LONDON SEWAGE COMPANY.

REPORT

UPON THE

VARIOUS PLANS PROPOSED FOR RENDERING AVAILABLE THE MANURE

CONTAINED IN THE

SEWAGE WATER OF THE METROPOLIS,

WITH A DETAILED

EXPLANATION OF THE PLAN PROPOSED BY THE COMPANY,

AND AN

ESTIMATE OF THE COST OF THE WORKS

AND OF THE

ANNUAL EXPENDITURE AND REVENUE.

BY

THOMAS WICKSTEED, Esq.,

ENGINEER TO THE COMPANY.

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LONDON SEWAGE COMPANY.

To the Provisional Committee.

GENTLEMEN,

HAVING received a letter, signed by Mr. Morewood, one of your Committee, and by your Secretary, Mr. Andrew Martin, appointing me Engineer to the Company, I proceeded to cause the necessary surveys and levels to be taken, from which the plans and sections for the proposed works, north and south of the Thames, were made and completed, and deposited in conformity with the Standing Orders of Parliament, by the 30th of November last. The plans for the parishes are now in a state of considerable forwardness, and will be ready for deposit previous to the 31st instant, which is the limit of time allowed by the Standing Orders.

In conformity with further instructions received from you, *to report upon the advantages or disadvantages of the schemes proposed*, for collecting and rendering available, as a manure, the sewage water of the Metropolis, I beg leave to present the following Report.

REPORT.

It is not my intention to occupy your time with observations upon the advantages to be derived from the introduction of a valuable manure at a less price than is now paid, or in informing you that there is a large quantity of valuable manure in the sewage water of the metropolis and of all other towns, most of which is now allowed to run to waste; as these facts must now be quite familiar to you.

My object in this Report will be, *to show the impracticability of certain schemes that have been proposed for obtaining this manure, as the reason for my not recommending them for your adoption, and to show the practicability of the plan hereinafter explained*, and which it is proposed shall be carried into execution by your Company.

In order to set before you the state of the case as to the quantity of land in England available for a new manure, and the extent required for the consumption of the quantity produced, it is necessary to go into some statistical details.

The whole area of England is equal to 50,387 square miles, or 32,247,680 statute acres, divided as follows:*—

Arable land . . .	13,252,000
Pasture . . .	12,380,000
Uncultivated . . .	6,615,680
Total . .	32,247,680

* Macculloch's Geographical Dictionary.

Professor Johnstone, the author of "Lectures on Agricultural Chemistry and Geology," after enumerating the relative values of the different animal manures, states that—

> "Each must be capable of exercising an influence upon vegetation peculiar to itself.
>
> "Hence the practical farmer sees the reason why no one *simple* manure, such as hair or flesh, can long answer on the same land, and why in all ages and countries the habit of employing *mixed* manures and artificial composts has been universally diffused. When mixed manures are not employed, the kind of manure used must, after a time, be changed. A species of *rotation* of manures must be introduced, in order that a second or third species of manure may give to the land those substances with which the first was unable to supply it."—*Elements of Agricultural Chemistry and Geology*, p. 172.

There can be little doubt of the truth of this observation, and, therefore, in introducing a manure which, although well known, has not hitherto been extensively used on account of the present expensive mode of obtaining it, and which therefore may be called *new*, it must not be supposed that it will entirely supersede the use of other manures, as those now in use, including farm-yard manure, may safely be calculated as sufficient for at least one-half of the cultivated lands in England. Supposing such to be the case, and that half of the *uncultivated* ground could be brought into a state of cultivation, if the cost of manuring it were sufficiently reduced, then the area of land in England, that may be assumed to be available for the application of the new manure, will be as follows:—

Arable land . . .	6,626,000
Pasture	6,190,000
Uncultivated . . .	3,307,840
Total . .	16,123,840

It is to be observed here, that I do not give the foregoing estimate as an accurate one; indeed, the quantity stated is probably the extreme quantity. It will, however, be found sufficiently near for the purpose for which I introduce it.

The supply of sewage water north and south of the Thames, is at present equal to 265,142 tons per diem, or 96,776,830 tons per annum.*

Supposing the *whole* of the fertilizing matter, *both mechanical and chemical*, to be abstracted from this quantity, it will, according to the analysis of your consulting chemist, Mr. Aikin, and of your assistant-chemist, Mr. Nash,† be equal to 1 in 236,‡ which will give 410,000 tons of solid manure per annum, and its value will be equal to that of guano, sold in the market at £8 per ton, although its constituents may be somewhat different. If we take the quantity of manure required to keep a farm in good heart, as equal to 4 cwt. of guano § per

* See Report of Mr. Geo. Hawkins to the Commissioners of Sewers of Westminster and part of Middlesex, on the average discharge of sewage: printed by order of the Court, Oct. 5, 1845.—See also Appendix (A).

† These gentlemen conducted their analyses without any knowledge of each other's proceedings.

‡ Mr. Phillips' analysis of the Edinburgh sewer water shows *that* water to contain 1 in 214.

§ See Johnstone's Elements of Agriculture, Chemistry, and Geology, p. 166.

acre, and suppose for the arable land a 5 years' rotation, then 4 cwt. per acre in 5 years will be equal to 4 cwt. per annum for 5 acres of *arable* land ; and supposing that the *pasture* and *uncultivated* grounds will bear 3 cwt. every year, it will require 1,689,716 tons of the solid manure to supply the 16 millions of acres before referred to: assuming that the remaining 16 millions of acres are already provided for by the use of other manures, this may be considered the amount of *new* manure required for the *whole area of England*; and as the quantity supplied from the London sewers has been shown to be equal to 410,000 tons, or one-fourth of the whole quantity required for England, the area of land to produce a market will be equal to one-fourth of the area of England, or 8 millions of acres ; and this is upon the assumption that the whole of the cultivators of the land will use the new manure for one half of their farms: if this be not done, then a still more extended area will be requisite.

This statement alone, it might be supposed, would be sufficient to show the impracticability, in a *commercial* point of view, of the proposed system of supplying *liquid* manure,

"By means of a system of pumping-engines and pipes, analogous to that of the great water companies." *

For who would think of laying pipes over 8 million of acres, embracing the whole area of

* See Prospectus of the Metropolitan Sewage Manure Company.

the following counties, viz. :—Middlesex, Surrey, Kent, Sussex, Hants, Wilts, Dorsetshire, Berks, Oxfordshire, Bucks, Herts, and Essex? In addition to this, it may be supposed, the inhabitants of the numerous large towns in those counties would be as desirous as the inhabitants of the metropolis, both for reasons of health and profit, to get rid of their sewage water; and how can it be expected that the landowners near those towns should seek from the *metropolis* that which they can obtain at much less cost in their own immediate *neighbourhood*? Nevertheless, as the evidence given before the Health of Towns Commission, in which the practicability of such a scheme is attempted to be shown, is continually quoted, and has very recently been so in a report on the improvement of Leicester, by the " Water Supply, Drainage, and Towns Improvement Company," it may be worth while to enter further into detail, with reference to the statements on which these opinions are founded, and if, in doing so, I may find occasion to mention any individual by name, it is solely for the sake of distinguishing clearly the statements or opinions on which I may be commenting, and not with any intention to make personal allusions.

EXAMINATION OF THE SCHEME FOR DISTRIBUTING SEWER WATER BY PIPES AND MACHINERY.

In June 1844, immediately after the publication of the First Report of the Health of Towns Commissioners, a statement was published, to which the names of Mr. Smith, of Deanston, and others, are attached, in which it is said that—

"A plan has been *matured*, with the co-operation of several eminent agriculturists, engineers, and others conversant with the various bearings of the subject, upon which *specific calculations have been made*, and it appears that the *liquid* manure from the sewers may be supplied to the extent of about *thirty miles round London*, at the rate of *one hundred tons per acre per annum, at 3d. per ton* (or £1. 5*s*. 0*d*. per acre), and that at this price it will yield a *very liberal profit*. The scheme will eventually embrace *the whole of the sewage on both sides of the Thames*; but it is proposed at first to limit the operations to those comprised in *King's Scholars Pond* and *Ranelagh Districts*, which will suffice for distribution over upwards of *one hundred square miles*, comprising a large extent of poor lands particularly susceptible of improvement." *

In a prospectus issued by the Metropolitan Sewage Manure Company, in October 1845, where the capital required is stated at £1,500,000, and in which Mr. Smith's name appears as Consulting Agricultural Engineer, more details are given than were contained in the statement of June 1844, already referred to. It states:—

"A plan was *long since* formed, which has undergone the consideration of *practical* and *scientific men*, and the result is, that a *complete*

* The Italics in this and all following quotations are principally, if not entirely, mine.

scheme has been *matured* for conveying the sewage water of London, by means of a system of *pumping-engines* and *pipes analogous* to that of the *great Water Companies*, and thus distributing the fertilizing fluid over the land, in such manner and proportions as may be best adapted to the various kinds of field and garden cultivation.

