a few flints and some patches of sand | 9 | 6 | |
| | | 21. Very light-grey chalk, with a few flints | 30 | 0 | |

| | | | ft. | in. | Depth. ft. | in. |
|---|---|---|---|---|---|---|
| Chalk, 586 feet. | *Lower Chalk without flints* (294 ft.). | 22. Light-grey chalk, with a few thin beds of chalk-marl subordinate | 133 | 0 | | |
| | | 23. Grey chalk-marl, with compact and marly beds and occasional pyrites | 161 | 0 | | |
| | *Chalk-marl* (47 ft. 6 in.). | 24. Grey marl | 20 | 0 | | |
| | | 25. Harder grey marl, rather sandy and with occasional iron-pyrites | 27 | 0 | | |
| | | 26. Hard rocky marl | 0 | 6 | 910 | 6 |
| | Upper Greensand (72 ft. 6 in.). | 27. Bluish-grey marl, rather sandy; the lower part more argillaceous | 58 | 9 | | |
| | | 28. Dark-green sand, mixed with grey clay | 13 | 9 | 983 | 0 |
| | Gault (130 ft. 6 in.). | 29. Bluish-grey micaceous clay, slightly sandy | 39 | 0 | | |
| | | 30. Ditto, with two seams of argillaceous greensand | 6 | 7 | | |
| | | 31. Micaceous blue clay | 84 | 11 | 1113 | 6 |
| 188 ft. 6 in. | | 32. Red and yellow sands, and sandstone | 1 | 0 | | |
| | | 33. Compact red clay, with patches of variegated sandstone | 4 | 0 | | |
| | | 34. Pure dark red clay | 4 | 7 | | |
| | | 35. Red clay, whitish sands, and mottled sandstone | 3 | 0 | | |
| | | 36. Hard red conglomerate, with pebbles of syenite, greenstone, trap-rock, quartz, hornstone, red claystone-porphyry, and fossiliferous schist, well rounded, and varying in size from a marble to a cannon ball | 2 | 0 | | |
| | | 37. Micaceous red clays, mottled in places | 26 | 0 | | |
| | | 38. Seams of white fissile sandstone and red sand | 3 | 8 | | |
| | | 39. Mottled sandstone | 0 | 4 | | |
| | | 40. Red sand and sandstone with small pebbles and *Belemnites*, and a few small phosphatic nodules | 2 | 0 | | |
| | | 41. Seams of red sandstone and white sands | 4 | 0 | | |
| | | 42. Pebbly red sands, and fissile sandstone | 1 | 0 | | |
| | | 43. White and red sandstone | 5 | 0 | | |
| | | 44. Fine light-red sands | 2 | 9 | | |
| | | 45. Hard fissile sandstone | 0 | 3 | | |

| | | ft. | in. | Depth. ft. | in. |
|---|---|---|---|---|---|
| 188 ft. 6 in. | 46. Very fine light-red sand | 4 | 0 | | |
| | 47. Pure red clay | 2 | 0 | | |
| | 48. Red and mottled clayey sands, with some iron-pyrites | 1 | 3 | | |
| | 49. Red sandy micaceous clay with fissile sandstone | 2 | 5 | | |
| | 50. Compact hard greenish sandstone | 10 | 0 | | |
| | 51. Very micaceous red clay | 1 | 0 | | |
| | 52. Grey and red clayey sands | 1 | 1 | | |
| | 53. Light-coloured soft sandstone with fragments of *Ammonites* | 2 | 1 | | |
| | 54. Red sand and sandstone (highly inclined ?) | 6 | 2 | | |
| | 55. Greenish sandstone | 4 | 0 | | |
| | 56. White and grey clayey sands, with iron-pyrites | 2 | 0 | | |
| | 57. Reddish argillaceous sands, with seams of sandstone | 3 | 8 | | |
| | 58. Micaceous red clay | 18 | 4 | | |
| | 59. Seam of greenish sandstone | 0 | 5 | | |
| | 60. Red mottled and micaceous clay, with patches of light-coloured sand and fragments of *Ammonites* and of a *Scaphite* | 14 | 6 | | |
| | 61. Red compact micaceous clay, with *Belemnites* | 20 | 0 | | |
| | 62. Red quartzose and micaceous sandstone | 2 | 0 | | |
| | 63. Brownish-red clayey sand and sandstone | 4 | 0 | | |
| | 64. Very hard micaceous sandstone, with small pebbles of white quartz | 4 | 0 | | |
| | 65. Light red argillaceous sand | 10 | 0 | | |
| | 66. Red sandstone, micaceous and quartzose | 8 | 0 | | |
| | 67. Light red clayey sands (with small angular fragments of chert or flint ?) | 2 | 0 | | |
| | 68. Whitish and greenish hard sandstone (horizontal ?) | 6 | 0 | | |
| | | | | —1302 | 0 |

## THE WORKS OF THE PLUMSTEAD, WOOLWICH, AND CHARLTON CONSUMERS' PURE WATER COMPANY.

This Company is not incorporated by a special Act of Parliament; but was fully registered on the 14th October 1852, under the Act 7 & 8 Vict. c. 110.

The works were established for the supply of water to the above-named parishes in 1854, and they have now been in actual operation about two years.

They are in competition with the Kent Water Company over a considerable portion of the district supplied.

