ON THE FUTURE WATER SUPPLY OF LONDON.

BY

GEORGE WILLOUGHBY HEMANS, C.E.

AND

RICHARD HASSARD, C.E.

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FUTURE WATER SUPPLY OF LONDON.

THE ideas on which the following project is based, have been for a long time under consideration, and the descriptive particulars were actually preparing for circulation when the public were presented with the views on this subject of a very eminent gentleman, Mr. Bateman, C.E., in the form of a pamphlet, ably written and extensively circulated, and which has already attracted a large amount of remark and approval.

It is felt, therefore, that these suggestions appear now somewhat at a disadvantage, particularly as the sources of water supply recommended would seem at first sight to demand works, in length and extent of greater and more startling magnitude, than even the already sufficiently bold project of Mr. Bateman, for bringing water to London from the Welsh Hills at a distance of 183 miles. The sources herein recommended lie at a distance of 240 miles from London, but notwithstanding this increase of distance, we believe that when the subject is fully investigated, it will appear that our project—although involving an apparently larger outlay in the first instance—will, from the absolute certainty of the rainfall, the extraordinary purity of the water, the facilities afforded by the existing lakes for the construction of immense Reservoirs, and from the revenue which may fairly be expected from the sale of water in the districts traversed by the aqueduct, be found the best and cheapest which has yet been proposed, and that ultimate economy will arise from its selection.

The future water supply of London, from its magnitude and importance, from the sanitary considerations involved in its successful elucidation, and having in view the enormous and rapidly increasing population which will afterwards be dependent upon it for one of the chief necessaries of life, is a question without parallel in the history of engineering, in ancient or modern times.

Of the existing water supply, little need be said; that it is imperfect and unsatisfactory, both on account of quality of water, the intermittent nature of the supply, and rate of charge, is admitted on all hands; whilst, from the peculiar circumstances of the case, it is scarcely possible for the Water Companies to afford a supply much larger in quantity, or better in quality, than that at present furnished; they have done their best to carry out the obligations imposed on them by the Acts of 1852, and have expended large sums in their attempts to do so; the limit they can attain, has, however, been nearly reached, and if the Metropolis is to have a supply of pure water, such as is now enjoyed by many of the provincial cities and large manufacturing towns in the kingdom, it is full time that measures should be taken to investigate the question, and secure a suitable district from which to obtain it, there being very few available localities now unappropriated, or which will not, owing to the growing necessities of this populous country, shortly be appropriated, for the supply of other towns and districts.

The population of London and its suburbs has increased of late years in such an extraordinary ratio,—with the probability of at least this rate of increase being maintained,—as to render it absolutely essential, that any scheme now put forward, should be designed so as to admit of a quantity of water, at least double the existing consumption, being brought to the Metropolis, from time to time, as the requirements of the district demand additional supplies.

The population of the Metropolis and suburbs may be taken at 3,000,000, and the quantity of water now actually supplied by the different companies at nearly 100,000,000 gallons daily.

Of this, a very large proportion (about one half) is extracted from the Thames, above tidal influence, as required by the Acts of 1852, and such a serious diminution of the volume of water in the river flowing onwards to London, has of late attracted great public notice, to which it is not necessary at present further to advert.

The following extracts from the Registrar General's monthly reports, as published in the "Times," will show the qualities of the waters so obtained, as well as those of the waters of the other sources from which the Metropolis is now supplied.

"Analysis of the Metropolitan Waters, in December, 1865, by Professor Frankland, F.R.S., of the Royal College of Chemistry:—

Names of Water Companies.	Solid Matter in 100,000 parts of the Waters.	Organic and other Volatile Matter included in Col. 1.	Amount of Oxygen required for oxidation of Organic Matter.	Degrees of Hardness.*		
				Permanent.	Temporary.	Total.
Thames Water Companies.						
Chelsea . . .	28·00	1·52	·1942	7·0	9·1	16·1
West Middlesex .	28·91	1·49	·1045	6·8	11·9	18·7
Southwark & Vauxhall . . .	31·32	1·98	·1972	7·4	11·5	18·9
Grand Junction .	29·51	1·91	·1722	7·4	11·0	18·4
Lambeth . .	29·06	1·08	·0842	8·8	7·6	16·4
Other Water Companies.						
Kent . . .	37·45	0·61	·0070	8·8	17·4	26·2
New River . .	30·02	0·54	·0396	7·0	14·1	21·1
East London . .	33·90	1·56	·1274	7·2	15·0	22·2
South Essex . .	38·10	0·86	·0112	5·8	19·0	24·8

The table may be read thus—100,000 lb. of the Chelsea water contained 28·00 lb. of solid matter, of which 1·52 lb. of organic and other matters were driven off by incineration. ·097 lb. of oxygen were required to destroy organic matter in the said quantity of Chelsea water. Of the solid matter, 16·1 lb. are carbonate of lime or its equivalent; of which 9·1 lb. are got rid of by boiling, and 7·0 lb. remain.