"The average quantity required for agriculture is estimated at 80 *tons per acre*, which can be supplied within about 20 *miles round the metropolis* at less than a quarter of the cost of stable or farm-yard manure, and at *one-tenth of the expense*."

In the first instance the Company's operations are to be confined to the King's Scholars Pond and Ranelagh Sewers—

"The contents of these sewers will be raised by powerful steam-engines and distributed by pipes over an extent of *sixty square miles*, through the gardening and agricultural districts to the *westward*. A sum of £300,000 only will be required to carry this part of the plan into effect.

"A *careful* and *moderate* calculation has been made of the annual outlay and income, from which it can confidently be stated, that the *undertaking will realize a net profit of at least* 15 *per cent*."

Amongst the authorities quoted in support of the practicability of the scheme is Dr. Arnott, a gentleman of the highest standing in the *scientific* world, but not an *Engineer*, who states, that—

"Engineers who pump from the Thames many miles above London to supply pure water to the inhabitants, *could as easily*, by pumping away to *any desired distance* the fluid from the drains, supply the most valuable manure yet known, &c."

In a little pamphlet published by the Company, they make the following statements, and refer to their authority:—

First,

"It is admitted, on all hands, that the value of liquid manure is such as amply to repay the expense of its conveyance."

The authority quoted is Mr. E. Cresy, Architect, who states in evidence—

"*If* the contents *of all* the sewers *could* be brought to a *convenient* situation for disposal, it would sell for a *very considerable sum*, and amply repay the cost of *any means* that might be used to bring it there."

Second,

"It is also proved that the conveyance by pipes is by far the most economical means of transport."

The authority quoted is Mr. Joseph Quick, of the Southwark Water Works, who states in his evidence that—

"There would be *no impracticability* or difficulty, *if* the sewage was collected into shafts, as it could be pumped out through *large mains to any districts where it might be required*. The expense of doing so would be *less than that of pumping water* through the mains and minor distributionary branches required for supplying a district."

Third,

"And on comparing the relative expense of conveying solid and liquid manure, we arrive at the striking conclusion, that the cost of the conveyance of liquid manure by pipes, is, at the very outside, *one-twentieth* of the transport of solid manure *by carts*."

The authority quoted is Mr. T. Hawksley, Engineer of Nottingham: he states in evidence that—

"The cost of transmitting water to a distance of *five miles*, and to a height of 200 feet, including wear and tear of pumping machinery, fuel, labour, interest of capital invested in pipes, reservoirs, engines, &c., amounts to 2¼*d*. per ton; the cost of *cartage* to the same distance and height will, under favourable circumstances, amount to 4*s*. per ton."

Fourth. In the Report of the Poor Law Commissioners, p. 53, it is stated that—

"By the application of capital and *machinery*, the cost of conveyance of substances in suspension in a fluid, even at the Water Companies' prices, may be rendered *thirty*, and even more than forty times as cheap as collection by *hand labour* and *removal by cartage*."

Fifth,

"The practicability of the plan proposed by the Sewage Manure Company is amply proved by experiment."

The authority quoted is Mr. Smith, of Deanston, who in his evidence says—

"The water could not *well be distributed over the open tillage land by irrigation*: it would, therefore, be necessary to resort to some mode of distributing it, by jet. This requires the conveyance of the *water in pipes*, under a *pressure* of from 100 *to* 150 *feet of altitude*, to a *number* of *convenient points* in the *different farms* where it is to be used. In this there is *no difficulty*: it is a *simple engineering question*, the success of which is *certain*, whilst the *cost* can be estimated on *known data*. I made an experiment on a large scale at the Southwark Water Works, which satisfied me of the practicability of distribution by the jet. With an altitudinal pressure of 120 feet of water, and using a 2½ inch hose with a discharging orifice or nozzle of one inch in diameter, I found that I could from *one point* distribute water over an area of *two* statute acres; but to be safe, say *one* statute acre. Dividing the quantity so required *annually* into *three portions*, for *separate applications*, *one jet of one inch orifice* will deliver *each portion* in *about an hour*, as ascertained from data founded on an experiment made the same day, to ascertain the quantity of water discharged in a given time from a similar orifice, with a similar pressure."

The foregoing is all the Metropolitan Sewage Manure Company give in support of the *practicability* of their scheme; but before proceeding further, I may observe that if the quotation from Mr. Hawksley's evidence had been continued, it would have appeared that his opinion refers only to water containing 1 part *solid* in 20 of *liquid* matter. The continuation of the quotation is as follows:—

. . . "The quantity of water annually consumed by one individual amounts to about 20 tons, and the refuse produced is *usually estimated* at about 1 ton; consequently, 21 tons of liquid manure must be transported in place of 1 ton of solid manure; thence it appears, that the expenses of conveyance to a distance of 5 miles in the liquid and solid states will be almost precisely equal."

How erroneous this estimate of the proportion is, will be seen by a reference to the analysis of Mr. Aikin, Mr. Phillips, Mr. Nash, and Mr. West, of Leeds, as quoted in Mr. Smith's Report.

It appears very clearly that this plan depends, not upon the observations of witnesses loosely made in evidence, without any estimates being produced to support them, but chiefly upon the authority of Mr. Smith's report and estimates, published by the Health of Towns Commission: which must therefore be examined closely, to ascertain their value.

Mr. Smith states in a paragraph, the *latter* portion only of which is quoted in the pamphlet,—

"In making an application of the *whole sewer* of a town, so great a *proportionate annual income* could *not* be obtained as has resulted from the application *of small portions*, as the *difficulty* and *expense* of conveying it to a *distance* would require a *greater* expenditure of money in the apparatus necessary to accomplish that object, whilst the *value* of the *produce* resulting from the application would be *diminished* by its *greater distance* from the *locality* of *consumption*."

He further states, that the water must be at a pressure of from 100 *to* 150 *feet at the point where it is to be distributed by hose* over the land, which must be the means employed for the *greatest* portion; because—

"A *demand* for grass grown by the application of sewer water in *irrigation has a limit*, which would *compel* the application of the *greater* portion to the enrichment of *tillage* lands, the results of which have *not* hitherto been found so *profitable* as those from grass lands."

With a pressure at the hose of 120 feet, he found that he could, through a 2½ inch hose and a 1 inch nozzle,—

"Distribute water over an area of *two* statute acres—but to be safe, say *one* statute acre."

One statute acre however is the utmost extent to which the water could be distributed under that pressure, and then it would in effect be similar to the forcible jet from a fire engine.

"Dividing the quantity so required annually into *three* portions for *separate* applications, *one* jet of one inch orifice will deliver each portion in *about an hour*."

After stating that from 100 to 150 feet will be necessary to force the jet, and if the land rises an addition must be made to the pressure equal to the rise in the land, Mr. Smith states that for his estimate he assumes 200 feet total height to raise the water,

... "as the water of most towns can be disposed of at from 50 to 100 feet, and will *seldom* be required to be raised more than 400 *feet*."

Mr. Smith therefore has assumed a mean head, say 125 feet, as the mean head or pressure for the jet, and 75 feet as the mean elevation of the ground —together 200 feet.

But after determining on the mean head required, he adds,—

... "*part* of the altitude will be *necessarily* expended in overcoming the *friction* of the conveyance pipes, which will *of course increase with the distance*."

This is very correct; but the *exact* head required to overcome the friction should have been determined before Mr. Smith could have been possessed of sufficient data upon which to form his estimate.

He further states—

"In making the following estimate, I have confined the district to be supplied to an area of *four square miles*, containing 2,560 statute acres. I have supposed the whole to have been laid off in *ten acre fields*, and have put down the position of the service pipes, in such order as to effect the distribution of the water over each *forty acres*, by a hose-pipe 312 *yards long*."

He also gives the following data: main pipe, 1 mile for suburbs, and 2 miles to cross the square, or 3 miles total length; diameter 12 inches, and the service pipes 4 inches,—

... "which is very ample, as never more than 2 or 3 jets will be playing from *one* service pipe at the same time."

The quantity of water Mr. Smith proposes shall be raised is 45,875,200 gallons,* the height 200 feet, and the power of the engine 30 horses.