*Source of supply.*—This new Company's supply is derived from a well and deep boring in the chalk, the water from which, when first raised, has always an equal temperature of about 52 degrees Fahrenheit; but the special advantage afforded to the tenants of the Company is that the water is softened by Dr. Clark's process. When first pumped from the well this water has 21½ degrees of hardness, that is to say 21½ grains of hardening matter in the gallon, 14½ of which are derived from carbonate of lime held in solution by an excess of carbonic acid gas. The softening process precipitates 13 grains of this carbonate of lime, and leaves a clear bright water of only 8¼ degrees of hardness.

A short description of the softening process, extracted from Dr. Clark's paper read before the Society of Arts, and also an account of the mode of its application to these works by Mr. Homersham, the engineer, under whom the process has been very successfully carried out, will be found prefixed to our separate observations on this subject further on.

*Reservoirs.*—The water, with the lime added, is raised into three open reservoirs of a collective area of 8,549 superficial feet, each reservoir being capable of holding 200,000 gallons. They are constructed of concrete walls lined with brick, and the whole are inclosed within a boundary brick wall. These reservoirs are alternately filled and left to settle. When the precipitation is complete, for which not less than 24 hours should be allowed, the clear softened water is raised into covered service reservoirs, whence it is distributed throughout the district.

One of these service reservoirs is situated near Plumstead Common, and commands a service of 157 feet above Trinity high water mark. It covers an area of 10,121 square feet, and will hold 12 feet depth of water. It is constructed in two divisions, and is

covered with brick arches resting on girders and columns.

The other service reservoir is situated on the side of Shooter's Hill, and commands a level of 311 feet above Trinity high water mark. It is 3,918 superficial feet in area, and 13 feet 3 inches deep. The supply is not yet furnished from this upper reservoir.

*Filtration.*—The water is not filtered, this operation being wholly unnecessary. The water comes from the well perfectly bright; and no difference in this respect can be detected after it has undergone the softening process. This process, however, possesses the further great advantage of preventing subsequent vegetation, from which the supply would otherwise suffer deterioration, if kept in open reservoirs.

*Engine Power.*—The amount of steam power at present employed by the Company is nominally 35 horses; but the engine is said to be capable of working up to 60 indicated horses. It is a double-acting condensing engine, cylinder 29 inches diameter, stroke 5 feet. It performs 30 double strokes or revolutions per minute. Steam is used at a pressure of 30 lbs. on the square inch above the atmosphere. The engine house is constructed for the erection of a duplicate engine.

"*Consumption of Smoke.*"—No apparatus is employed for this purpose. The boiler is large; there are two fire-places; and alternate stoking, combined with care, are the means relied upon for the prevention of smoke.

*Mains, Branches, &c.*—The total length of pipeage already laid by the Company is about 16 miles, the mains and services varying in size from 16 inches to 2 inches in diameter.

A plan of the mains and district mains, as required by the Metropolis Water Act, 1852, does not appear to have been yet completed. A plan exists at the office, to a scale of 12 inches to the mile, showing the pipes as they were originally proposed to be laid

down, but the alterations have not yet been inserted.

*Quantity of Water pumped.*—The quantity of water pumped for many weeks in succession has been 550,000 gallons per day for seven days in the week, but the average quantity cannot yet be stated.

The supply is given to 3,000 houses, so that 183 gallons are furnished per house per day for all purposes.

The supply is given daily, or twice a day, if required, but except in a very few instances, it is not now constant. In the commencement of their operations the Company furnished a constant supply, but the house apparatus and arrangements over which they had no control, are said to have been defective, and to have caused such excessive waste as to compel the Company to abandon the system. The engineer apprehends no great difficulty in the constant supply, if proper apparatus is used, and the connections are carefully made to a proper system.

The area of the district at present supplied by this Company, and the sites of the works and reservoirs, are coloured brown on the accompanying plan.

*Cost of the Works.*—The total expenditure upon the works of this Company has been about 50,000*l.*, of which 3,700*l.* has been the cost incurred in the adoption of the softening process.

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## General Remarks.

As we have thought it desirable to enter upon the separate consideration of Dr. Clark's softening process as a general question, we have little to observe upon these works, except that they have been well carried out, and that considering that this is the first attempt at the complete and permanent application of that process to waterworks for domestic supply, the arrangements appear to be of a very matured and satisfactory character. They have completely settled the question of the practicability and easy working of the process, and of the great advantages of its adoption in all similar cases.

Owing to the great demand upon the works, there is reason to fear that it has not always been practicable to allow sufficient length of time for the complete precipitation of the chalk, and that the water has, at times, been delivered to the customers in a somewhat turbid state. A certain amount of deposit in the service reservoir also rather favours this conclusion; but this is a defect which is remediable at any time by extension of the works.

The water has been raised to the service reservoirs after 16 hours rest, but this would not appear to be sufficient time for complete precipitation of the chalk. Twenty-four hours should be allowed.

It would be an improvement if there were four reservoirs for precipitation, and if they were covered. In the construction of the settling reservoirs already formed, the engineer has provided for arching them over at any time.

One ton of the burnt lime added to the water is said to produce 3½ tons of precipitate. The Company have not yet tried the commercial value of this material.

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## DR. CLARK'S PROCESS FOR SOFTENING WATERS.

Before offering any observations on the applicability of this process to the water supply of the metropolis, under present circumstances, we think it may be useful to give an explanation of what the process is, in Dr. Clark's own words, which we have extracted from the paper read at a meeting of the Society of Arts on the 14th May last, "On means available to the metropolis and other places for the supply of water free from hardness and from organic impurity."

