(1) பக்கங்களின் எண்ணிக்கை 44 + 2

(2) புதுக்கித் திருப்பிய நாள் ஆகஸ்ட் 1990

(3) ஆதாரங்குறிப்பவர் சுருக்கொப்பம்

தமிழ்நாடு ஆவணக் காப்பகம்.

தமிழ்நாடு அரசு

பொதுப் பணித் துறை

அரசாணை எண். —
மு. கோப்புத் தாள் எண். 2078

அச்சகம்
பலவகை

நாள் : 12.8.1893.

198 .

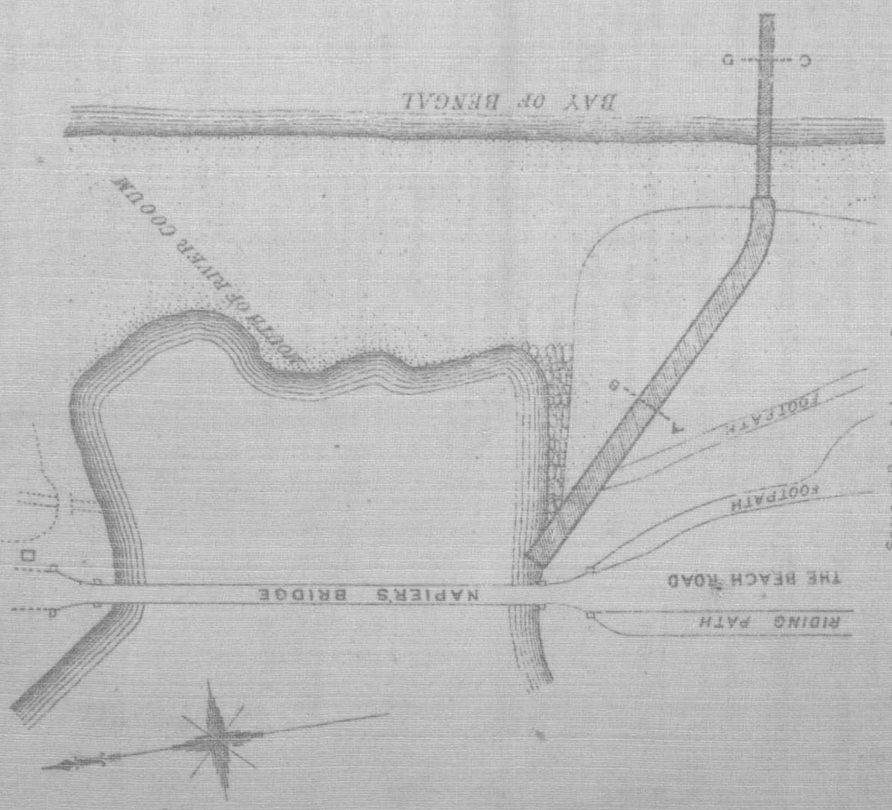
மடிக்கவோ கண்டபடி கையாளவோ கூடாது

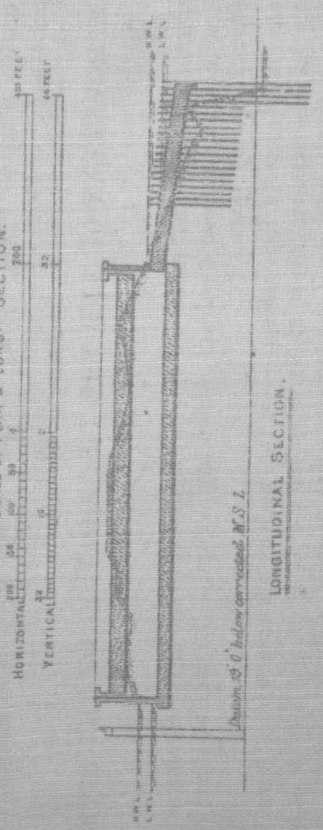
ஆவண. கா-1—18,000—15-6-87.

MADRAS DRAINAGE.

DESIGN FOR THE FLOW AND EBB OF TIDAL WATER INTO AND OUT OF THE

RIVER COOUM.