As Mr. Smith does not state for what period of time he intends the engine to be employed to distribute the quantity of water, the only way in which that can be ascertained is by calculating what an engine of the power described by him can raise: thus, a 30-horse power engine will raise 79.2 cubic feet of water 200 feet high in a minute, and 57,024 cubic feet, or 355,373 gallons, of water in twelve hours. If the farmer does not manure his land on Sundays, then it would take $21\frac{1}{2}$ weeks per annum, working 12 hours per diem, or $10\frac{3}{4}$ weeks per annum, working night and day, to distribute the 45,875,200 gallons.

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* See Mr. Smith's Report to the Health of Towns Commission, "On the Application of Sewer Water for Agricultural Purposes."

The quantity of sewer water to be supplied is equal to 17,920 gallons per acre per annum, one-third of which Mr. Smith says can be delivered in one hour, or 99.55 gallons, or about 16 cubic feet, per minute. At this rate the engine would supply 5 jets only at a time. Mr. Smith provides for 64 jets, and 8 lines of services each 2 miles long, which gives 8 plugs to each line of service pipes. Mr. Smith says he never intends more than 2 jets to be playing at one time on a service. But if, instead of the jets playing for an hour over an acre, they are playing for rather more than three hours; then 2 jets on each service, or 16 jets, may be playing together, and the engine will supply them. *This is the most favourable view of the case for Mr. Smith, as affects the cost.*

Then for the purpose of ascertaining the amount of friction, we must calculate the quantity of water passing through the main to be as follows :—

1st.	The *whole*	through the first	$1\frac{1}{4}$	mile to the first services.
2nd.	$\frac{7}{8}$	through the next	$\frac{1}{4}$	mile.
3rd.	$\frac{6}{8}$	,,	$\frac{1}{4}$	,,
4th.	$\frac{5}{8}$	,,	$\frac{1}{4}$	,,
5th.	$\frac{4}{8}$	,,	$\frac{1}{4}$	,,
6th.	$\frac{3}{8}$	,,	$\frac{1}{4}$	,,
7th.	$\frac{2}{8}$	,,	$\frac{1}{4}$	,,
8th.	$\frac{1}{8}$	,,	$\frac{1}{4}$	,,
			3 miles.	

And taking the services according to the plan given as extending one mile on each side of the main, and that one-sixteenth of the whole of the water passes through the first half mile, and one thirty-second only passes through the second half mile, then the *additional* head required to overcome the friction of the water passing through the main, services, and hose, will be equal to 24 feet; but if only 8 jets, or half the number in the former estimate, are playing at the same time, then the water must travel through the hose at twice the velocity, and the head of water to overcome the friction must be 35 feet, and if only 5 jets are open at the same time, as proposed by Mr. Smith, to deliver the same quantity of water in the same time, the additional head required to overcome friction would be still further increased to 67 feet. Mr. Smith however seems to have lost sight of the fact that the friction of water through pipes increases as the squares of the velocity, and that to force double the quantity of water through the same sized pipe, is equivalent to doubling its velocity, and would therefore require four times the pressure, and consequently an addition must be made to the proposed head (viz. 200 feet) of 24 feet, 35 feet, or 67 feet, depending upon the number of jets opened at one time, which regulates the delivery; and if in the latter case the level of the ground proposed to be manured should be 133 feet above the town,* there would be *no pressure*

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* That this elevation may be expected in cases where it is necessary to go to a distance from the town, seems to have been anticipated by Mr. Smith himself, in his statement quoted in page 12 of this Report, where he states "That the water of most towns can be disposed of at from 50 to 100 feet, and will seldom be required to be raised more than 400 feet."

at the nozzle to create a jet at all, unless the head or pressure were increased beyond the 200 feet, and which head, to produce the effect Mr. Smith proposes, must be 224 feet, or 235 feet, or 267 feet, depending upon the number of jets playing at *one* time. But taking the most favourable arrangement for working the jets, which will be when the greatest number are playing at one time, the proposed head must be increased to 224 feet, and the power to $33\frac{6}{10}$ horses, and this will be putting the scheme in a much more practicable form, and will enable me to check the estimates.

Mr. Smith however further asserts that the twelve inch pipe is ample for *double* the extent of country, and therefore considers he may reduce his estimate of the cost of the main to one half.*—If the main is ample for *double* the extent of country, it must be capable of conveying *double* the quantity of water, and of supplying the additional number of services for *double* the extent, and the head required to overcome the friction will be increased; with sixteen jets playing *on each plot*, it will be equal to 92 feet instead of 24 feet; with eight jets *on each plot*, it will be 104 feet instead of 35; and with five jets on each plot, 135 feet instead of 67. It is evidently erroneous therefore to suppose that the

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* "One-half of the cost of the main pipe is only charged, as, from its "position and capacity, it is sufficient to supply other sections of land of "equal extent."—See Mr. Smith's Report on the Application of Sewer Water to Agricultural Purposes. Published by the Health of Towns Commission.

same sized pipe *could* convey *double* the quantity of water "to supply other sections of land of equal extent."

Again: Mr. Smith gives another estimate of the cost of supplying *double* the quantity of sewer water to the *same* section, and assumes that this can be done for the *same* outlay, forgetting that the head for friction must be quadrupled; and that if 16 jets are to be supplied with double the quantity of water, it would require a head of 96 feet instead of 24 feet; and for 8 jets it would be 140 feet instead of 35 feet; and for 5 jets 268 feet instead of 67 feet; but taking, as before, the most favourable case, that of the 16 jets, the head of water must be 296 feet instead of 200 feet; and the power required for raising *double* the quantity of water, under this *increased* pressure, must be equal to 88.8 instead of 30 horses power.

Mr. Smith gives estimates of the cost of supplying the respective quantities before mentioned, which are now given in juxtaposition with mine for the same purposes; they are as follows:—

	Mr. Smith's.	Mr. Wicksteed's.
1. Estimate of the *probable* expense of receiving tanks, pumping-engine, pipes, hose, &c., for raising, conveying and distributing sewer water over an area of four square miles—the quantity equal to 17,920 gallons per acre	£9,499 1 6	£36,765 0 0
2. Estimate for delivering *double* the quantity of sewer water, or 35,840 gallons . . .	9,499 1 6	56,651 0 0

Mr. Smith then gives the following estimates of the annual cost of distributing the sewer water, in which he allows only five per cent. interest upon capital for profit. In my estimate, which I place in juxtaposition with his, I have allowed the same rate of interest, although it should be remarked that in the prospectus of the Metropolitan Sewage Manure Company, the *expectation* is held out of *fifteen* per cent. profit, and I can hardly consider it probable that capital would be embarked in an undertaking of this character unless the *original* calculations showed at least ten per cent. profit.

	Mr. Smith.				Mr. Wicksteed.		
	£.	s.	d.		£.	s.	d.
1.—Annual cost of carrying on Works	1,633	15	7		5,289	2	0
Cost of manuring one acre with sewer water	0	12	9		2	1	3
Ditto with guano, 2½ cwt., at 8*s*.	1	0	0		1	0	0
Ditto farm-yard manure, 15 tons, at 4*s*.	3	0	0		3	0	0
	£	s.	d.				
According to Mr. Smith's Estimate, sewer water is *cheaper* than guano	0	7	3	per acre			
According to my Estimate, sewer water is *dearer* than guano .	1	1	3	,,			
The outlay per acre, according to Mr. Smith's Estimate, is . .	3	14	2				
And according to mine . .	14	7	2				

SECOND ESTIMATE.

	Mr. Smith.			Mr. Wicksteed.		
	£.	s.	d.	£.	s.	d.
Annual expense of carrying on Works for supplying 35,840 gallons of sewer water per acre	2,115	16	8	8,028	5	6
Cost of manuring one acre with sewer water	0	16	6	3	2	9
Ditto guano, 5 cwt., at 8*s*. .	2	0	0	2	0	0
Ditto farm-yard manure, 30 tons, at 4*s*.	6	0	0	6	0	0
According to Mr. Smith's Estimate, sewer water is *cheaper* than guano . . .	1	3	6			
According to my Estimate, it is *dearer* than guano . .	1	2	9			
The outlay, per acre, according to Mr. Smith's Estimate, is .	3	14	2			
According to mine . .	22	2	7			

The chief error, in this latter case, arises from the assumption that *double* the quantity of sewer water may be supplied without increasing the outlay; but even the first estimates are based originally upon a fallacious supposition, viz.:—that 2,560 acres of ground *can* be procured in *one square*, so that mains and services may be laid with the greatest advantage, within *one* mile from a town, that *all* the land, arable and pasture, shall be covered with 80 tons or 160 tons (as the first or second proposal may be adopted) *every* year, and that the distribution of this over the plot of ground may be going on for 21½ weeks in each year, if the supply is given in the day-time only, or for 10¾ weeks if it is given continually night and day.