Dr. Clark observes:—

"In order to explain how the invention operates, it will be necessary to glance at the chemical composition and some of the chemical properties of chalk; for while chalk makes up the great bulk of the matter to be separated, chalk also contains the ingredient that brings about the

separation. The invention is a chemical one for expelling chalk by chalk.

"Chalk then consists, for every 1 lb. of 16 oz., of

| | |
|---|---|
| Lime - - - - - | 9 oz. |
| Carbonic acid - - - | 7 oz. |

"The 9 oz. of lime may be obtained apart, by burning the chalk, as in a lime kiln. The 9 oz. of burnt lime may be dissolved in any quantity of water, not less than 40 gallons. The solution would be called lime water. During the burning of the chalk to convert it into lime, the 7 oz. of carbonic acid are driven off. This acid, when uncombined, is naturally volatile and mild; it is the same substance that forms what has been called soda water, when dissolved in water under pressure.

"Now so very sparingly soluble in water is chalk by itself, that probably upwards of 5,000 gallons would be necessary to dissolve 1 lb. of 16 oz.; but by combining 1 lb. of chalk in water with 7 oz. additional of carbonic acid (that is to say, as much more carbonic acid as the chalk itself contains), the chalk becomes readily soluble in water, and when so dissolved is called bicarbonate of lime. If the quantity of water containing the 1 lb. of chalk with 7 oz. additional of carbonic acid were 400 gallons, the solution would be a water of the same hardness as well water from the chalk strata, and not sensibly different in other respects.

"Thus it appears that 1 lb. of chalk, scarcely soluble at all in water, may be rendered soluble in it by either of two distinct chemical changes—soluble by being deprived entirely of its carbonic acid, when it was capable of changing water into lime water, and soluble by combining with a second dose of carbonic acid, making up bicarbonate of lime.

"Now if a solution of the 9 oz. of burnt lime, forming lime water, and another solution of the 1 lb. of chalk and the 7 oz. of carbonic acid, forming bicarbonate of lime, be mixed together, they will so act upon each other as to restore the 2 lb. of chalk, which will, after the mixture, subside, leaving a bright water above. This water will be free from bicarbonate of lime, free from burnt lime, and free from chalk, except a very little which we keep out of account at present for the sake of simplicity in this explanation. The following table will show what occurs when this mutual action takes place:—

| Agents. | | | Products. | |
|---|---|---|---|---|
| Bicarbonate of lime in 400 gallons - | Chalk with Carbonic acid | 16 oz. = 7 oz. = | 16 oz. of chalk. = 16 oz. of chalk. | =2 lb. |
| Burnt lime in 40 gallons of lime water - - - - | | 9 oz. | | |

"But, instead of the whole chalk being separable by the process from the water, only 10-11ths would be separated; so that, with regard to chalk, the accurate result would be expressed, if we suppose 440 gallons of similar water to be operated upon, containing 17½ oz. of chalk. There would be separated, 16 oz.;—there would remain in solution, 1½ oz. Or, to express the result with reference to a single gallon, each gallon would contain of chalk, if unsoftened, 17½ grains; if softened, 1½ grains; and would deposit 16 grains.

"Here is a convenient place to explain a mode of expressing hardness, in very general use now, but first invented by me, in connection with certain new chemical tests of water, in order to work out conveniently the softening process that has been described.

"*Each degree of hardness is as much hardness as a grain of chalk, or the lime, or the calcium, in a grain of chalk, would produce in a gallon of water, by whatever means it may be dissolved.*

"Thus, our supposed water would be 17½ degrees of hardness before softening; 1½ degrees after softening. And this would be the real result, supposing there were in the water no other hardening matter but chalk; but in the best quality of chalk water from springs or wells in the chalk strata around the metropolis, there is actually present a small proportion of other hardening matter, such as to prevent the water from being softened lower than 2½ degrees. A gallon of such water, after being evaporated, was found to have held in solution of solid matter—

| | Grains. |
|---|---|
| Before softening - - | 23 |
| After - - - - | 7 |
| The difference - - | 16 |

was due to chalk removed by the softening process.

"These explanations will make it easy to comprehend the successive parts of the softening process."

It will be gathered from our description of the Plumstead, Woolwich, and Charlton Waterworks that this scientific and ingenious process no longer remains in the position of a beautiful theory of the laboratory, of which the practical application is doubtful, it having now been in operation for two years on so large a scale with eminent success and advantage.

We shall now give Mr. Homersham's account, extracted from the proceedings of the meeting before referred to, of the mode in which the process is there applied.