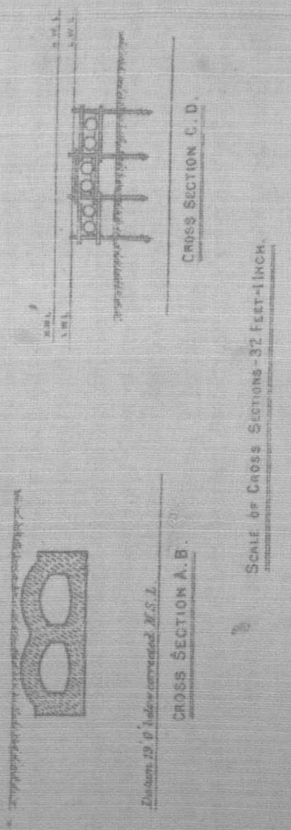
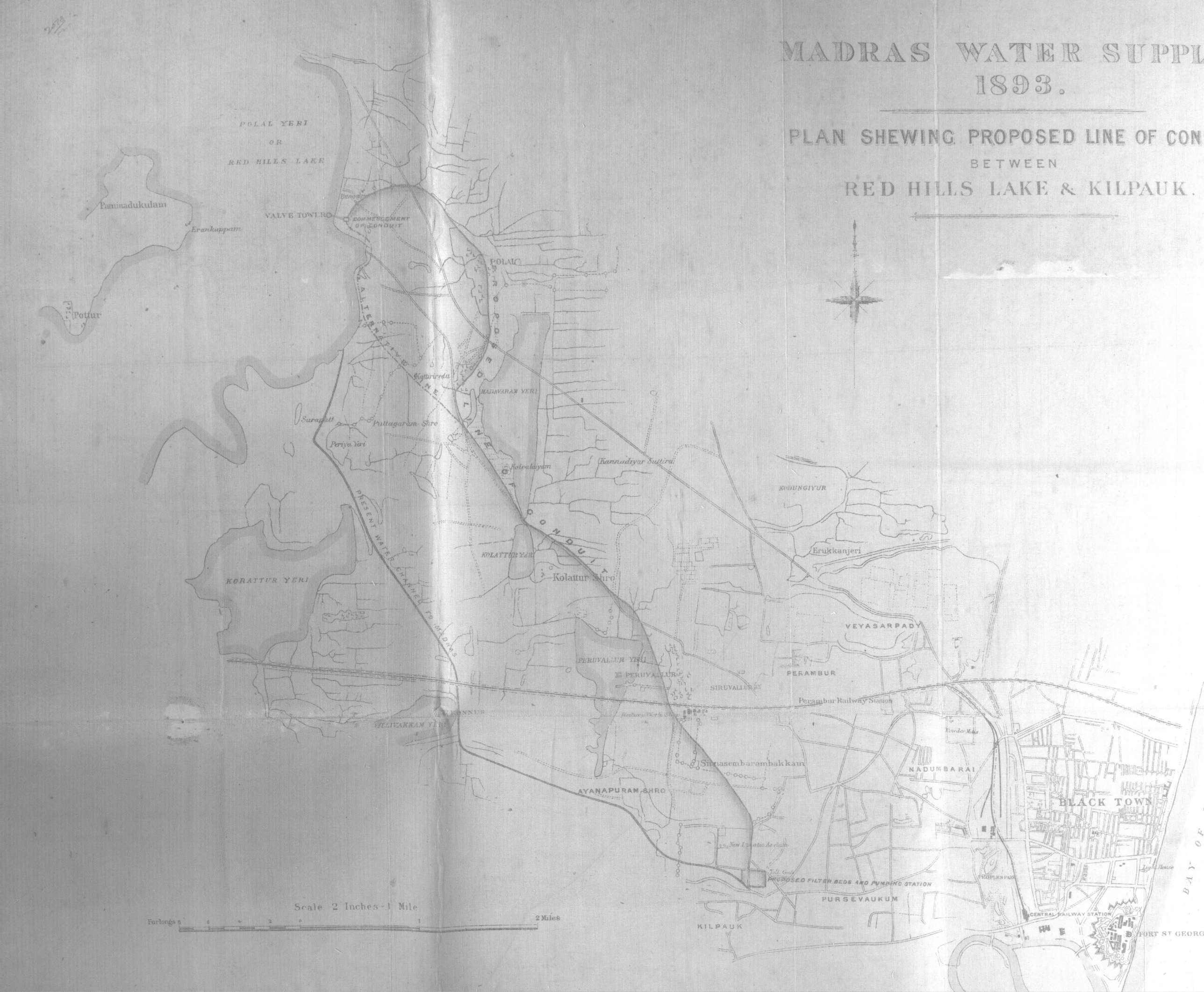


PHOTO-ZINCO. SURVEY OFFICE, MADRAS
1893

MADRAS WATER SUPPL
1893.