Mr. Smith then states—

"I have ascertained that the quantity of sewer water due to a town of 50,000 inhabitants amounts to about 1,190,080,946 gallons per annum, which quantity will yield an annual application of 17,920 gallons per acre to an extent of 66,410 acres. Taking the average cost of guano and farm-yard manure, as shown in the first and lowest estimate, at £2 per acre, and deducting 12*s.* 9*d.*, the cost of the application of the sewer water, there will appear a saving due to the sewer water of £1. 7*s.* 3*d.* per acre; allowing one-half thereof to go to the farmer, there will remain a free income due to the sewer water of £45,241, which is nearly £1 per head of the population."

Now, if the assumption were correct, that to transmit a much larger quantity of sewer water to a greater distance required no greater outlay in engines and pipes than for the smaller quantity, for which the previous estimate, referred to in this statement, was made, then the deduction would be correct also, *if* at the same time *the estimate* were correct. According to *my* estimate, however, previously given, instead of a *saving* of £1. 7*s.* 3*d.* per acre, there is a *loss* of 1*s.* 3*d.* per acre; but in examining the estimate of the cost of distributing the quantity of sewer water referred to by Mr. Smith in the paragraph quoted above, it would seem that he had not gone into a detailed estimate of the cost, but had arrived at it by analogy, derived from estimates which I think I have shown to be founded upon an erroneous basis. I will, therefore, proceed to examine the accuracy of the data given, and then to estimate the probable cost of the works for collecting and distributing by machinery the 1,190,080,946 gallons of sewer water described by Mr. Smith, upon what I conceive to be correct data.

First. In the instance given by Mr. Smith, the quantity of sewer water stated to be supplied by the town is *double* the quantity, in proportion to the number of inhabitants, that is supplied under ordinary circumstances (i. e. independently of storms or heavy rains) by the sewers of the Metropolis;* but as he only calculates 5 cwt. of fertilizing matter in 80 tons, while, according to Mr. Phillips' analysis, the quantity in the Edinburgh sewer water is $7\frac{1}{2}$ cwt., it may be assumed that Mr. Smith contemplates raising a large quantity of rain or drainage water, as well as sewage water.

The annual quantity proposed to be supplied is equal to 5,326,748 tons; of this Mr. Smith calculates that 5 cwt. in 80 tons, or $\frac{1}{320}$, is the weight of the solid, or 16,646 tons per annum; and as it has been shown that 410,000 tons† per annum will be sufficient to manure 8,000,000 of acres, so 16,646 tons per annum will be sufficient for 324,800 acres. This extent, therefore, of land, and not 66,410 acres, must be provided as a market for the whole of the sewage water proposed to be distributed.

Second. The next point for consideration, and a most important one, in reference to the supply of sewer water by pipes, is the actual number of days during the year, on which the engines can be kept

* See Appendix (A).

† See pp. 4, 5, of this Report.

at work pumping the sewer water on to the lands—as it is evident that upon this point must depend the power of the engine, the size of the pipes, and the capacity of the reservoir for preserving the sewage, at periods when it cannot be thrown over the land. Assuming the periods for this purpose to be on the aggregate equal to six weeks in the year, and that the engine will be constantly pumping sewer water during this time, 7 days per week, for 12 hours each day, the quantity of water raised by the engines must be equal to 6,300 cubic feet per minute.

Third. As the sewage water is constantly flowing every day throughout the year, while the period for delivering it upon the lands is but six weeks—i. e. 504 hours in 8,760, it is evident that the reservoir must be capable of holding the supply afforded during 8,256 hours, or 5,020,278 tons; consequently, the capacity of the reservoir will be 6,663,917 cubic yards, and at a depth of twelve feet, or four yards, its area at the mean water line will be equal to 344 acres—if a square, the length of each side will be 1,290 yards, or nearly three-quarters of a mile.

Fourth. Taking Mr. Smith's standard of 200 feet as the whole pressure at the engine, which, as he proposes to raise the water over a standpipe column, may be considered sufficient,* the power of the

* The height of the standpipe lately erected by me at the Grand Junction Water Works, near Kew Bridge, is about 210 feet,—the height of the Monument is about 202 feet.

engines required will be equal to 2,389 horses, and should it be thought advisable to increase the pressure, the power must also be increased in the *same* ratio.

Fifth. As 150 feet pressure will be required at the nozzle to distribute the water over an acre of ground, then, assuming the country to be *level* all round the town within a circle of twenty-five miles in diameter, or for 507 square miles, which is about the area required for the disposal of the manure, then there will be 50 feet left for friction. But it is almost destroying the *feasibility* of a pipe water scheme to suppose such an improbable case; for, if the land be upon a dead level for $12\frac{1}{2}$ miles all round a town, how is the water that is *poured* upon it to be got rid of? when it has deposited its manure, where is it to run to?

Sixth. Mr. Smith calculates that a mile of main is required to supply every two square miles of surface, and four miles of services for every square mile of surface. According to this rule, for the 507 square miles it would require $253\frac{1}{2}$ miles of main, and 2,028 miles of services.

To put the case in as favourable a position as possible, I will assume that the engines are placed in the centre of the lands to be manured, and that the length of each main will be $12\frac{1}{2}$ miles: it will require 20 mains of that length to deliver the quantity; and adopting the most favourable position of their all starting from one centre, then each main will have to convey 315 cubic feet of water per minute, and each main must be 25 inches in diameter.

Upon the foregoing data an estimate may be made (although practically it would be found to be far under the cost, as the radiating arrangement of mains could not be adopted) for the reservoir, land, engines and buildings, mains, and services.

	£.	s.	d.
Reservoir containing 6,663,917 cubic yards, cost estimated at 1*s.* 6*d.* per cubic yard of contents, including all expenses	499,793	15	6
Mains, 25 inches in diameter, 253¼ miles at 71*s.* per yard run, including laying, or £6,248 per mile .	1,583,868	0	0
Services, 4 inches diameter, 2,028 miles, at 6*s.* per yard run, including laying, or £528 per mile .	1,070,784	0	0
Engines, pump work, boilers, buildings, and chimnies for 2,389 H. P. at £120 per horse power .	286,680	0	0
Contingencies, including hose, cocks, standpipes, &c., Land for Reservoirs and site of Buildings, at 10 per cent.	344,112	11	6
Total	£3,785,238	7	0

	£.	s.	d.
Outlay for the supply of 80 tons of sewer water, stated by Mr. Smith as the quantity required for an acre	56	16	11
Ten per cent. upon capital expended, to include working expenses and profits	378,523	0	0
Cost of manuring one acre with sewer water	5	13	8
Ditto ditto, with guano, 2½ cwt., at 8*s.*	1	0	0
Ditto ditto, farm yard manure, 15 tons at 4*s.* . . .	3	0	0
Sewer water *dearer* than guano . . . . , .	4	13	8
,, ,, *dearer* than farm-yard manure	2	13	8
,, ,, *dearer* on the average of the two	3	13	8

The cost of sewer water would then be 17½*d.* per ton, to produce a profit of five per cent.; to produce a profit of fifteen per cent. it must be charged at 35*d.* per ton instead of 3*d.* as proposed by Mr. Smith, upon whose plans and estimates the "Water

Supply, Drainage, and Towns Improvement Company," and the "Metropolitan Sewage Manure Company," seem chiefly to rely.

Upon an examination of the estimates hereinbefore given, so far from confirming Mr. Smith's supposition that upon—

... "taking a general view of the subject we may safely assume a clear revenue from all towns of £1 for each inhabitant,"

I think it will appear that unless a very different mode for applying the manure from the sewage of a town be adopted, it will result in a *grievous loss instead of gain.*

Having now examined Mr. Smith's plans and estimates, it may be as well to inquire into the value of the evidence of other authorities quoted in support of the liquid scheme.

Mr. Hawksley's evidence in support of the scheme is merely, that if the sewer water contains one part in twenty of fertilizing matter, it will be as cheap to raise it by machinery as to cart it; but as Mr. Smith calculates that there is only one part in 320 of fertilizing matter, which would make it necessary to pump up sixteen times the quantity of water calculated on by Mr. Hawksley, and would therefore cost sixteen times as much, to produce the same quantity of fertilizing matter, Mr. Hawksley's evidence cannot be considered favourable to this scheme.