Mr. Homersham states,—

"The manner of carrying out the softening process at the works was as follows:—The lime used was flare lime, made from the upper chalk. Such lime, fresh burnt, was gradually slacked in small quantities in a tub with water, and was passed through a fine sieve, of about 10 meshes to the inch, into a cast-iron cistern. The cistern, which held about a day's supply when full, remained undisturbed for twelve hours, when a quantity of clear water, found to stand above the lime paste, was drawn off, and the lime paste or cream of lime, as it was called, was stirred up to make it all of a uniform consistency, when it was ready for use. A quart of such cream of lime contained in weight about 1 lb., or rather more, of dry unslacked lime. As the water (about 900 gallons a minute) was pumped up from the well, a suitable quantity of this cream of lime was passed, by means of a large cylinder and piston moved by the steam-engine, into the pipe through which the water was conducted from the well. The cream of lime and water were intimately mixed by causing them to pass together through two, what were called, agitators, placed at a little distance apart. Between the two agitators, a well, six feet internal diameter, and open at the top, was interposed, so that all the lime and water, after it had passed through the first agitator, went into this well on one side, and passed out of it again on the other side, to the second agitator, on its way to the depositing reservoirs. The object of this well, which was five feet deep below the entering pipe, was to allow any gritty matter that by accident might be introduced with the lime into the water to fall to the bottom, and so prevent its passing into the depositing reservoirs. The agitator merely consisted of an enlarged pipe, 21 in. internal diameter, and about 6 ft. in length, containing within and around it 3 plates of wrought iron, about 2 ft. apart, having in them about 110 holes, each one inch in diameter. As the lime and water passed together through the holes at a speed of about 50 inches a second, they impinged quickly against the water in the body of the pipe, which moved only at the rate of 12 inches a second. The lime and water in this way became intimately mixed, and passed on together into a reservoir prepared to receive them, capable of containing (after leaving

room for the chalk deposit at the bottom) 600,000 gallons, or one day's supply. The reservoir was divided into three compartments, each capable of holding 200,000 gallons, for convenience in emptying and filling. When the reservoir was being filled, the lime, at the commencement of filling, was added in excess to the water, so much so, that when the reservoir was only three-fourths full, the remaining fourth part was filled up with pure water from the well. In practice, the adjustment of the exact proportions of lime and water was very easy; the silver test was used for the final adjustment of each compartment of the reservoir, as described in Dr. Clark's paper. The reservoir being thus filled with lime and water, and adjusted by the silver test, in about 16 hours afterwards all the chalk or carbonate of lime had fallen to the bottom, the water had become perfectly clear, and it was then pumped up to the service reservoir for the supply of the consumers. When the reservoir was emptied of the softened water down to within about two feet of the bottom (so as not to disturb the deposit), it was again filled with lime and water as before, the deposit not being taken out until it was 17 or 18 inches deep; this did not occur more than once in eight or ten weeks. The pipe through which the water passed from the well, after the cream of lime was mixed with it, to the depositing reservoirs, was a closed cast-iron pipe, 14 inches in diameter, and about 75 yards in length. It was found for this length, at Plumstead, that the pipe got very slowly coated with a deposit of furr or crystallised carbonate of lime. The same kind of furring or deposit of chalk also took place in the agitators, but by making proper provision for clearing out the deposit which adhered to those parts, they could very easily be kept clear."

As the operation is thus found to be perfectly practicable, there now only remains for consideration the balance of the advantages of the process with the expense of the operation in any individual case.

In order to a clear understanding of these points, —so much erroneous statement having been put forward on the subject,—it may be well to consider what are the limits of the application of the process, what are the benefits to be derived, and what is the probable cost.

The process is confined in its softening action to those waters of which the hardness is derived from

carbonate of lime, or precisely those which are similarly softened by simple boiling of the water. The action of boiling disengages or expels the free carbonic acid from the water, just as the caustic lime added by Dr. Clark's process neutralizes or takes it up, and the carbonate of lime, no longer held by it in solution, separates, and adheres to the sides and bottom of the vessel.

The advantages of the process may be considered under three heads:—health, comfort, and economy.

1. The comparative wholesomeness of hard and soft water for drinking has been a subject of much discussion of late years, but there does not appear to be any conclusive evidence which would allow of any correct estimate of their comparative effect upon the system. Although there can be little doubt that where waters are impregnated with some 60 or 80 degrees of hardening matter its removal would be beneficial, it is contended by many that chalk, to the extent that it exists in the waters supplied by the London companies, cannot be considered injurious to health. Upon this point we do not pretend to offer an opinion; in speaking of the advantages of the softening process to health, we refer simply to the value which it is said to possess, of removing, *in part*, organic impurity in solution in water, and which ordinary filtration will not disengage. We are not aware that it has been practicable to determine the extent of this property of the process; but that it effectually prevents the rapid vegetation which ensues on the escape of free carbonic acid gas from water derived from the chalk, and allowed to rest, has been most satisfactorily proved at the Woolwich works.

2. The comfort of a soft water for personal ablution and bathing will be admitted by all as no mean consideration in favour of the process.

3. The economy to be derived from the use of the softened water is stated to consist of the saving in tea and other articles of infusion; in soap and in soda; the saving of labour in washing, and of the wear and

tear of clothes; the avoiding of incrustations of engine boilers, kettles, and other vessels.

The chief economy will obviously be in tea and in soap, but while admitting that this must be considerable, we must express our opinion that the savings that have been calculated in these articles from the use of softened water, have been much over-rated.

The Commissioners who reported in 1851 on the chemical quality of the supply of water to the metropolis found that the hardness of London water, *as it is commonly used after boiling*, was about 5 degrees; while without heating it amounts to 14 degrees. It is probable that the water used for making tea may not usually be boiled sufficiently long to reduce the hardness to this extent, and therefore that a saving of tea somewhat considerable would in such case result from the use of water which had undergone the softening process, but we presume that no such economy can be reckoned upon as would be found from the use of the softened water as compared with another which derived its hardness from other sources than carbonate of lime not reducible by boiling. And in the matter of soap, although every hundred gallons of water derived from the chalk strata, are said to be capable of destroying and rendering of no effect 30 ounces of soap more than if it had undergone the softening process, it is obvious that this forms a most erroneous basis of calculation of the actual waste incurred from the use of such water. In all washing operations the soap is effectively used with comparatively a very small quantity of the water in the vessel, the bulk of the water in use being in fact employed in rinsing, in getting rid of the soap that has performed its office, the destruction of which is then no longer of any consequence.