With the exception of the water supplied by the Kent and South Essex Companies, the waters again exhibit this month

* The degree of hardness hitherto employed by chemists is that first proposed by Dr. T. Clark—viz., one grain of carbonate of lime, or its equivalent, in one imperial gallon of water, or one part in 70,000. The degrees of hardness used in the above table are readily converted into Clark's degrees by multiplying by 7, and then moving the decimal point one place to the left.

a marked increase in the total amount of solid impurity as compared with last month; this applies also to the water supplied by the Lambeth Company, which was the only one which, in October, showed no increase of residue over the preceding month. On the other hand, the organic and other volatile matter has (with the exception of the water supplied by the Grand Junction Company) decreased; while the amount of oxygen required for oxidation of the organic matter is in most cases less than in November.

The waters of the Chelsea, Lambeth, Southwark, Grand Junction, and East London Companies were turbid when drawn from the Companies' mains.

The second column of this table contains the amount of solid matter left on evaporation and desiccation at 120 deg. C.—130 deg. C. (248 deg. F.—266 deg. F.)

The results are recorded in 100,000 parts. By moving the decimal point one place to the right, the above figures express in milligrams the quantities contained in one kilogram of the several waters.

IN FEBRUARY, 1866.

Names of Water Companies.	Number of Houses supplied in Jan., 1866.	Average Daily Supply of Water in Gallons during the Month of January, 1866. (See Note.)	Solid Matter in 100,000 parts of the Waters.	Organic and other Volatile Matter included in Col. 4.	Amount of Oxygen required for oxidation of Organic Matter.	Total Hardness.*
Thames Water Companies.						
Chelsea . .	26,436	7,658,800	31·14	2·59	·0912	21·1
West Middlesex	35,486	7,657,423	30·40	2·00	·0739	19·8
Southwark and Vauxhall .	73,594	12,125,000	30·90	2·40	·0643	20·7
Grand Junction	25,308	8,067,112	31·40	1·60	·0555	22·2
Lambeth . .	35,420	7,620,200	31·16	1·65	·0592	21·0
Other Sources.						
Kent . .	32,412	5,376,676	37·92	1·80	·0104	27·4
New River .	111,864	22,330,000	29·50	1·68	·0576	22·0
East London .	88,340	17,592,000	32·78	1·68	·0636	23·1
South Essex .	750	161,000	40·60	1·36	·0086	26·5

Note.—The quantities of water here given include the supply for manufactures and for various purposes other than domestic consumption. The table may be read thus:—The Chelsea Water Company supplied 26,430 houses, and an average daily quantity of 7,658,800 gallons in the month of January; 100,000 lb. of the Chelsea water in February contained 31·14 lb. of solid matter, of which 2·59 lb. of organic and other volatile matters were driven off by incineration. ·0912 lb. of oxygen was required to destroy organic matter in the said quantity of Chelsea water. 21·1 lb. are carbonate of lime or its equivalent. The fourth column of this table contains the amount of solid matter left on evaporation and desiccation at 120 deg. C.,—130 C., (248 F.—266 F.). The results are recorded in 100,000 parts. By moving the decimal point one place to the right the above figures express in milligrams the quantity contained in one kilogram of the several waters.

* The degree of hardness hitherto employed by chymists is that first proposed by Dr. T. Clark—viz., one grain of carbonate of lime, or its equivalent, in one imperial gallon of water, or one part in 70,000. The degrees of hardness used in the above table are readily converted into Clark's degrees by multiplying by 7, and then moving the decimal point one place to the left.

In comparison with the month of January the majority of the waters exhibit an increase in the total amount of solid impurity: the West Middlesex, New River, and East London Companies' waters form the only exceptions to this rule. The amount of organic and other volatile matter is also greater in all the waters, except those of the Grand Junction, Lambeth, East London, and South Essex Companies. Lastly, a larger quantity of oxygen is required for the oxidation of the organic matter than in the preceding month; the Chelsea, Grand Junction, South Essex, and Lambeth Companies' waters only being excepted.

The waters of the Chelsea, Southwark, Lambeth, New River, and East London Companies were turbid when drawn from the Companies' mains."

The analysis for January was not published, but it will be evident from the remarks in that for February, that the water must have been of a quality similar to that of the preceding and following months.

It will be apparent also, from the above statements, that as regards six of the Water Companies, for some periods of the year at all events, private filtration would be necessary, (it is in fact extensively practised,) to ensure to the consumers a bright and potable water.

Taking, for example, the month of February, it would appear that out of a total daily average supply of 88,588,211 gallons, no less than 67,326,000 gallons, or more then $\frac{3}{4}$ths of the whole, were delivered to the consumers in a turbid state.

The attributes of the future supply must be, quantity, purity, and softness, with distribution at high pressure, on the constant system.

It would not be prudent, therefore, to provide for an eventual supply of less than 250,000,000 gallons daily, that is, 200,000,000 gallons for the Metropolitan Districts proper, and 50,000,000* gallons for sale to districts traversed by the aqueduct in transitû into London.

Experience has hitherto shown that the largest waterworks are in the end the cheapest; and those

* A small addition to the size and cost of the aqueduct would enable the provincial supply to be increased at any future time to 100,000,000 gallons daily.

which furnish the largest quantity, and combine a supply for trading and manufacturing purposes, with that for domestic and private consumption, invariably supply water at the lowest rate, to the ordinary consumer—that is to the public at large.