As regards the other authority quoted, viz. Mr.

Joseph Quick, of the Southwark Water Works, who states that the *expense* of pumping *sewer water* would be *less* than that of pumping *water for the supply of a town*, I refer again to Mr. Smith's case of the 50,000 inhabitants, and repeat that the cost would be £3,785,238. 7*s.* 0*d.*, while the cost of supplying a town of 50,000 inhabitants with water, would not (unless under very unfortunate local disadvantages, or ignorance on the part of the engineer) amount to more than £50,000.

But as the "Water Supply, Drainage, and Towns Improvement Company," in their recent Report upon the Improvement of Leicester, a town containing 50,000 inhabitants, state that the water works will cost £69,000,* while the distribution of the sewer water will cost only £40,000, it may be as well to bring before you the following facts:—A town of 50,000 inhabitants will require 900,000 gallons of water per diem, to be raised under a pressure of 150 feet, while, according to Mr. Smith, the sewage water to be pumped away is equal to 3,260,000 gallons, which must be raised 200 feet. Now even assuming that *the sewage water can be used by the farmers every*

* The estimate for the whole improvement is as follows. I have considered the item for irrigation to be for distribution of sewer water.

Water Works	£69,000
Street Sewage	30,000
House Drainage	10,000
Irrigation	40,000
Total	140,000

day in the year, as water is used in the houses of the town, it would require *five* times the number of engines to raise it, and the quantity being three or four times greater, it would require *pipes three or four times larger* than the water pipes for the supply of houses: as regards the *extent* of pipage too, the water required according to Mr. Smith, for *two statute acres,* is equal to the supply of *one house only*; the extent of pipes must therefore be infinitely greater, and it would not pay to establish water works in a town where there was only *one house in two acres* of ground. In addition to this, if the quantity to be supplied is three or four times as great, the pipage must be *further* increased, in length and quantity, three or four times.

With these facts before us, and without reference to estimates, I would ask what reliance can be placed upon such assertions? But the fact is, that the error throughout has arisen from imagining that a *fixed rate of cost* could be obtained, *applicable in all cases,* for that which science and experience alike tell us must be variously affected, according to locality and many other conditions, varying in every separate undertaking.

If, however, it be stated that the projectors of this mode of supplying sewer water depend chiefly upon supplying lands that require irrigation, where, I would ask, can they find a sufficient extent of land in the neighbourhood of any town to consume any considerable portion of the sewage; and if the *whole* of the sewage is not removed from the town, what public benefit is obtained? There are no doubt many instances of localities, where, as in the case of Edinburgh, from the natural position of the town, the water from the sewers may be caused to flow over the land, without the aid of artificial power; but there is no instance, that I am aware of, of the *whole* of the *sewage water* of a town being so consumed.

And although, under such circumstances as I have mentioned, it may be profitable to the person whose property is improved, it is not so to the public. On the contrary, by distributing the sewer water over large areas of *land*, a great nuisance is created, which the public would be very glad to get rid of.

Again, it is stated that sewer water would be very useful for *tillage lands*, and that a *shower* of it upon the young growing crops would be very advantageous; but what would the farmer think of a $2\frac{1}{2}$ inch hose, 312 yards, or a furlong and a half long, weighing, with the water contained in it, nearly $1\frac{1}{2}$ tons, being drawn over the crops, to distribute such a jet of water, as before described? And, even supposing the crops would bear this, how could the water be distributed equally like a shower of rain? and, if it were not so, is it not a fact, that in some parts of the field, large quantities of the sewer water would be deposited, and in other parts scarcely any; in some places too much, and in others too little? and what kind of crop must the farmer look for from such a distribution? It would be very similar to neglected pasture land, where, if the manure that falls from the cattle is not distributed, it causes the grass to become coarse and rank on those spots where the dung has fallen.

I have now, I think, stated enough in my examination of the authorities quoted in support of the plan for distributing *sewer water*, whose testimony is, of course, open to remark and consideration by all, to show that, in my opinion, no reliance is to be placed upon them; and being perfectly satisfied of the utter impracticability, in a *commercial* point of view, of carrying out such a plan, on account of the enormous outlay required, (although it may not be *physically* impossible,) I have not, for an instant, proposed to myself to suggest to this Company the plan of conveying the sewage water of London,

"By means of a system of pumping-engines and pipes analogous to that of the great Water Companies;"

and I speak very confidently on this point, from the knowledge I have obtained in carrying out that system for *Water* Companies.

EXAMINATION OF THE SCHEME FOR COLLECTING THE SOLID MATTER OF THE SEWAGE.

As far as I am aware, all the schemes that have hitherto been proposed for collecting the solid matter of the Metropolitan sewers have gone upon the plan of having an intercepting sewer, but with a *fall equal to the natural fall of the land, or of the Thames at low water.* Mr. Dean, in his evidence before the Health of Towns Commissioners, proposed a plan for conveying the sewage north of Whitechapel Road, Leadenhall-street, Cornhill, Cheapside, Newgate-street, Holborn, and Oxford-street, by a sewer into the West Ham marshes below Woolwich, and states that the fall from the Post Office to *low* water mark at Woolwich is 54 feet, and the distance about seven miles; but let it be noted, that if the sewage of Holborn and Oxford-street is to be carried into the marshes by means of a sewer, it must pass under Farringdon-street and the Fleet sewer, the latter of which is, at its outfall, twelve feet below high water at Blackfriars Bridge, or more than ten feet above *low water* at Woolwich; and supposing the proposed sewer to be at least eight feet deep, then the bottom of it at this point would be *two feet above low water at Woolwich, which is the standard by which we must be guided, and not the fall between the surface of the highest ground in the City of London and the lowest water at Woolwich.* Now, if we take a fall of twelve inches per mile for the proposed sewer, its outlet in the marshes would be at a level of five feet *below* low water at Woolwich, and consequently the product could not run off even at dead low water; this scheme, therefore, may be dismissed as impracticable, and I am not aware that any other scheme has been proposed for collecting the solids, which is not liable to the same objection.

PLAN PROPOSED FOR ADOPTION BY THE LONDON SEWAGE COMPANY.

Before describing in detail the plan that I have to propose, I will state the principles upon which I consider any scheme for applying profitably the sewage water of London should be based.

First. The public, as well as the promoters of the schemes should be benefited. It should therefore be so comprehensive, that *all* the *sewage* of London could be diverted from the Thames: here, however, I should remark, that there is a manifest distinction between *sewage* and *drainage* water. The *sewage* water consists of the contents of water-closets, stables, slaughter-houses, refuse drains, and all kinds of filth calculated to cause offensive nuisances which are carried down by the *ordinary* water of a sewer.

Drainage water is the water which enters the sewers in large quantities after long continued rain or storms, and after having scoured them out at its first flush, and freed them from filth, becomes nothing more than land water, which, in the absence of subterranean channels, would find its way down the vallies upon the surface, and flow ultimately into the river.

This drainage water, when it had performed its brief duty in cleansing the sewers, would be of the same character as the flood waters which do *now* flow into the Thames from the land on its banks, and would not therefore contaminate the river to a greater extent or for a longer period than is now the case, from the flood waters to which every river is more or less liable.

This being the case, I propose to allow the drainage water to take its accustomed course into the river, after having used it as long as I require its services in scouring out the sewers, so that the *sewage* may be saved.

Unless the principle which I have thus laid down and enlarged upon be adhered to, the benefit to the public, which *must be the ostensible*, and *should be the real* ground of an application to Parliament for exclusive privileges, becomes comparative and questionable, depending upon the extent to which the projectors propose to carry out their scheme.

What, for instance, will be the benefit to the public from the Metropolitan Sewage Manure Company's scheme? They propose, as we have seen, to pump up two-thirds of the *liquid* from two sewers, (Ranelagh and King's Scholars Pond,) but apparently make no provision for the removal of carcases and other offensive solids which must continue to flow into the Thames ; and even if we put aside this important consideration, the fact remains, that the quantity which this Company proposes in the first instance to remove is only equal to $6\frac{1}{2}$ per cent. of the ordinary quantity of sewage flowing into the Thames. It is easy to imagine the degree of importance which the public will attach to the abstraction of so small a proportion of the filth of the sewers.

The second principle which I would lay down, is, that the present sewers should be undisturbed, becoming tributaries to the intercepting sewer or conduit which it is proposed to construct.