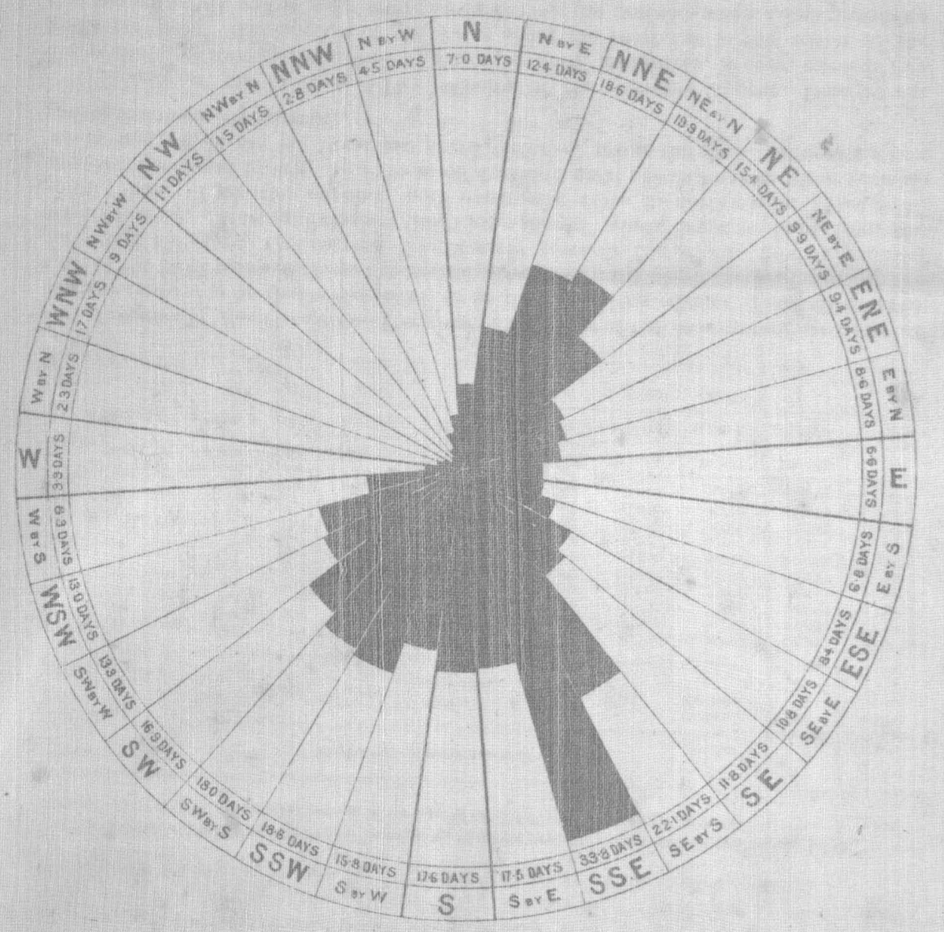
PLAN SHEWING PROPOSED LINE OF CON
BETWEEN
RED HILLS LAKE & KILPAUK.



7678
2

DIAGRAM SHEWING THE AVERAGE NUMBER OF DAYS IN EACH YEAR THE WIND BLEW FROM DIFFERENT POINTS IN MADRAS DURING THE TEN YEARS FROM 1881 TO 1890 INCLVE.

From Meteorological Observations at the Government Observatory, Madras.



SCALE

DAYS 10 5 0 10 20 30 DAYS

REG: No. 908 — COPIES 105

PHOTO-ZINCO. SURVEY OFFICE, MADRAS.
1893

Actual Receipts

2078/4

GOVERNMENT OF MADRAS.