This project is therefore put forward for the supply, not only of London, but where necessary, of the vast population lying between the districts from which it is proposed to obtain the water, and the Metropolis itself; and in these intermediate districts lie the populous and thriving towns of Lancashire, of the Potteries, and of the Midland Counties.

By such an arrangement it is obvious, that the cost to all parties will be materially lessened.

To obtain this necessarily great quantity of water, of requisite purity and softness, we must seek a district of considerable area, free from peat and contamination of every kind, where the rainfall is large, and ascertained beyond doubt by a long series of observations, and where facilities exist for storing up the surplus waters of wet seasons, at such altitudes as to permit of the supply being drawn off and conveyed to London by gravitation, and of being delivered there at about 220 feet above high water; using in all cases where practicable, the existing covered service reservoirs, and, failing these, covered service reservoirs to be constructed in such localities as may be found on investigation most advantageous for utilizing the present pipes and works of distribution.

This altitude of about 220 feet for distribution would be most convenient and suitable for the entire of the Metropolitan Districts, would ensure an ample pressure for ordinary domestic supply and in case of fire, and would avoid the abandonment and destruction of the existing appliances of distribution, which would be entailed by the use of a much higher pressure, and by the adoption of a different system of service; in fact the Metropolis is so large as to preclude its being dealt with, otherwise than in districts, excepting by the abandonment of a great portion of the present works and pipes, involving an obnoxious and undesirable expenditure.

There are, it is true, some elevated suburban districts for the service of which, it would still be necessary to raise water by pumping, but these could not, under any circumstances, be included in a project for the supply of the Metropolitan Districts by gravitation, and their area is comparatively so small, that it is scarcely necessary to notice them in the consideration of this important subject.

Those well known mountain ranges of the counties of Westmoreland and Cumberland, draining into the rivers Lowther, Eamont, and Greta, and adjoining the lakes of Haweswater, Ullswater, and Thirlmere, possess all the attributes of a locality from which an enormous amount of the purest possible water may be obtained; and the existing lakes can easily and at small expense be adapted to form immense reservoirs for its conservancy and storage, at convenient altitudes for the water to be drawn off and conveyed by gravitation to London.

By this process of conservancy, the expense and inconvenience of constructing such a number of wholly artificial reservoirs, as would otherwise be necessary for the storage of the immense requisite quantity of water, will be obviated.

The area from which water is herein proposed to be collected, extends over 177 square miles, the altitudes varying from 500 to 3200 feet above the sea. These, however, are the extremes, the mean altitude will probably be 1300 or 1400 feet above sea level.

The entire district is bare hill pasture, and rock of the primitive formations, and excepting a small area, in the vicinity of Ullswater, which can easily be excluded from the scheme, is free from mineral workings, or other sources of contamination, and the waters are of remarkable purity and softness, as the following analyses by and letter from Professor Way will show.

GRAINS PER IMPERIAL GALLON.

	River Lowther.	Haweswater Lake.	Ullswater Lake.	Thirlmere Lake.
Lime	1.54	0.50	0.81	0.42
Magnesia	0.50	0.18	0.20	0.14
Soda	0.80	0.71	0.51	0.46
Chlorides of Sodium & Potassium	0.48	0.40	0.69	0.77
Oxide of Iron, Silica, &c. .	0.50	0.25	0.20	0.05
Sulphuric Acid . .	0.51	0.51	0.37	0.44
Carbonic Acid . . .	2.05	0.82	1.03	0.56
Organic Matter . .	0.62	0.62	0.35	0.77
Total Impurity . . .	7.00	3.99	4.16	3.61
Hardness before boiling	5.2°	2.0°	2.1°	1.5°
Hardness after boiling	4.4°	1.8°	2.1°	1.5°

These substances are probably combined as follows:—

GRAINS PER IMPERIAL GALLON.

	River Lowther.	Haweswater Lake.	Ullswater Lake.	Thirlmere Lake.
Carbonate of Lime . .	2.75	0.90	1.45	0.75
Carbonate of Magesia .	1.05	0.36	0.42	0.29
Carbonate of Soda . .	0.70	0.56	0.40	0.20
Sulphate of Soda . . .	0.90	0.90	0.65	0.78
Chlorides of Sodium and Potassium . . .	0.48	0.40	0.69	0.77
Oxide of Iron, Silica, &c. .	0.50	0.25	0.20	0.05
Organic matter . . .	0.62	0.62	0.35	0.77
Total Solid Matter . .	7.00	3.99	4.16	3.61

106, *Leadenhall Street, E.C.*,

March 21st, 1866.

DEAR SIR,

I enclose the Analyses of the Waters of the River Lowther and of the three Lakes, Haweswater, Ullswater, and Thirlmere.

As might have been expected, none of them shew more than a small proportion of solid matter per gallon; the River Lowther is the least praiseworthy on this account, though even that sample contains only 7 grains of total impurity per gallon.

The proportion of organic matter in all the samples is small; the water of the River Lowther is, however, slightly coloured, no doubt from peat.

The waters of the three Lakes are as soft as any natural waters can be; the water of the River Lowther does not equal the others in this respect, but as compared to the usual Towns' supplies, would be considered a soft water.

On the whole, I have no hesitation in saying, that any one of these waters, or a mixture of them, would be admirably suited for the domestic supply of town populations, whether large or small.