At present it is necessary to make the main sewers of great capacity, because their contents can be delivered into the river, at or near low water only —a period at which the delivery upon the shores is most offensive to the public; and although this part of the evil might in some measure be remedied by the adoption of the plans proposed by Mr. Walker and Mr. Page, for extending the existing sewers *into* low water, still the contamination of the river would remain the same. At all other states of the tide, the sewage is pent up and held back, these large sewers becoming reservoirs to contain the quantity collected during those periods in which the height of the tide prevents its discharge into the river.

Another evil now arises, not more offensive than injurious: the foul air not being carried with the current into the river, necessarily and naturally rises through any openings it can find, and a stream of noxious effluvia is evolved.

A further disadvantage resulting from this penning up of the sewage, is, that the current through the sewers being checked, the water becomes quiescent, and the heavy particles previously held in mechanical suspension are deposited, and accumulate. When the current in the sewers re-commences, it is slow, depending upon the rate at which the tide falls in the river. Until it has fallen below the level of the pent-up sewage, there is *no* fall in the sewer. Then as the tide falls inch by inch, so does the fall in the sewer increase, but not in the same ratio, because the water being always running, the relative difference between the two levels is always diminishing. The case would be different were the sewer water held back by mechanical means, until there was a sufficient fall of tide in the river ; but it is not so— the process is gradual, and no fall is obtained sufficient to scour away the accumulated deposits. Hence the necessity of manual labour to clear away these offensive deposits, which must be brought to the surface, or for machinery for carrying it off by flushing, and the demand for larger supplies of water, which would be useless unless there was an uninterrupted current in the sewers.

Hence also arises the necessity for prohibiting the discharge of the street sweepings into the sewers, as they would add to the deposit already referred to, a further quantity of heavier matter.

A consideration of these difficulties will, I think, render it obvious that any plan which does not make provision for their removal would be imperfect.

Thirdly. The contents of the sewers should be conveyed to a considerable *distance* from the metropolis. This is necessary, in order to guard against making the *works* of the Company as great a nuisance, or nearly so, as the existing sewers. There can be no doubt that any plan for establishing works in the heart of the metropolis, or at the west end of the town, at the *mouths* of the sewers, where the contents are to be collected for removal, and from whence they are to be pumped up and conveyed, would produce as great a nuisance as the present open sewers, and one as pernicious to the health of the inhabitants of the neighbourhood. Not only, however, should the whole contents of the sewers be carried to a distance without being allowed to see daylight until their destination is reached, but when collected at the terminus the ill effect of the noxious vapours should be destroyed, so that the influence of any effluvia should not be felt at any great distance from the works.

Fourthly. The scheme should provide for the abstraction of the greatest possible quantity of fertilizing matter from the sewer water in the most concentrated form. This form will be the *solid* form, because there can then be no question about a market, or as to the means of transit by land and water; the fact being established, that although, under certain conditions, we may admit, water may be conveyed by means of engines and pipes, for a distance of five miles, at a cost of only one-twentieth of the sum that must be expended in carting the same weight to the same distance,* it does not follow that the same proportion would hold good for conveying it two miles, or twenty miles, or two hundred miles. Nor is it a very wise plan in recommending what is represented as a *cheap* means of conveyance, to compare it with the most costly, only, of all other modes of transit; a comparison should be made, not only with the cost by animal power,† but also with the cost by canals, by ships, and by railways; for it is very certain that no farmer will purchase a manure, *merely because it is in his neighbourhood*, if he can obtain from a distance of 200 or 300 miles an equally valuable manure at less cost.

Fifthly. The scheme should be so contrived, that the plan of the works may be rendered intelligible to all who will give their attention to it. It should be so simple, that all may see that what is intended can be effected, and that the cost may be estimated with certainty, and that the means by which a profit is to be obtained may appear clear and definite.

How can these desiderata be secured, in the case of the liquid scheme, where the market must be

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* Even this is upon the supposition that there *is* 1 part solid in 20 parts of liquid.—See pages 10 and 25 of this Report.

† See Extract from Report of the Poor Law Commissioners, page 9 of this Report.

constantly uncertain, and liable to be removed or destroyed if those in the neighbourhood decline in the first instance to be purchasers, or do so at a subsequent period, having discovered some cheaper manure? How can there be any certainty of profitable returns in a scheme which thus involves the liability to be called upon in any year to double the length of pipes and engine power, and consequently to increase the capital in proportion, to supply the *same* article in the *same* quantities at a *greater* distance, and at a *greater* expense, but *for the same price*? Who can estimate the cost of such a scheme? or who can calculate upon the certainty of a *continuance* of profit, even supposing that a profit should be obtained in the *first* instance?

Sixthly. The scheme should be such as to show a profitable return to the capitalist, while at the same time the manure could be sold to the consumer at a *cheaper* rate than other manures could be supplied. Unless this be the case, there can be no certainty of a market. Show to landowners that you can supply them with a quantity of manure equal in quality to any they have hitherto used, and at a cheaper rate, and common sense will bring a market; but if, as the promoters of the Liquid scheme *propose*, you offer 80 *tons* of sewer water at 3*d.* per ton, (or 20*s.* per 80 *tons*,) which will only produce the same effect as 2½ *cwt.* of guano, also costing 20*s.*, I need scarcely ask, whether, in almost every instance, the landowner would not prefer 2½ cwt. of guano to 1,600 cwt. of sewer water?

Lastly. It appears to me that the *Public* want the neighbourhood of their houses to be freed from an unhealthy nuisance—the *Landowner* wants to have the cost of cultivating the land reduced, so that he may bring a greater extent into profitable cultivation, and that there may be less necessity to rely upon foreign aid. The Shipping Interest, and Railway and Canal Carriers, want the introduction of *new* articles of commerce to increase their profits, and the Promoters of this scheme want to be assured of a profitable return upon their outlay.

If the scheme embraces these important desiderata it will undoubtedly meet with support from all classes.

DETAILS OF PROPOSED PLAN.

First. As regards the north side of the Thames, it is proposed to construct a Circular Sewer of eight feet diameter: to extend from the Ranelagh Sewer at the end of Grosvenor-road, to pass through, in an easterly direction, Grosvenor-road, Grosvenor-street West, Lower Grosvenor-place, Stafford-row, James-street, York-street, Tothill-street, Westminster Abbey-yard, King-street, Whitehall, Strand, to the end of Fleet-street; from thence a sewer of twelve feet diameter in continuation across Farringdon-street, through Ludgate-hill, the south side of St.

Paul's Church-yard, Watling-street, Budge-row, Cannon-street, across King William-street, through Eastcheap, Little Tower-street, Great Tower-street, Trinity-square, Tower-hill, Upper East Smithfield, Parsons-street, Ratcliffe-highway, Butcher-row, White Horse-lane, Commercial-road, East India-road, under the River Lea, above the Iron Bridge, and from thence in a straight line through the West Ham Marshes, to the proposed works of the Company, situated in an angle formed by the western banks of Barking Creek and northern banks of the Thames.

The bottom of the proposed Sewer at the end near Ranelagh Sewer will be 29 feet below the *bottom* of the Ranelagh Sewer, and 31 feet below Trinity high water mark at Vauxhall Bridge; and therefore at a 16 feet tide it will be 15 feet below *low* water: the height of the Sewer here will be 8 feet inside.

The bottom of the Sewer will fall 12 inches per mile, or, in the whole length of 11½ miles, 11 feet 6 inches, which will be the difference between the level of the bottom of the sewer at the commencement and the bottom of the sewer at its termination in the Barking Marshes, or 42 feet 6 inches below high water at Woolwich; or at a 22 feet tide, 20 feet 6 inches below *low* water at Woolwich.

The position of the proposed intercepting sewer is at a distance from the river, in order to avoid the expense of tunnelling through uncertain ground, and in order to avoid also, as much as possible, the water with which any work carried on close to the river would undoubtedly be encumbered, and which, even if it were practicable to carry on the work in spite of it, would render the cost of the work so uncertain, that it would be impossible to estimate the amount of capital required.

Nevertheless, a more *regular* line than that proposed might have been laid down with advantage, but for the necessity of compensating all the owners of the houses under which it must pass. A tortuous course through the streets, where neither notices nor compensations would be required, was for this reason considered to be the wisest and most economical plan to adopt.

To have carried the intercepting sewer along the banks of the Thames at and in front of the mouths of all the sewers, would have involved an enormous expenditure and great uncertainty; whilst the plan now proposed involves only the diversion of the present sewers between the intercepting sewer and the river, should it be considered requisite, in order that the sewage from the houses in that space may flow into the intercepting sewer instead of into the river.

The depth under ground of the intercepting sewer is regulated by the depth of the London Bridge Sewer, the mouth of which is nearly at a level with low water.