LOCAL AND MUNICIPAL DEPARTMENT.

READ—the following paper :—

Despatch from the Right Honorable Lord KIMBERLEY, Her Majesty's Secretary of State for India, to His Excellency the Right Honorable the Governor in Council, Fort St. George, dated India Office, London, 8th June 1893, No. 3, Public Works.

With reference to the correspondence quoted in the margin, I transmit herewith, for your Excellency's information, twenty-five copies of Mr. Edward Cousins' report on the proposed drainage and water-supply of the City of Madras, and improvement to the river Cooum.

Letter from Govt. of Madras, No. 2049 M., Local and Municipal, of 13th December 1892.
P. W. Despatch to Government of Madras, No. 1, of 26th January 1893.

ENCLOSURES.

Report upon Drainage of the Town and District of Madras, 1893.

PALACE CHAMBERS, WESTMINSTER,
7th March 1893.

SIR,

On 21st August 1891, I received a letter from the Secretary of State for India which, with the exception of certain omissions, is given below.

I have, &c.,

(Signed) EDWARD COUSINS.

To the Hon'ble J. F. Price, Chief Secretary to Government,
Fort St. George, Madras.

(Extracts from letter referred to.)

P. W., 1493.

"INDIA OFFICE, WHITEHALL, S.W.,
"*20th August* 1891.

"SIR,

"The Government of Madras and the Madras Municipality are desirous of improving the water-supply and drainage of the City of Madras, and that Government have requested that a duly-qualified expert be deputed to Madras to examine and report upon the subject.

"The Secretary of State for India has been informed by the Local Government Board that you are willing to undertake the duty in question. The Secretary of State in Council accordingly offers the appointment to you.

"Your arrival in Madras should not be later than the 15th October next, in order that you may watch and note the effects of the north-east monsoon, which usually sets in about the 20th of that month. I am to add that the Government of Madras have already been requested to send home information on the question of Water-Supply and Drainage of Madras, in order that you may study the same on your voyage out.

"I am, &c.,

(Signed) "HORACE WALPOLE."

"Edward Cousins, Esq., C.E.

REPORT.

DRAINAGE OF THE TOWN AND DISTRICT OF MADRAS.

Previous Reports.—In accordance with the preceding instructions I arrived in Madras on 14th October 1891. I received at Aden, upon the voyage out, the copy of a report upon the water-supply and drainage of Madras, which had been submitted to the Government of Madras in November 1890 by a Committee, consisting of Colonel Pennycuick, R.E., the Chief Engineer, Public Works Department, as President; Mr. J. A. Jones, M.I.C.E., Sanitary Engineer to Government; and Dr. W. G. King, Acting Sanitary Commissioner. To this report were appended various suggestions by gentlemen not on the Committee.

I also received the report of a scheme for the improvement of the river Cooum, by Mr. J. A. Jones, M.I.C.E., submitted by him in December 1890, with a note upon this scheme by Colonel Pennycuick, R.E., and the reply of Mr. Jones.

After my arrival in Madras I was also furnished with the following reports:—

1855.—Report upon the Drainage and Water-supply of Madras, by Lieutenant O'Connell, R.E.
1856.—Report of a Committee on a plan for cleansing the Drains of Black Town.
1861.—Memorandum on the Drainage and Water-supply of Madras, by Mr. D. Horgan, C.E.
1865.—Report on a Project for the Drainage of the Town of Madras, by Major Hector Tulloch, R.E.
1867.—Report on the Madras Water-works, by Mr. W. Fraser, C.E.
1869.—Water-supply Works, Additions, by Mr. Standish Lee.
1872.—Report of the Water-supply Committee.
1874.—The Sewerage of Madras, by Mr. Standish Lee.
1875.—Report of the Drainage of Madras, by Mr. W. Clarke, C.E.
1877.—Report on the present condition of the Madras Water-works, with schemes for their improvement, by Mr. J. A. Jones, C.E.
1878.—Drainage of Black Town, by Mr. J. A. Jones, C.E.
1880.—Report on the Drainage of Black Town, by Mr. J. A. Jones, C.E.
1882.—Monograph on the Madras Water-supply and the Irrigation Extension Project.
1885.—Scheme for the Improvement of the Water-supply of Madras, by Mr. J. A. Jones, C.E.
1887.—Report of the Water-supply Committee.
1890.—Drainage of a portion of Mylapore, by Mr. R.E. Ellis, C.E.
1890.—Report on Mr. Jones' Scheme for the improvement of the Water-supply of Madras, by Mr. R. E. Ellis, C.E.
1890.—Alternative Scheme for the Improved Water-supply of Madras, by Mr. R. E. Ellis, C.E.