I am, dear sir,

Yours truly,

J. THOMAS WAY.

G. W. Hemans, Esq., C.E.

These results, although so favourable, exhibit the waters in their worst aspect and condition; the samples for analysis having been taken in January last, immediately after long continued and heavy rains, and include the drainage from the small mineral district, which is intended to be excluded from the scheme.

On the subject of the sufficiency of the rainfall, no difference of opinion, happily, can arise.

The observations of the late Dr. Miller from 1847 to 1853 inclusive, as published in "Beardmore's Manual of Hydrology," give for the district and neighbourhood an average mean annual rainfall, for that period of 100·56 inches, as will be apparent from the following table (No. I.)

It is a matter much to be regretted that the records of rainfall for this hill district, so carefully compiled up to 1853, should have been for the most part discontinued after Dr. Miller's death, as the years 1854 to 1859 inclusive, were dry years, the mean annual rainfall of the ten years 1850 to 1859, as given by Mr. G. J. Symons in his "British Rainfall" for 1863, as registered at the Seathwaite Guage, being 126·98 inches, as against 138·52 inches, the mean annual rainfall of the seven years ending 1853, and the mean annual rainfall at the Keswick Guage being 55·01 inches as against 60·82 inches for the same period of time, being in the first case ·92 and in the second ·90 per cent. of the mean annual rainfall of the seven years ending with 1853, which was a very dry year.

The years 1864 and 1865 were also dry years, the latter indeed, in the north-western counties, being one of extreme drought; the mean rainfall in the lake district for that year, having been only 80·38 inches, or about 80 per cent. of the mean annual rainfall (100·56 ins.) of the district for the seven years ending with 1853. (See Table No. 3.)

Table No. 1.

Name of Station.	Keswick.	Loweswater.	Crummock Lake.	Gatesgarth.	Eskdale Head.	Wastdale Head.	The How Troutbeck.	Ambleside.	Langdale Head.	Seathwaite.	Stonethwaite.	The Pike.	Great Gable.	Sprinkling Tarn.	Brant Rigg.	Seatoller Common.	The Stye.
	ft.	ft.	ft.	ft.		ft.	ft.	ft.	ft.	ft.	ft.	ft.	ft.	ft.	ft.	ft.	ft.
Height above Sea .	258	336	260	290		247	503	190	250	368	340	3166	2925	1900	924	1338	948
	ins.	ins.	ins.	ins.	ins.	ins.	ins.	ins.	ins.	ins.	ins.	ins.	ins.	i ns	ins.	ins.	ins.
Year 1847 .	58·28	66·30	82·32	106·20	74·90	96·30	78·00		112·90	129·20	106·20						
1848 .	66·40	76·67	98·07	133·50	86·80	115·30	91·30	77·60	130·40	160·90	130·20	94·70	91·30	148·60	109·20	139·50	
1849 .	48·80	55·28	70·21	97·10	71·20	107·20	75·40	65·30	107·80	125·50	94·30	83 20	84·90	121·10	87·30	109·00	
1850 .	59·53	68·80	85·66	108·80	81·70	108·80	79·80	79·80	126·60	144·00	105·80	80·30	87·30	127·80	91·10	138·80	174·30
1851 .	62·32	67·10	84·08	107·00	78·60	97·90	80·80	84·20	116·80	139·60	114·10	71·30	85·70	134·80	89·50	141·40	169·60
1852 .	79·97	80·53	103·40	134·90	88·80	109·60	115·40	104·30	134·10	156·70	133·90	81·30	81·20	125·30	98·20	156·60	167·70
1853 .	50·44	59·61	72·09	99·10	63·10	83·40	66·00	66·30		113·70	95·60	56·20	59·70	94·60	73·40	111·40	124·90
Total Rain	425·74	474·29	595·83	786·60	545·10	718·50	586·70	477·50	728·60	969·60	780·10	467·00	490·10	752·20	548·70	796·70	636·50
Mean Annual Rainfall . .	60·82	67·75	85·12	112·37	77·87	102·64	83·82	79·58	121·43	138·52	111·44	77·83	81·68	125·37	91·45	132·78	159·12

Mean Annual Rainfall of the whole District for the above periods, 100·56 inches ; and for the very dry year, 1853, 80·60 inches.

Table No. 2, also from Beardmore's Manual of Hydrology, giving the number of days' rain which actually fell during the seven years from 1847 to 1853 inclusive, at several of the Stations enumerated in the foregoing Table.

TABLE No. 2.

Name of Station.	Keswick.	Loweswater.	Crummock Lake.	Wastdale Head.	The How Troutbeck.	Ambleside.	Seathwaite.	Stonethwaite.
Height above sea	ft. 258	ft. 336	ft. 260	ft. 247	ft. 503	ft. 190	ft. 368	ft. 340
	days.	days.	days.	days.	days.	days.	days.	days.
Year 1847 . .	204	190	199	226	188		202	196
1848 . .	229	217	207	243	201		332	224
1849 . .	205	191	185	236	186	159	193	183
1850 . .	209	198	204	248	185	182	222	199
1851 . .	211	202	206	232	195	178	219	206
1852 . .	204	201	194	212	202	204	221	207
1853 . .	172	189	183	203	173	149	217	191
Mean number of day's rain per year	205	198	197	228	190	174	229	201

Giving in the whole district a mean number of 202·75 days' rain in each of the foregoing years.