Notwithstanding these over-estimates, however, the great advantages of the softened water cannot be questioned, and they are well worthy consideration in all places supplied with water to which the process is applicable.

The softening process is applicable with most advantage not to river waters but to clear spring waters, such as are usually derived from wells in the chalk, or to other waters of which the hardness is derived from carbonate of lime, but which have acquired no tinge or discolouring admixture.

In this case the precipitated pure carbonate of lime is stated to possess considerable commercial value as an excellent material for whiting, which, according to Mr. Homersham's calculations, would nearly pay for the whole working expenses, and interest on the capital expended for establishing the process. The public would, in such case, enjoy all the advantages of the system almost free of cost.

If the process were applied to a water which has taken up any impurity or discolouring matter, as the water of the Thames, for instance, it is admitted that the precipitate would be valueless; but, notwithstanding this, looking at all the comfort and advantages to be derived from the use of a soft and pure water, we believe that there are few cases in which we should hesitate to recommend its adoption.

As regards the Metropolis, if the application of the softening process had formed one of the requirements of the Act of 1852, many of the companies' arrangements would necessarily have differed widely from those which have been carried out, but considerable savings might probably have been effected in them which would in part have compensated for the additional outlay.

Reckoning the cost of the process upon the experience of the works of the Woolwich and Plumstead Company, the expenditure for works executed *de novo* for the whole of the metropolis would have amounted to about half a million sterling, and the working expenses to about £20,000 per annum; but now that the new works and arrangements of the several companies have been completed, it is impossible to say what expense would be involved in its adoption; and independently of any outlay that might be required in addition to the large sums which the companies have been already called upon to expend,

it is contended that the process would now be in great part unsuitable for, if not quite incompatible with, those works and arrangements just carried out for the improvement of the supplies.

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## EXAMINATION OF THE RIVER THAMES ABOVE THE NEW SOURCES OF SUPPLY.

In the course of our early examinations of the works of the water companies which derive their supplies from the river Thames, we could not fail to observe the very turbid and discoloured state of the water, an effect that is said to be for the most part due to the clay washed down by the heavy rains, and is found to be common also to the River Lea. But this fact, coupled with our observations in other places, of the injurious effects upon rivers and streams which have arisen from the drainage of the neighbouring towns into them, led us to consider it of importance to inquire as to the amount of deterioration to which the supplies of water furnished to the metropolis might be subject by the drainage of the towns situated above the newly adopted sources.

It is difficult to determine from what amount of population the Thames above Hampton may be said to receive the sewage either directly or by means of its tributaries, but at the smallest computation it is a very considerable number.

We were the more impressed with this point of inquiry from the fact, that the most urgent question which now presents itself in the progress of the sanitary improvement of many of the country towns, of which the drainage has been carried out without proper means for utilising or treating the sewage matter, is the serious pollution of the rivers and streams to which the outfalls are conducted.

The rapidly increased pollution of the Thames from the same cause within tidal influence, during the last few years, has been matter of surprise and comment for some time, and, looking at the evil consequences of such contamination of waters furnished

for domestic use, it is matter for regret that the alteration of the sources of supply was not sooner commenced.

At the time of the outbreak of cholera in 1848, the state of the river at the point whence the Lambeth Company drew their supply was found to be so bad as to induce them to take measures at once for the alteration of their source. At that time the water delivered by the Southwark and Vauxhall Company, taken at ebb-tide and carefully filtered, enjoyed a comparative reputation for purity, and yet within the short period to the succeeding epidemic, the river at this higher point became so rapidly worse as to lead to the fearful increase of mortality which has been so conclusively deduced from a comparison of the death rate among the tenants of the two companies in the same district.

It should be borne in mind that this source of danger in a water supply is scarcely removable by any amount of care on the part of a company. It is not within the control of ordinary filtration. The poison being there in solution, there seems to be no cure but the abandonment of such a source of supply, and the works of the Southwark and Vauxhall Company, for this purpose, were in progress at the very time of the outbreak of cholera which is proved to have committed such increased ravages within this district.

Consideration of these facts led us, as we have said, to an examination of the River Thames above the new sources of supply. We commenced our inspection at Caversham Bridge, above Reading, about 50 miles beyond Hampton, now the highest point of supply on the river. We took 17 samples of the water below the several towns and the tributary streams of the Thames.

The weather was dry during the whole of the time, and our examination satisfied us of a very perceptible increase of matters in suspension in the water in its progress downwards from one point to the other, and this increase was especially noticeable after passing

Windsor and Eton, two towns of which the drainage has been latterly carried out to a great extent, without the adoption of any means for avoiding pollution of the river.

To what extent the danger of such pollution may be obviated by the action of the atmosphere, or by other causes, in so great a length of flow as there is between these places and the sources of metropolitan water supply, we do not suppose that anybody is capable of determining We can only notify the considerable increase of matter in suspension which was perceptible in the water as we passed down the river, and which implied, to our minds, corresponding impurity in solution.