The necessary communication between the present sewers and the intercepting sewer will be effected by means of shafts from the top of the proposed sewer to the underside of the existing sewers, so that whatever flows through the present sewers *must* flow into the intercepting sewer, unless, in case of long-continued rains or storms, when, if much more than double the usual quantity of water should pass down, then as soon as the intercepting sewer is fully charged, the surplus water would run off through the old channels into the Thames. The sewers will, however, at these times, be relieved by an additional outlet of large capacity, the proposed sewer forming a communication with the Thames at Barking. All the flaps at the mouths of the present sewers will have to be made water-tight, to prevent the water of the Thames flowing at high water into the intercepting sewer, *unless required*, although this, of course, will not prevent their being available for allowing the surplus waste to flow into the Thames when necessary.

The quantity of water passing down the sewers on the north side, under ordinary circumstances, every twenty-four hours, is as follows :*—

	Cubic feet.
Westminster and Holborn and Finsbury divisions, per diem	3,784,704
City and Tower Hamlets	3,260,416
Total	7,045,120

The proposed sewer has a fall of 12 inches per mile, which will give a velocity of 120¼ feet per

* See Report of Mr. Geo. Hawkins to the Commissioners of Sewers of Westminster and part of Middlesex, on the average discharge of sewage: printed by order of the Court, Oct. 5, 1845.—See also Appendix (A).

minute in the 12 feet sewer, and $98\frac{2}{10}$ feet per minute in the 8 feet sewer; and they will deliver, when running full bore, the following quantities of water per minute, and per day of 24 hours, viz.:—

12 feet sewer, 13,588 cubic feet per minute, or 19,567,080 cubic feet per diem.

8 feet sewer, 4,935 cubic feet per minute, or 7,107,166 cubic feet per diem.

The smaller, or 8 feet sewer, will, therefore, deliver about double the quantity at present supplied by the Westminster and Holborn and Finsbury divisions; and the larger, or 12 feet sewer, will deliver more than $2\frac{3}{4}$ times the quantity at present supplied by all the divisions north of the Thames; this will be an ample provision for the future.

The main sewer will terminate in a receiving reservoir, in the Barking Marshes, in which arrangements will be made for separating the stones, brickbats, and other heavy materials, the carcases and other large floating bodies that may be carried down, from the ordinary sewage water, which latter will be pumped up continually as it flows out of the mouth of the sewer, so as always to preserve the necessary fall of water in the sewer. The engines will be equal to an aggregate power of 1,060 horses, and will be capable of raising, when worked at their full power, 56 feet high, 18,112,320 cubic feet in 24 hours, equal to more than $2\frac{1}{2}$ times the present ordinary quantity of sewer water.

The sewer water will be raised into reservoirs sufficiently elevated to allow of its solid contents being deposited at a level above the Trinity high water mark, so that it can easily be shipped, or loaded into railway trucks, and that the refuse liquid may be discharged at all states of the tide.

Although in the size of the sewer, and the power of the engines, provision is made for more than double the present quantity of sewage supplied, yet the calculations of profits are based upon the present quantity only, and no increase is included for the additional manure to be hereafter derived from the street sweepings, which, when the works are completed, may be at once allowed to be swept into the sewers—and stations will be provided along the line of sewer, to enable the scavengers to deposit night soil, or dung. These stations will, however, be enclosed, so that no nuisance will be created in the neighbourhood, and, when once deposited, the matter will be carried by the current of water in the intercepting sewer rapidly to the terminus.

It may be necessary here to explain the way in which the proposed scheme will afford the opportunity of obtaining these last-named advantages—at present, as before observed, the water, for a certain period in every twelve hours, is at rest. In this period a deposition takes place, and the current afterwards is too sluggish (except during heavy rains, or when the same effect is produced by flushing) to scour it out; but if the outfall is at a lower level *at all times*, as it will be when the proposed sewer becomes the outfall, then the current will be continuous; and although the bottom of the present sewers should remain unaltered, nevertheless, as the water will flow from the outlets without interruption, so the fall in it will be greater and the current stronger,* and thus the present sewers will become capable of carrying off not only a larger quantity of matter, but a larger quantity of *heavier* matter.

A great improvement in the construction, and a saving in the cost of future sewers, will also be promoted by this plan; because, as the outlet will be considerably lower than at present, the sewers may be laid at a greater inclination, and a smaller size will be equally effective.

And further, those parts of the metropolis which cannot be properly drained on account of their low level, may be so when the new sewer is made.

When the whole contents of the sewers have been received in the first reservoir, at the mouth of the intercepting sewer, it is intended, as previously stated, to separate the heavy materials and the large floating bodies from the sewer water; the heavy materials will be taken out at once; the floating bodies will be raised into a separate reservoir, and subjected to the action of lime, which will promote their decomposition; and some portions will be exposed to a mechanical process to reduce them minutely, when the manure will be precipitated to the bottom of the reservoir.

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* The importance of a constant current will be further evident, on reference to an extract from a Report from Mr. Aikin.—See Appendix (B).

The sewage water will be mixed with a certain portion of lime, (which will prevent any effluvium from extending beyond the limits of the works,) and then pumped up into an elevated reservoir, in which it will be allowed to rest for a sufficient length of time for deposit, and by a system of reservoirs this process will be carried on continually.

The deposit in the reservoirs will be removed periodically, and dried by artificial means, and then compressed and packed up, ready for transmission by land or water to any part of the world.

In order to ascertain the quantity of manure to be obtained in the solid form from the sewage water, careful experiments have been made by your chemists. Before giving the results, it is right to state that it is believed a greater quantity of matter *may* be extracted; but whether the further quantity can be obtained at so small a cost as to render it worth while to make provision for doing so, I have not yet ascertained: the following results, however, are certain, and upon quantities that are *known* to be obtainable, the calculations of profit are made.

The average quantity of solid matter obtained from sewage water taken from sewers in Westminster, the City, Holborn, and Finsbury, and the Tower Hamlets, was 1 part solid in 1120 parts of liquid. By adding lime in the proportion of 1 part of lime to 2800 parts of crude sewer water, a quantity of fertilizing matter held in solution in the sewer water is precipitated, equal to 1 part in 1120 parts in sewer water.—By this process none of the lime is lost; or if any slight loss should occur, its weight is made up by the additional manure deposited, and the lime itself, when deposited, forms a good manure with the other portions. Thus adding together the matter collected by simple deposition, the lime and the matter precipitated by it, we have the total quantity of manure deposited in the reservoirs equal to $\frac{1}{466}$. Thus dividing a given quantity of sewage water into 13,080 parts, it will be found to consist of—

Valuable mechanical deposit	8¼
Useless do. do.	4¼
Valuable chemical precipitate	12½
Lime as manure	5
Sewer water allowed to flow away from the Reservoirs	13,050
	13,080

In the sewage water allowed to flow away from the reservoirs there still remains 1 part in 408 parts of solid matter held in solution, separable only by evaporation; of this, however, a large proportion is, according to Mr. Aikin, common salt only.

Then taking the daily quantity of sewer water upon the north side as equal to 7,045,120 cubic feet, this divided by 466 will give 15,118 cubic feet, or (taking it at the weight of water only) 420 tons per diem of highly valuable manure in a *solid* and *easily transmittable* form.

As regards the south side of the Thames, it is ascertained, that if the Earl Sewer were of sufficient capacity, or, in other words, if the sewer water could be taken off continuously, which in ordinary times would make it sufficiently capacious, the relative levels of the sewers on the south side are such that their whole contents might be led into the Earl Sewer.

It is, therefore, proposed to construct a circular sewer of 8 feet in diameter, commencing at or near to the Earl Sluice, then passing in an easterly direction through Grove-street, Victualling Office Row, part of Lower-road Deptford, part of High-street Deptford, Union-street, New-road, under Deptford Creek, through Bridge-street, Nelson-street, Rodney-road, Trafalgar-road, part of Lower Woolwich Road, then turning in a northerly direction down Horn-lane into the Greenwich Marshes to the proposed works of the Company, situated on the banks of the Thames, between the Tide Mill and Sluice House.

The bottom of the proposed sewer at the end near the Earl Sewer will be 12 feet below the bottom of the Earl Sewer, and 29 feet 7 inches below Trinity high water mark, and therefore, at a 20 feet tide, it will be 9 feet 7 inches below low water.

The height of the sewer here will be 8 feet inside.