During the six months I was in Madras I gave my careful attention to the subjects in question, and now have the honour to submit the result of my investigations in this report, with the necessary general explanatory plans, sections, and estimates.

Situation and Extent of the District.—Madras lies upon a low, sandy plain, which forms a portion of the coast of the Bay of Bengal. It extends for a distance of nearly nine miles from north to south along the shore, and inland for about three or four miles.

Geology and Surface.—The surface and sub-soil consists, as a rule, of deposits of white and grey sand, in which occur, at irregular intervals, thin beds of clay. Water is found below the surface at various depths, but generally in the low-lying parts of the districts it corresponds with the mean level of the sea. At no part of this sandy plain within the city limits are there any considerable elevations of the surface; the

maximum heights are from 20 feet to 24 feet above mean sea-level, while many portions of the town are only 2 feet to 6 feet above that level. The average-elevation of the surface may be taken at about 9 feet or 10 feet; the higher portions of the ground run generally in the form of ridges, and advantage has been taken of this fact in arranging for the necessary gradients of the proposed sewers.

Rainfall and Surface Water.—As the system of sewerage which I propose to recommend is to exclude all rain-water, except that which may find its way from the yards and courts of houses into the sewers, the question of rainfall is not so important a matter for consideration in the scheme as it would be if the sewers were intended to carry off storm-water as well as the sewage. I will, therefore, only make a few general remarks upon it as connected with the drainage of the district.

Meteorological Records.—I find, from the meteorological observations made at the Government Observatory, Madras, by the late Mr. N. R. Pogson and Mr. C. Michie Smith, the present Astronomer to Government, that the average rainfall during the last 30 years is 49·68 inches per annum; almost the whole of this falls in the months of October, November and December, the mean monthly falls during the years 1861—90 being: October 10·80 inches, November 13·60 inches, and December 5·75 inches.

Annual Rainfall.—The annual rainfall, however, varies considerably. In 1884 the fall was 78·92 inches, whereas in 1876 it was only 21·60 inches. There appear to be groups of years in which the rainfall is considerably above the average; for instance, in the five years from 1870 to 1874, inclusive, the average annual rainfall was 63·77 inches, and in the six years from 1879 to 1884, inclusive, the average fall was 58·29 inches. Other groups again fall below the average, as in the three years 1867–68–69, when it was but 32·70 inches; 1875–76 29·36 inches, and 1888–89 35·69 inches.

Excessive Rainfalls.—The largest daily fall during the past 30 years occurred on 18th May 1877, when 13·01 inches fell, and with respect to other phenomenal downpours Mr. C. Michie Smith, the Officiating Government Astronomer, to whom I am indebted for much of the preceding information, says:—

"I have myself seen a rainfall of 2 inches in 20 minutes, while 2 inches in an hour is not very uncommon. A rainfall of over 10 inches in 24 hours has been recorded on probably about a dozen occasions in the last 75 years, and the maximum recorded is, I think, under 20 inches."

TABLE showing maximum Rainfalls in one day, chiefly during Monsoon periods, from 1861 to 1890.

Year.	Date.	Fall.	Year.	Date.	Fall.
1861	6th November	4·98	1876	10th November	2·30
1862	14th December	3·28	1877	18th May	13·01
1863	4th ,, ...	5·48	1878	6th October	4·37
1864	18th November	9·35	1879	8th ,, ...	3·66
1865	25th ,, ...	4·73	1880	28th November	5·66
1866	5th December	7·99	1881	12th ,, ...	8·19
1867	30th November	3·54	1882	29th ,, ...	7·38
1868	4th June	4·08	1883	2nd October	4·88
1869	31st July	2·10	1884	7th November	5·72
1870	20th October	5·93	1885	16th ,, ...	6·00
1871	1st November	4·84	1886	9th ,, ...	2·90
1872	13th October	7·79	1887	28th October	5·75
1873	1st December	6·57	1888	31st ,, ...	9·20
1874	24th October	7·47	1889	18th December	5·07
1875	14th November	3·50	1890	27th October	2·25

Vital Statistics—Birth-rate.—I find from the report of the Health Officer for Madras, Dr. J. Nield Cook, for 1890 and 1891, that the total number of births registered during 1890 was 17,569, being an increase of 1,220 over the preceding year. The rate was estimated at 44 per 1,000 per annum, as against 40·9 the preceding year.