In addition to the foregoing information, we have the following Table No. 3 of Rainfall for the six years 1860-65, as compiled by Mr. G. J. Symons, and published in "British Rainfall:"—

TABLE NO. 3.

Name of Station.	Scafell Pike.	Wastdale Head.	Brant Rigg.	Sprinkling Tarn.	Stychead Tarn.	The Stye.	Seathwaite.	Stonethwaite.	Keswick.	Lanerigg in Grasmere.	Ambleside.	Lesketh Howe.	Windermere Howe.	Ambleside Loughrigg.	Patterdale House.	Lowther Castle.	Eusemere Hill, Ullswater.
Height above the Sea	ft. 3200	ft. 247	ft. 695	ft. 1985	ft. 1472	ft. 1077	ft. 422	ft. 330	ft. 270		ft. 150	ft. 200	ft. 470	ft. 570	ft. 500	ft. 840	ft. 560
	ins.	ins.	ins.	ins.	ins.	ins.	ins.	ins.	ins.	ins.	ins.	ins.	ins.	ins.	ins.	ins.	ins.
Year 1860 .							142·20		54·17	104·87		79·97	102·58			45·33	
1861 .							182·58		74·42	123·22		98·03	116·26				
1862 .							170·03		61·37			88·26	94·27				
1863 .							173·84		71·54			81·69	84·97			45·76	50·45
1864 .	73·20	86·78	7·21	119·52	108·73		134·67	100·76	52·68		74·40	74·09	75·74	74·63	61·49	35·08	
1865 .	49·12	75·73	68·27	103·84	99·85	149·07	117·49	84·13	49·18		65·78	65·80	64·05	71·00	61·99		

Mean Rainfall of the District in the Year 1864 = 81·99 inches.
Ditto 1865 = 80·38 "

These last are rather lower than the true mean rainfall, owing to there not having been a guage at the Stye in the year 1864, and owing to the Scafell guage being rendered useless from snow during the greatest portion of the first three months of 1865.

In estimating for the supply of London and the intermediate towns, the water producing capabilities of the district, we take it, to avoid question, at somewhat less than its minimum, viz., at 80 inches.

In a precipitous hill and rocky district, such as this, the loss from evaporation and absorption will be small, probably not more than 12 inches, we take it however at 14 inches, leaving 66 inches as the minimum depth of available rain during a continuous period of dry seasons.

This would be equivalent to a supply of 464,719,562 gallons daily throughout the year; and is a quantity much larger than required, or indeed than could be conveniently dealt with.

It is proposed therefore to limit the supply from this district to 250,000,000 gallons daily, and to give, as compensation, a quantity nearly equivalent to one-third of the abstracted rain, viz. 450,000 gallons daily for each square mile of drainage area.

By such an arrangement, the floods now running to waste, would be to a great extent controlled, and the dry weather yield of the district probably doubled in volume.

It will be evident that the district is capable of supplying a far larger quantity of water than that which it is proposed to take from it; in fact, the main cost of the project would be incurred, not in collecting and impounding the water, but in conveying it from its native district to the places of consumption.

The descriptive particulars of the project are as follows, and will best be understood by reference to the accompanying Map.

The districts from which water is proposed to be taken, with two small exceptions, lie on the northern slopes of the range of hills towering over Grasmere, Windermere and Kendal, and draining into the rivers Lowther and Greta, and into the lakes of Haweswater, Ullswater and Thirlmere.

On the eastern side of the collecting ground, the works would commence on the river Lowther, at Cooper's Green, in Sleddale, by an intercepting conduit, passing from thence round the hills to Swindale, where the first auxiliary reservoir would be constructed, and on to Haweswater, the surface of which would be raised 42 feet, or to 736 feet above the Ordnance datum.

From the north end of Haweswater another intercepting conduit would be constructed, passing round the eastern slopes of Bampton Common, and conveying to that lake the waters of the Hows Beck, Gill Beck, and Heltondale Beck streams.

A third conduit or watercourse would be constructed from the river Lowther, commencing at a point about one-and-a-half miles below the village of Askham, passing round the hill to the west of Clifton, along the eastern slope of the valley of the river Eamont, and terminating at the north end of Ullswater, into which lake, and into the river Eamont it would deliver at Pooley Bridge.

These three conduits would intercept all the waters of the river Lowther, and its tributaries above Clifton, and conduct them into the Swindale auxiliary reservoir, and into the Haweswater and Ullswater lakes.

From the north-western end of Ullswater, a conduit would be constructed to Dacre Bridge, which would intercept and conduct into it the waters of the Dacre Beck, and its tributaries.

Thirlmere would be raised 64 feet, or to 597 feet above the Ordnance datum, and from its northern extremity conduits or catchwater drains would be constructed in easterly and westerly directions; the first named would pass round the northern slopes of Matterdale Common, and intercept the waters of the Mosedale Beck, Trout Beck and Barrow Beck streams, and complete a zone of intercepting conduit and watercourse between the northern extremities of Ullswater and Thirlmere lakes.