The bottom of the sewer will fall 12 inches per mile, or, in the whole length of $3\frac{1}{2}$ miles, 3 ft. 6 in., which will be the difference between the level of the bottom of the sewer at the commencement, and the bottom of the sewer at its termination in the Greenwich Marshes, or 33 feet 1 inch below Trinity high water mark, or, at a 22 feet tide, 11 feet 1 inch below low water in the Thames opposite the proposed works.

The works will be similar to those already described for the north side, but on a smaller scale.

The quantity of water passing down the sewers on the south side of the Thames, and which may be brought through the Earl Sewer to the intercepting sewer, will be, under ordinary circumstances, equal to 2,457,600 cubic feet per diem,* and the proposed sewer will be capable of delivering 7,107,166 cubic feet per diem, or very nearly three times the quantity at present supplied. The engines will be capable of lifting this latter quantity into the reservoirs when working at full power. Then taking the present daily quantity of water, and calculating by the same rules as those adopted for the north side, the quantity of highly valuable solid manure collected each day will amount to 146 tons.

The solid manure obtainable from both sides of the river will be equal to *at least* 566 tons per diem, or 206,590 tons per annum.

ESTIMATES.

The cost of the proposed sewers, reservoirs, buildings, wharfs, machinery, and land, on both sides

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* See Report of Mr. Geo. Hawkins to the Commissioners of Sewers of Westminster and part of Middlesex, on the average discharge of sewage: printed by order of the Court, Oct, 5, 1845.—See also Appendix (A).

of the river, including all engineering charges and expenses from the commencement to the termination of the work, except the expenses of parliamentary opposition, will not exceed £1,300,000 which will leave £200,000 for law and parliamentary expenses, and for real or imaginary cases of compensation, the total being £1,500,000—the capital proposed to be raised.

ANNUAL EXPENDITURE AND REVENUE.

EXPENDITURE.

The total annual expenses of carrying on the works, including labour, coals for engines, and for drying the manure, lime, offices, officers, rent, taxes, repairs of works and machinery, will not exceed	£300,000
Reserved fund for renewal of works, improvement of the existing sewers, if beneficial to the Company, &c. &c. 5 per cent. on Capital	75,000
Profit at 15 per cent.	225,000
	£600,000

REVENUE.

206,590 tons of manure (see p. 48), in a highly dried state, compressed and packed, at £3 per ton	£619,770

The necessary works might be so far completed in two years from their commencement, as to be in partial operation, and ready to produce a revenue.

The price per ton, in the above estimate of revenue, is low,* and may be still further re-

* The price of inferior guano is £6, £7, or £8 per ton, while the best is £12 per ton.

duced, if the manure be taken from the works in a moist state, or before drying, according to the quantity of water which it contains.

Before bringing this Report to a close, I beg permission to make a few general observations on the important subject which has been under consideration.

It is not to be expected that this manure will entirely supersede the use of others; because, although there are many descriptions of land on which this manure alone would produce a very advantageous result, there are others on which the existing manures, with an admixture of the new manure, would be more useful.

As it could not be used in any one locality to the exclusion of all other manures, it became a necessary and important feature of the present plan, that the manure should be obtained in the most concentrated form, so as to allow of easy transmission at a low price, to any part of the world—failing in this, there would undoubtedly be great difficulty in obtaining a market for the quantity which will be produced.

Although the collection and disposal of the solid manure is the main object of the plan which I have submitted to you, yet there will be nothing in the arrangement of the works on either side of the river to prevent the use of the sewer water in its crude state in the contiguous marshes. On the contrary, every facility will be afforded for its application, as the whole will be raised into reservoirs to a level of about 11 feet above the marshes, so that the neighbouring landowners may avail themselves of it for irrigation, if the expense of conducting it to their farms presents no obstacle; and whether it will do so or not, will depend upon the mode decided upon: if carried by an open cutting, there would be fall enough to convey the water to a very considerable distance.

I must not omit to call your attention to the fact, that as the plan which I have submitted to you will be carried into effect by means of a tunnel, or subterranean sewer, there will, in its progress, be no interference with the present sewers, and no disturbance of the streets and pavements, except at those points where the shafts will communicate with the proposed new sewer.

It should be mentioned also, to guard against any apprehension which might be excited by the first hasty examination of the scheme, that the depth below the surface will be such as to prevent, in the manner in which it is proposed to carry on the work, any possibility of danger to the houses or buildings above it.

In conclusion, I beg leave to express my hope that I have shown that the proposed undertaking will be beneficial to the *Public*, the *Landowners*, the *Shipping Interest*, and the Railway and Canal Carriers, as well as *profitable* to the Promoters.

The subject is one to which I have devoted considerable attention. In 1841 I reported to Major Baeyer, the Commissioner sent to this country by his Majesty the King of Prussia, for the purpose of ascertaining how Berlin could be sewered, a plan, of which the principle was similar to that now laid before you, as far as concerns the mode of increasing the natural fall by mechanical means, Berlin not being elevated more than 10 or 11 feet above low-water in the river.

This being so important a feature in the proposed plan, and the chief cause of the outlay being comparatively so trifling, I have thought it right to state the fact just mentioned, in order to show that the question has been under my consideration for some years.

The very careful examination which I have lately made of the proposed scheme enables me to speak with certainty both as to its being effectual for the objects proposed, and as to the ample amount of my estimate for carrying out the works in the most complete manner.

I am, Gentlemen,

Your obedient servant,

THOS. WICKSTEED,

Engineer to the Company.

Old Ford,

December 22nd, 1845.

APPENDIX.

(A.)—Report, pp. 21, 41, 48.

According to Mr. Hawkins, Assistant Surveyor to the Westminster Commissioners of Sewers, "The ordinary daily amount of sewage discharged into the river on the north side would be 7,045,120 cubic feet, and on the south side 2,457,600 cubic feet, making a total of 9,502,720 cubic feet;" and the area of land included "within the whole of the Metropolitan Commissions of Sewers," is 43 square miles on the north, and 15 square miles on the south, together 58 square miles, or 37,120 acres; the daily amount of sewage is therefore equal to 256 cubic feet per acre.

This quantity of 256 cubic feet per acre per diem is equal to a depth of 25.68 inches in 12 months.

The Water Companies on both sides of the river supply 2,025 millions of cubic feet per annum, which over the same area would be equal to a depth of 15.02 inches in 12 months. Taking the supply of water from the wells of the manufactories in London to be equivalent to the loss by evaporation, absorption, &c., from the supply by the Water Companies, and taking therefore the whole 15.02 inches as flowing into the sewers, there remains a deficiency of (25.68 – 15.02) 10.66 inches.

The fall of rain in London being an average of 62 years, was equal to 19.261 inches, and if 10.66 inches be taken from it, there are 8.601 inches left for evaporation, &c. and considering the nature of the ground, this proportion may perhaps be sufficiently near the truth.

Mr. Roe, Surveyor to the Holborn and Finsbury division of sewers, calculates the quantity of sewage water passing down the Fleet Sewer, as equal to 695 cubic feet per minute (in his evidence he calls it 692.8), and that the area drained is equal to 4,444 acres, which he states to be $\frac{4}{7}$ths of the whole area of the Holborn and Finsbury division, which is therefore equal to 7,777 acres, and the daily quantity would therefore be equal to 1,000,800 cubic feet. This, divided by 4,444 acres, gives 225 cubic feet per acre, instead of 256, as calculated by Mr. Hawkins, or 12 per cent. less.

Taking Mr. Hawkins' calculation of the extent of the districts, north and south, at 37,120 acres, and the population at 1,626,935, there will be 44 (nearly) individuals for every acre. And in the Holborn and Finsbury division, taking Mr. Roe's calculation of the extent of district at 7,777 acres, and the population at 370,111, there will be 49 (nearly) individuals for every acre. The difference between the two *may* arise from the Holborn and Finsbury divisions being more densely peopled than the whole.

According to Mr. Hawkins, the sewer water daily per individual will be equal to 5.84 cubic feet, or 36.39 gallons.

According to Mr. Roe, 4.73 cubic feet, or 29.47 gallons.

But according to Mr. Smith, of Deanston, 10.46 cubic feet, or 65.2 gallons.

(B.)—Report, p. 44.

"From the facility with which the various matters discharged into the sewers undergo decomposition, when diluted with water, and at a favourable temperature, it is evident that the shorter the time that they remain in the sewers, the more valuable they will be, because the less decomposed. It may, therefore, be confidently anticipated that a plan which, by means of a constant current, clears out these matters from the sewers in proportion as they are poured in, will furnish them in a state considerably more beneficial to the farmer, and nearly approaching to that of night-soil, which is considered as the richest of all manures."—*Mr. Aikin's Report.*

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