Death-rate.—The total number of deaths during the year in question, 1890, was 17,194, against 17,086 of the year before, giving a ratio of 43·1, against 42·8 per

1,000 per annum. The heaviest death-rate, 46·1, was amongst the Mussulmans, the next, 43·7, being that of the Hindus, whilst the Christians 34 is by far the lowest. The mortality in 1890 was highest from July to October, at which time cholera was prevalent in Madras, the number of the deaths ascribed to that epidemic being 744; the average of the 10 previous years was 339·4, the highest number being 1,193 in 1884, and the lowest numbers 2 in 1880 and 4 in 1886. The following table, taken from the Administration Report of the Madras Municipality for 1890–91, shows the average number of deaths for 10 years, and specifies the causes of death:—

TABLE showing the average Deaths in Madras for ten previous years ending 1889, as contrasted with the Mortality of the year 1890.

Year.	Deaths from Special Diseases.						Deaths from other Diseases.	General Total.	Ratio per 1,000.
	Small-pox.	Measles.	Fevers.	Bowel Complaints.	Cholera.	Total.			
1880	869	105	3,549	2,249	2	6,774	8,133	14,907	37·4
1881	1,654	299	3,698	1,925	126	7,702	7,785	15,487	38·9
1882	355	148	3,706	2,110	461	6,780	7.389	14, 69	35·5
1883	1,957	138	3,470	2,284	169	8,018	7,864	15,882	39·8
1884	4,064	133	3,779	2,574	1,193	11,743	8,380	20,123	50·4
1885	26	67	3,59	2,807	184	6,679	8,246	14,925	37·4
1886	1	250	3,801	2,386	4	6,642	8,057	14,699	36·8
1887	13	73	4,037	2,911	530	7,564	8,628	16,192	40·6
1888	36	49	3,872	2,568	543	6,568	8,871	15,439	38·7
1889	45	1,204	4,154	2,993	182	8,578	8,508	17,086	42·8
Total ..	9,020	2,466	37,161	25,007	3,304	77,048	81,861	158,909	..
Average ..	902·0	246·6	3,716 1	2,500·7	339·4	7,704·8	8,186·1	15,890·9	39·8
1890	78	412	4,685	2,704	744	8,623	8,571	..	43·1

Direction of Sea Currents.—The general direction of the currents off the coast of Madras appears to be that which is taken by the prevailing winds. Thus, during the time of the N.E. monsoon, from the middle of October until about the beginning of the following February, the current sets steadily towards the south, flowing parallel with the coast. During February the "long-shore" winds begin to blow from the south; these check the current, and eventually turn it northwards. The S.W. monsoon continues to urge it in the same direction until about August, when variable winds and calms set in; these last until October, when the N.E. monsoon again causes the southerly current.

Velocity of the Currents.—The velocity of the currents appear, from recent observations, to average from 1 to 1¼ knots per hour, and rarely, if ever, exceeds two knots per hour. The motion of the water along the coast due to the action of the tide is very small, and is only appreciable during the periods when calms prevail or the change in the monsoons is about to take place.

Rise and Fall of the Tide.—The average rise and fall of the tide upon this coast is about three feet, but the maximum range from the highest high water to the lowest low water is a little over five feet; this range, however, is never reached in a single tide.

The "Open-channel" System of Drainage.—Madras is now drained upon the "open-channel" system, that is, the drainage of the houses is discharged into open channels in the streets, some of which are formed in the soil without brickwork, concrete, or any proper construction; whilst others are of defective brickwork, with open joints, &c.