The other conduit or catchwater drain would pass round Bleaberry Fell, and along the edge of the table-land east of Watendlath, and extending up to the Blea Tarn would intercept all the upper waters of the Watendlath and Coldbarrow Fells.

By constructing a tunnel from the south end of Thirlmere, under Dunmail Raise Pass, and some short intercepting conduits from its southern extremity, the waters of about 6 square miles of a very wet district on the southern face of the hills, may be conducted to, and impounded in that lake.

When Thirlmere is full, or the streams in flood, the waters may be passed into a Reservoir to be constructed on St. John's Beck, immediately below that lake, where they would be impounded, and given out as compensation to the mill-owners on the River Greta, at and above Keswick; when both are full, the surplus waters may be passed into Ullswater, which with the auxiliary Reservoirs to be constructed in Martindale, would in conjunction with Thirlmere, be used for towns supply only.

The waters of the River Lowther, although of admirable quality, are the least desirable in the scale of excellence, and it is proposed to use them mostly for compensation, passing them in the first instance down the river Lowther itself to a point 1½ miles below Askham, from whence they would be conveyed by a new channel to Pooley Bridge, and there delivered into the river Eamont.

The water supplied to London and the intervening towns, would be taken almost entirely from Ullswater and Thirlmere lakes, and would be of extraordinary purity and excellence, being under two degrees of hardness, and containing, per imperial gallon, not more than about 4 grains of total impurity, of which scarcely more than half a grain would be organic matter.

Haweswater and Thirlmere are lonely and unfrequented lakes, occupying deep valleys, embosomed in mountains, and afford admirable sites, for the construction, at comparatively trifling expense, of immense reservoirs, to which additional supplies of water can with great facility be conducted.

The particulars of the reservoirs, would be as follows:—

Name.	Area of collecting ground in square miles.	Area of Reservoir in acres.	Content in Cubic feet.		Total Storage.
			For supply to Towns.	For Compensation.	
Swindale }	38	166		187,000,000	187,000,000
Haweswater }		683	235,200,000	961,100,000	1,196,300,000
Martindale }	95	255	336,000,000		336,000,000
Ullswater }		2,300	1,742,400,000		1,742,400,000
Thirlmere }	* 44	875	1,721,977,600		1,721,977,600
St. John's Beck Reservoir }		360		380,000,000	380,000,000
	177	4639	4,035,577,600	1,528,100,000	5,563,677,600

=to 120 days supply at 250,000,000 gallons per day, and to 157 days supply at 200,000,000 gallons per day—after giving credit for the average minimum summer yield, which will not be less than 40,000,000 gallons per day—and to 120 days compensation at 450,000 gallons per square mile of drainage area; this will more than suffice in a district of such constant rain.

There would not be any necessity, in the first in-

* If thought desirable, the waters from a further area of about 8 square miles draining into the Airy Beck and Dacre Beck, and now flowing into Ullswater, can easily be diverted and conveyed to Thirlmere.

stance, for constructing the Auxiliary Reservoirs in Swindale and Martindale, as until the towns' supply exceeded 200,000,000 gallons per day, Thirlmere and Ullswater would contain sufficient storage, and would be able, after giving credit for the summer yield, to work up to 135 days supply, whilst compensation water would be given out from Haweswater and from St. John's Beck Reservoirs; when the demand exceeds 200,000,000 gallons per day, these Auxiliary Reservoirs may be constructed, and if necessary, others in addition, as many sites are available; should the demand eventually exceed 250,000,000 gallons per day, a further area of 53 square miles of collecting ground may be obtained on the southern slopes of the range of hills above Ambleside and Kendal, by constructing reservoirs in the valleys traversed by the Troutbeck, the Kent, the Sprint, and the Bannisdale Beck streams, and an additional quantity of about 75,000,000 or 80,000,000 gallons daily may easily be obtained from these sources of supply.

As to the capability of the district, no doubt therefore can exist, and it is worth consideration whether it might not be the wisest course in the first instance to construct those portions of the Aqueduct, which cannot be added to from time to time, of sufficient capacity for this extended supply.

The surface of Ullswater lake would be ordinarily maintained at or about its winter level, and water drawn off from it for towns' supply at a depth of 20 feet, that is at about 460 feet above the Ordnance datum; the shores, however, are mostly of a steep and precipitous nature, and any injury to the scenery, or aspect of the lake, would be more of a fancied than real nature.

Of course it would be impossible to carry out a scheme of this magnitude without doing some injury, but in the construction of these great Reservoirs, it would be reduced to a minimum; for instance, for Haweswater and Thirlmere, the total area of additional land required would not be more than about 750 acres; and there would be no residential damage. The number of houses which would be affected would not exceed 17 or 18, all of which, excepting 3 or 4, are of the most ordinary class; and they can all, if necessary, be re-erected round the extended margin of the Lakes.

At Ullswater, the injury done, if any, would be very trivial. As long as the demand from the district did not exceed 200,000,000 gallons per day, it would not be necessary to lower Ullswater at all, until after a period of 67 days of absolute drought; Thirlmere being able to keep up the supply for that period of time; it would then take about 30 days more to lower Ullswater 8 feet, which would not be very much below its summer level; so that under these circumstances 97 days of continuous and absolute drought must occur before Ullswater would be sensibly affected.