We regret that there has been no opportunity for analysing the samples obtained; but, looking at the result of chemical examination of waters of more decided differences of quality than could be conceived to exist in these samples, we should not expect to find much chemical variety noted in them from which any positive conclusions could be formed; for, turning to the "Report of the Commissioners on the Chemical Quality of the Supply of Water to the Metropolis," published in June 1851, we find, in the analyses of those waters in which we should have expected the most marked contrast, namely, those from Lambeth, from Battersea, and from Thames Ditton, the following figures:

Extract from Analyses of Thames Waters.

| | Grains in Imperial Gallon. | |
|---|---|---|
| | Organic Matter. | Ammonia. |
| Lambeth - - - | 2·59 | trace. |
| Battersea - - - | 1·51 | 0·03 |
| Thames Ditton - - - | 2·29 | trace. |

From this extract it will be observed that the Lambeth water, which was then about to be volun-

tarily abandoned by the Company because of its polluted state, showed very little more organic impurity under chemical analysis than the Thames Ditton water which has been substituted for it. The Battersea water, supplied by the Southwark and Vauxhall Company, to the use of which a dire calamity was so soon to be traced, actually exhibited in this examination far less organic impurity than either of the others, or, indeed, than any of the Thames waters, and showed the minutest quantity only of ammonia.

The Battersea water no doubt had become worse at the time of the subsequent outbreak of cholera, but these are not differences from which the polluted state of the water at Lambeth and at Battersea even in 1851, as compared with that at Thames Ditton, could possibly have been inferred.

Turning also to the analyses contained in the "Report of the Committee for Scientific Inquiries in relation to the Cholera Epidemic of 1854," we find the following figures :—

"Water Supply of London."

Extract from Table of Analyses.

| — | Grains of Admixture per Gallon. | |
|---|---|---|
| | Organic Matter. | Carbonate of Ammonia. |
| Lambeth Company. Thames Ditton - - | 1·390 | ·064 |
| Grand Junction Company. Kew - - - - | 1·920 | — |
| Chelsea Company. Chelsea - - - - | 5·410 | — |
| Southwark and Vauxhall Company. Battersea - - - | 3·560 | ·840 |

From which it will be observed that although both the Chelsea and Battersea water have organic matter considerably in excess of the supply from Thames

Ditton, the Battersea water has it not so much in excess of the Thames Ditton supply as the Chelsea water has it in excess of the Battersea; while the water from Kew, within the tidal influence, and receiving the drainage of a very large population from immediately above, approaches much more nearly to the quality of the Thames Ditton water. Add to this that the Southwark and Vauxhall water, which was condemned as the worst supply, and the Thames Ditton water, the new source of supply, at that time certainly the best, were the only two waters then furnished to the Metropolis in which any trace of ammonia was found, and the inference will naturally be drawn that chemical analysis does not at present convey an exact understanding of the danger to health which a particular water may occasion. Indeed, we understand it to be an admitted fact that it is a most difficult thing to discover, by any chemical process hitherto adopted, the precise amount of these poisonous ingredients which may produce such injury to the system; while, on the other hand, it is impossible to say how small a quantity of such matter might not, under certain circumstances, be injurious.

Neither can such ingredients be usually detected by the senses. It is true that we found the filtered water of the companies in every case bright to the eye, and pleasant to the taste, but neither eye nor palate will discover even a dangerous amount of impurity in a water when that water is in a fresh and cool state. The waters from the shallow wells of London, perfectly bright as they are, frequently present, under examination, evidence of impurities derived from the innumerable cesspools and sewers with which the metropolis is riddled and traversed; but those impurities may not be detected by the senses. The water always comes cold and sparkling from the pump, and, in ignorance of such dangerous impregnation, it has been almost universally preferred for drinking. The fatal consequences that may ensue from the use of such waters are strikingly evidenced in the report by a committee of the vestry of St.

James's, Westminster, on the Cholera outbreak in that parish.

We are induced to call special attention to the point under consideration, because, when the inquiries were instituted by the General Board of Health in 1850 into the water supply of the metropolis, great stress was laid, apparently with good reason, by the Southwark and Vauxhall Company, upon the analyses conducted by eminent chemists, in opposition to any change of source of that very supply to which such evil consequences have since been traced, and it is not a matter of surprise that, backed by such analyses and by the opinion expressed by three of the first chemists of the day, that this water was, "in the full sense of the term, wholesome and proper for the supply of a town," remonstrances should even more recently have been urged against any such change.

Such a test, now oftentimes repeated, having been found wanting, or at the least uncertain, we venture to warn against too much confidence being placed in the result, if analysis should fail to detect any serious difference of quality between the water of the Thames at Caversham Bridge, and that now supplied from Hampton or Thames Ditton.

We know from experience, at all events, that whatever amount of pollution the river may now derive from the towns along its banks, is as nothing to what it will be when the drainage works, for which some of those towns are already preparing, will have been carried out.

That the water companies themselves are fully alive to the importance of this question, is evident from the large expenses which the Lambeth and the East London Companies have already taken upon themselves, and the New River Company have proposed to take, to remove the more immediate contamination to which their sources of supply are subject from this cause, and, looking at the enormous outlays to which all have been compelled in seeking purer supplies, in justice to them, we consider that measures should be adopted for removing any pre-

ventible cause of contamination which, by future increase may tend to mar the efficiency of the works which have been so well carried out.

But, as a question of public health, how much more would it appear to be an imperative duty, especially keeping in view the lesson which has recently been taught from too long neglect of precautionary measures, to urge that no step be left untaken in a case which involves the purity of the supply of water to nearly the whole population of the metropolis, for although our remarks have been directed more especially to the Thames, they are equally applicable to the Lea and to the Ravensbourne.