When the demand has increased to 250,000,000 gallons daily, and the Auxiliary Reservoirs have been constructed, with their aid the towns' supply could be kept up from Thirlmere for a period of 70 days, and it would then take 23 days more to reduce Ullswater 8 feet, so that in this case 93 days of continuous and absolute drought would be necessary before the Lake was reduced much below its summer level; and there is no record of drought of any such duration ever having occurred in this notoriously wet locality.

On this subject, we are indebted to Mr. Samuel Marshall, of Kendal, who has been a careful observer of rainfall there since 1822—for the following valuable information.

"The longest period of drought in this locality, (Kendal) during the last 44 years, occurred in the Spring of 1852, which, singularly enough, was also here the wettest year during that period.

From the 19th February to the 29th April there were but 3 days on which rain fell, and the aggregate fall was only 0·21 inches, being a period of 70 days with less than ¼ of an inch of rain.

The Droughts next approaching this in duration, occurred as follows.

In 1861, from the 1st April to the 8th June—a period of 69 days—there were but 9 days on which rain fell, with an aggregate fall of 1·65 inches.

In 1839, from the 28th March to the 4th June—a period of 67 days—there were but 12 days on which rain fell, with an aggregate fall of 1·97 inches.

In 1826, from the 28th April to the 28th June—a period of 60 days—there were but 8 days on which rain fell, with an aggregate fall of 1·12 inches.

In 1829, from the 14th December to the 8th February, 1830—a period of 55 days—there were but 5 days on which rain fell, with an aggregate fall of 0·65 inches.

The years 1844, 1853, 1864 and 1865 were also dry years, but with droughts of much shorter duration than those above mentioned."

It must be borne in mind also, that Mr. Marshall's observations relate to the rainfall at Kendal, which in many cases is not more than one half of that in the mountainous districts above, where there is often a considerable amount of rain, whilst it is fine weather in the low country adjoining.

The water from Thirlmere would be drawn off at its northern extremity, and conveyed to Ullswater by conduit and tunnel; the tunnel would be 8 miles in length, but shafts can be put down over the entire distance, and in such a case it is obvious, there would be no greater difficulty in constructing a long tunnel than a short one, it is simply a question of greater length and of additional shafts.

From Ullswater the supply would be drawn off from the south end of the Lake at Patterdale, and from thence carried by tunnel under Kirkstone Pass.

This tunnel would be the only work of unusual magnitude connected with the project; it would be $7\frac{1}{4}$ miles in length, but of this $5\frac{1}{4}$ miles would be ordinary and rather shallow tunnel, and would therefore present no difficulty; the central portion immediately under Kirkstone Pass would be $1\frac{3}{4}$ miles in length between the shafts, and would, at the rate of progress which has been effected at the Mont Cenis Tunnel, occupy in its construction about three years after the shafts were sunk.

No doubt, with the rock-boring machines of the present day, it might easily be completed in that or a less period of time.

From the south end of the tunnel the water would be conveyed to London by conduit, tunnel, and iron pipes; the aqueduct would pass by Ambleside and Kendal, and down the eastern side of Lancashire, avoiding the Wigan Coal-field, to the east of Manchester and of the Potteries district, and to the east of the Staffordshire Coal-field and of Birmingham, and onwards towards London, following a route nearly parallel with that of the London and North Western Railway, and would terminate in a large regulating reservoir to be constructed to the north of Harrow, at a distance of about 12 miles from Cumberland Gate, Hyde Park.

The project may in fact be briefly described as an aqueduct, or arterial conduit, deriving its supply from the great rainfall and natural reservoirs of the lake country, passing through the heart of England, and capable of affording, in transitû, a practically unlimited quantity of the purest possible water to the vast manufacturing districts and population on the line of its route, as well as to the metropolis itself.

Some portions of the project and of the aqueduct may be carried out in detail, as the demand for water increases from time to time.

We now come to the consideration of the financial part of the scheme.

Of late years it has been pretty well recognized, that all great projects of this and similar natures should be the property of the communities to whose necessities they minister, or in other words, that the consumers should be the proprietors of their own works, and guardians of their own interests.

It is also now equally recognized that the rates for water supply and drainage should be compulsory, and extend to all property within the area benefited. In different localities the rates are differently apportioned, but the principle is almost universally practised, and has been adopted in many large provincial cities and towns with great public advantage; it should, we conceive, *à fortiori*, be extended to the Metropolis, and the water supply placed under the control of the Metropolitan Board of Works, or of a similar Board, to be elected for the purpose, from the ratepayers themselves.

In this case, it would of course be necessary to purchase the existing Waterworks and incorporate them with the new project, securing to the different Companies the nett incomes they at present enjoy.

We learn from the pamphlet recently published by Mr. Bateman, C.E., on the water supply of London, that these in the aggregate amount to rather more than £400,000 per annum, whilst their gross receipts are about £700,000, or nearly 1*s.* in the pound, on the present rateable value of property in the Metropolis, which amounts to about £15,000,000 annually, and this would no doubt reach to a much larger amount by the time these proposed works were completed. We shall call it then £16,000,000, although, judging from the late ratio of increase, this would evidently be below the mark.

The cost of the project complete, for a daily supply of 250,000,000 gallons, we estimate at £12,200,000.

As, however, there would be no necessity for bringing the whole of this large quantity of water before the demand for it had actually arisen, we shall assume that 200,000,000 gallons only are brought in the first instance. That is:—

	Gallons.
For domestic consumption . . .	120,000,000
For public and trading purposes . .	30,000,000
For sale to population on line of conduit	50,000,000
Total	200,000,000

The cost of which would be:—

Conduits, reservoirs, and works of collection	£675,000
Tunnel from Ullswater to Ambleside	350,000
Aqueduct to London	8,125,000
Regulating reservoir, &c., near London	500,000
	£9,650,000
Interest on unproductive capital during an average period of 3 years, and other expenses . . .	1,550,000
	£11,200,000

The annual expenses would probably be—

Interest on £11,200,000 at 4 per cent. . .	£448,000
Collection, management, and casual repairs .	100,000
Present dividends to Water Companies .	425,000
	£973,000

To meet this we should have, after the works have been for some few years fairly in operation, a probable income of

From the sale of fifty millions of gallons daily, to towns, &c., on the line of aqueduct, at 3*d.* per 1000 gallons .	£228,125
From the sale of thirty millions of gallons daily in London, for public and trading purposes at 3*d.** per 1000 gallons	136,875
From an average rate of 10*d.* in the pound on a property of £16,000,000 .	666,666
	£1,031,666

which is £58,666 in excess of what is required, as shown above.

In the estimate of income, no credit is taken for the annual value of the assets and property of the Water Companies, which it would not be necessary to retain after the introduction of the new water supply.

This average rate of 10*d.* in the pound may be levied as may be deemed most equitable, say a 9*d.* rate for domestic consumption on an assumed house property of £12,000,000, and a public rate of 3*d.* on a total property of £16,000,000, this would amount—

For the Domestic Rate, to . . .	£450,000
For the Public Rate, to . . .	200,000
	Total £650,000

which would probably suffice.

* Only about one half the price usually charged.

It is not however to be expected, that the 50,000,000 gallons daily proposed to be sold to the towns and populations on the line of the aqueduct, could be disposed of all at once, and in estimating the rates likely to be levied on the citizens of London, we must take that into account, and we shall now consider the question as if no water were so disposed of.

This would leave a sum of £973,000—£136,875= £836,125 to be levied on the Metropolis, and would amount to an average rate of rather more than $12\frac{1}{2}$*d.*, say 1*s.* 1*d.* in the pound on all property; this would be the maximum rate which, under the most unpropitious circumstances, it would be necessary to levy, and which would not amount to more than the actual rate now levied on property in the Metropolis by the existing Water Companies.

It is more than probable, however, that by the time these works were completed, the rateable value of the Metropolitan Districts would amount to £18,000,000, of which probably three-fourths or £13,500,000 would be house property, and in this case, if no water were sold on the line of aqueduct, the rate necessary to be levied would amount to about $11\frac{1}{4}$*d.* in the pound.

If the rateable value amounted to £18,000,000, and 25,000,000 gallons were sold daily on the line of the aqueduct, the necessary Metropolitan rate would amount to nearly $9\frac{3}{4}$*d.*, say 10*d.* in the pound.

If, however, the sale of water on the line of aqueduct had increased to 50,000,000 gallons daily, and the rateable value of the Metropolitan Districts had increased to £20,000,000, — events by no means improbable, — the average necessary rate would not then amount to more than about $7\frac{1}{2}d.$, say $8d.$ in the pound, and this would gradually be diminished, as the rateable value of the Metropolitan Districts, caused by suburban extensions, and the springing up of a new and better class of property in the Metropolis itself, progressed; and to meet the future demands likely to arise from these and other causes, there would remain a further quantity of 50,000,000 gallons daily, to be supplied at an outlay of £1,000,000, which may be expended when the necessity arises.

On the subject of diminution of disease, of poors' rate, of fire insurance, and of taxation generally, consequent on the introduction of a plentiful supply of pure water, no remarks are necessary; such results are too well known to require comment.

We trust we have shown, that not only is London within the pale of an admirable supply, but that water of extraordinary purity and excellence may be readily procured and distributed to its inhabitants, at rates of charge at least equally moderate with those at which other large towns are supplied, and under no circumstances exceeding the rates levied for the present intermittent and unsatisfactory supply.

In the autumn of last year, when the plans and general features of this scheme were nearly matured, a letter from Mr. G. J. Symons, the well-known Meteorologist, appeared in one of the public Journals; in it was mentioned the feasibility of procuring water from the Westmoreland and Cumberland hills, for some districts in Lancashire, at that time suffering from drought, and since then, the subject appears to have been taken up by Mr. Dale, C.E., of the Hull Corporation Water Works; some particulars of a project for the purpose, put forward by that gentleman, having appeared from time to time in the Scientific Journal known as "Engineering."

Mr. Dale's project, as far as we can gather, is to supply a number of towns in Lancashire and Yorkshire, from Haweswater and Ullswater Lakes; but, excepting in the circumstance of these Lakes being included in our scheme, and forming a portion of it, there is no similarity or affinity between the respective projects.

G. WILLOUGHBY HEMANS.
RICHARD HASSARD.

1, *Westminster Chambers,*
July, 1866.