In many country towns, complete works of water supply and drainage have been carried out within the last few years, and the authorities, probably conceiving that there the problem of sanitary reform would end, have been content to discharge the whole sewage of their districts into the nearest watercourses. The magnitude of the new evil which arises,—the complete poisoning of the streams,—will, it is hoped, soon work its own remedy, and enforce the application of means for the legitimate disposal of the refuse in the fertilization of the lands. Already have several towns been compelled by legal proceedings, or by agreement with parties interested, to take measures for avoiding pollution of the streams, and there would appear to be no injustice, in any case, in urging upon all towns the adoption of a course which must ultimately tend to their own benefit and advantage.

We venture to hope that consideration of these facts may at least lead to the conclusion that a sufficient case is presented for further inquiry into the removable causes of contamination of the water supply of the metropolis above the present sources of supply.

## CONSTANT SUPPLY.

The purer sources of water supply required by the Legislature having now been adopted, and the water filtered and preserved in covered reservoirs from local impurities and atmospheric deterioration, if measures be taken for preventing pollution of the rivers themselves, the only remaining serious cause of contamination will be the cisterns, water-butts, and other means employed for storing the supplies now furnished by the companies. Although considerable improvement has already taken place in the distribution, and the water formerly supplied only on alternate days is now for the most part given daily, except on Sundays, to every part of each Company's district, its storage even from day to day in the private butts and cisterns of most houses, and especially in those of the poorer class, to a great extent destroys the advantages that so much pains have been taken to secure. The only complete remedy for this serious defect will be the constant supply, that is to say, a supply obtained at all times by direct communication of the house service pipes with the constantly charged mains of the companies, thus avoiding the necessity for any means of storage whatever on the private premises.

The constant supply would be the means of rectifying also another serious defect to which the public is not unfrequently liable in the present system, namely, the irregularities of the supply. Notwithstanding that the Companies have abundant means of furnishing any quantity of water that can be legitimately used throughout their districts, loud complaints are too often heard of a want of water in certain localities. The deficiency would appear to arise not from actual lack of water, but from some irregularity from time to time in "*districting*" the service, which the constant supply would obviate. We would allude also to the great advantage of constantly charged mains, in case of fire, as no small consideration, but we refrain from entering at length upon this and other points involved in this important

part of the question of a proper water supply, as the provisions of the Metropolis Water Act, 1852, empowering the inhabitants under certain conditions to require the constant service, do not come into operation until five years after the passing of that Act, namely, 1st July 1857. There appear, however, to be no practical difficulties in the way of this boon to the public. It will involve, no doubt, considerable changes in the private works for the prevention of accident and waste, and the Act provides for the proper examination of these works by the Companies' officers.

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## SUMMARY.

We beg to present in the tabulated form on the opposite page, a concise view of the main features of the entire works of the metropolis water supply, already separately described.

In bringing the chief works of the several Companies thus into juxtaposition, various anomalies and disproportions become apparent, which seem at first sight to be irreconcilable, such as the quantity of water supplied, the amount of steam power provided, the area of reservoirs and of filter beds, and the cost of the works as compared with the number of houses supplied by each of the Companies. But while, on the one hand, many of these seeming disproportions would doubtless be approximated by a full exposition of the various and special circumstances of each case, it must be borne in mind, on the other hand, that these works are for the most part the progressive growth of many years, under many professional advisers working independently, and under whom, with no uniform plan of action for guidance, very different views would be sure to find expression.

The only disproportion of the kind to which we consider it desirable to direct special attention, as probably affecting at times the quality of the supplies, is the very small amount of filtering area provided in some of these works as compared with that of others.

According to the return furnished by the several Water Companies in 1850, it appeared that 270,581 houses were then supplied with water, the gross daily quantity delivered having been 44,383,332 gallons. It will be observed from the preceding table that the supply of water to the metropolis has now reached the enormous quantity of upwards of 81 million gallons per day, *it having been nearly doubled in the short space of six years.* It is furnished to 328,561 of the 340,000 houses which now form the aggregate within the Registrar General's district. Thus, the

## Table of the entire Works of the Metropolis Water Supply.

| List of Metropolis Water Companies. | Sources of Supply. | No. of Houses supplied. | Gross Quantity supplied per Day. | Aggregate nominal Steam Power. | Length of Mains and Branches. | Area of subsiding Reservoirs. | Area of Filter Beds. | Area of open Reservoirs for filtered Water. | Area of covered Reservoirs for filtered Water. | Cost of Works, as per former Return. | Cost of Alterations and of New Works. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | *Gallons.* | *Horses.* | *Miles.* | *Acres.* | *Acres.* | *Acres.* | *Acres.* | £ | £ |
| New River - - | River Lea, Chalk Springs, &c. | 95,083 | 25,000,000 | 1,442 | 400 to 500 say 450 | 66·00 | 9·00 | None. | 3·76 | 1,421,717 | 566,084 |
| East London - - | River Lea - - | 70,000 | 16,000,000 | 840 | 331 | None. | 12·00 | None. | 2·50 | 745,781 | 250,000 |
| Southwark & Vauxhall. | River Thames, at Hampton. | 41,529 | 10,331,122 | 1,065 | 432 | 7·88 | 4·40 | None. | None. | 435,247 | 214,010 |
| Lambeth - - | River Thames, at Thames Ditton. | 28,541 | 6,109,000 | 680 | 206 | None. | 0·73 | 1.25 | 3·00 | 307,352 | 301,633 |
| West Middlesex - | River Thames, at Hampton. | 25,732 | 6,895,368 | 480 | 178 | 16·00 | 4·50 | None. | 1·75 | 648,560 | 157,399 |
| Chelsea - - | River Thames, at Seething Wells. | 25,030 | 5,323,000 | 700 | 198½ | 3·50 | 2·00 | None. | 2·50 | 455,712 | 472,324 |
| Grand Junction - | River Thames, at Hampton. | 17,221 | 6,714,292 | 1,440 | 117 | 7·69 | 5·17 | None. | 1·07 | 522,295 | 211,128 |
| Kent - - | River Ravensbourne - | 16,077 | 3,500,000 | 500 | 124 | 5·20 | 2·65 | 1·55 | None. | 202,104 | 27,022 |
| Hampstead - - | Ponds and Chalk Well | 6,348 | 603,060 | 72 | 33½ | 35·00 | 0·14 | None. | None. | 81,231 | 33,224 |
| Plumstead & Woolwich. | Chalk well - - | 3,000 | 550,000 | 35 | 16 | 0·19 | None. | None. | 0·32 | None. | 50,000 |
| | Totals - - | 328,561 | 81,025,842 | 7,254 | 2,086 | 141·46 | 40·59 | 2·80 | 14·90 | 4,819,999 | 2,282,824 |

average daily supply of water for all purposes, which in 1850 was 164 gallons per house, is now, in 1856, 246 gallons per house. The total nominal engine power employed and in reserve is equal to 7,324 horses. The mains and branch pipes for bringing the water from the several sources, and distributing it in the districts, exclusive of the private service pipes, form a total length of 2,086 miles. The filter beds cover an area of upwards of 40 acres. Before the passing of the Metropolis Water Act of 1852, considerably more than half the supply was not filtered; subsiding reservoirs were in such case the only means of clearing the water of impurities in suspension; these are now for the most part employed as well as the filter beds, the total area of subsiding reservoirs in use being upwards of 141 acres in extent. The filtered water is stored in fourteen covered reservoirs comprising an area of nearly 15 acres, and in four uncovered reservoirs, of not quite 3 acres, which are beyond five miles distance from St. Paul's. The cost of the new works executed under the Metropolis Water Act, 1852, and the recent Acts of the several companies, has amounted to £2,282,824, making with the former expenditure, as shown by the returns of 1850, the cost of the entire water works of the metropolis *upwards of seven millions sterling*. Even this amount, however, will fall short of the total expenditure; for the intermediate outlays between the former returns and the passing of the new Acts, and the cost of many works in hand, but not yet complete, are not included in this sum.

In presenting this summary of the establishments to which our inquiries have been directed, we desire to observe, in order to guard against misconception as to the omission of other valuable matter, that we have sought only, in fulfilment of our instructions, to give such a general description of the engineering features of the works of each company as would furnish a correct idea of the aggregate works of metropolitan water supply. Numberless points of details of construction, and information concerning the working of

these establishments, would, no doubt, have been interesting in themselves, but they scarcely appeared to be necessary, keeping in view the main object of the inquiry with which we have had the honour to be intrusted, while such an extension would have involved a very elaborate and lengthened report, the preparation of which would have required much longer time than it appeared desirable to devote to the inquiry.

In conclusion, we desire to observe, as the result of our investigations into the present state of the metropolitan water supply:—

1st. That the requirements set forth in the commencement of our Report, comprising the 1st, 2nd, 3rd, 4th, 14th, and 17th clauses of the Metropolis Water Act, 1852, have, in all essential respects, been fully and satisfactorily complied with by the several Companies, (the provisions for constant supply not coming into operation until the 1st July 1857). The new works have not, in fact, been limited to what a bare compliance with those provisions would have fulfilled. Measures have been adopted for the general improvement of the supplies, which evince a proper anxiety on the part of the companies in the discharge of the duties of their position towards the public.

2nd. That having regard to the serious state of contamination to which many of the rivers and streams of the country are being reduced by the drainage operations carried out in the neighbouring towns, and by the direct discharge of the sewage without any means adopted for the prevention of the pollution of the waters,—a condition which is evidenced to the inhabitants of the metropolis by the suddenly increased pollution of the Thames itself at the points whence their water supply has but recently been drawn,—we desire to recommend that early attention be directed to the towns draining into the Thames and its tributaries, and into the Lea and Ravensbourne, above the present sources of supply, so that measures may be adopted with regard to the drainage of those

places which will permanently preserve the supply of water to the metropolis in its utmost practicable state of purity.

We have the honour to be, Sir,
Your very obedient servants,

HENRY AUSTIN,
*Chief Superintending Inspector.*

WM. RANGER,
*Superintending Inspector.*

ALFRED L. DICKENS,
*Superintending Inspector.*

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# GENERAL BOARD OF HEALTH.

# REPORTS

TO THE

## RIGHT HON. WILLIAM COWPER, M.P.,

PRESIDENT OF THE GENERAL BOARD OF HEALTH,

ON THE

# METROPOLIS WATER SUPPLY,

UNDER THE PROVISIONS
OF THE METROPOLIS WATER ACT.

Presented to both Houses of Parliament by Command of Her Majesty.



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