The open channels in Black Town and a few other parts of the district have been recently reconstructed in a very superior manner to those which are generally found. Under the system now pursued all rubbish, dust, ashes, and the principal part of the solid excrementitious matter are collected and removed by the conservancy carts and disposed of in various ways. The fouled water from the houses, the urine,

part of the excreta mixed with the water used for the daily washing out of the privies, the bath and sink water, &c., are discharged through the present house drains into the open drains in the street.

Existing House-drains.—The house-drains are usually constructed of very imperfect brickwork, having open joints, and generally laid but a few inches below the level of the floors of the houses, with insufficient gradients. The soil for some distance round these drains must of necessity be saturated with sewage, which must injuriously affect the health of the occupants. These drains usually terminate at the front walls of the houses at a height of two or three feet above the public drains in the street; here the sewage pours or trickles down the surface of the front walls of the houses until it reaches the open channel, which conveys the sewage to a large open drain.

Thus it passes on into other wider and deeper open drains until eventually it is discharged into covered sewers, which convey the sewage to pumping stations, where it is pumped on to one or other of the eleven sewage farms.

When the engines or pumps at these stations are not at work, or if there is more sewage than the pumps and the land can deal with, the overflow at such times is discharged directly either into the River Cooum, the Buckingham or Junction Canals, or into the sea.

In some parts drains are found which do not connect with sewage farms, but empty their contents into the river, the canals, or into stagnant pools. Thus the sanitary aspect of a Madras street presents the spectacle of a row of open house-drains on either side of it discharging sewage matter into two open public drains. It is no matter for wonder that in all parts of the town the subtle odour of sewage, more or less strong, is distinctly apparent, and when the abnormally high death-rate, accelerated by these insanitary conditions, is considered, together with the moral effect which the constant sight of this filth must have upon the Native mind, no more crushing arguments against the "open-channel" system could be adduced. One disgusting practice alone under this system should be sufficient to ensure its abolition (I refer to the present method of the collection of the fæces by men and women).

If no back entrance exists to the house the Native must enter the back-yard by a small covered inlet, generally provided with a door. This opens from the street to the privy, where the man or woman collects the excreta of the household and conveys it to the pails in the carts in the streets which are provided for its removal to the depôt. The privy is generally washed out at the same time, the fouled water going into the open drain in the street.

I cannot speak too strongly against such a repulsive and loathsome practice. To the inhabitants it must be a source of supreme disgust, whilst its degrading influence upon those deputed to carry out such a work cannot be over-estimated. Even in Black Town, where the open-channel system is seen at its best, the concurrent evils can be plainly noted; but in other parts, where, either through choked-up channels or insufficient gradients, the sewage remains stagnant or soaks through badly-constructed or broken drains into the subsoil, the evil effects are patent to all.

A large proportion of the Native population are shopkeepers; these, with their assistants, sit month after month vending their wares in the impure atmosphere arising from the open drain immediately in front of their shops, whilst their customers stand over the same foul-smelling channel to make their purchases. The wonder is, not that the mortality returns are so high, but that they are so low, under these conditions.

The River Cooum.—The River Cooum rises in North Arcot, and enters the town at its western boundary, in close proximity to the Nungumbaukum tank.

At Egmore the loop commences, which almost entirely surrounds the populous district of Chintadripettah. It then flows past Government House, and, during floods, discharges itself into the sea near the marine villa attached to Government House. A branch of the river is thrown off near the Penitentiary, and rejoins the main stream near its mouth, thus enclosing a large piece of land called the Island. Into this branch the Buckingham Canal opens, whilst another, the Junction Canal, joins the main stream near the Senate House.

Length of the River.—The length of the river within municipal limits, as given by Mr. Jones in 1890, is 6·3 miles; the total area drained is 207 square miles, 8 square miles being within the limits of Madras. When a heavy rainfall occurs the river brings down a considerable volume of water; if the bar of sand at the mouth of the river is not open, the water accumulates and floods the island and some of the low-lying parts of the town.

Cutting the Bar.—Under these circumstances it has been the usual custom to cut a channel through the bar when the water has reached a certain level; the pent-up floods then pour out with considerable force, washing away the remainder of the bar and thus making a mouth for the river. The Cooum becomes a tidal river as soon as the flood waters have drained off, but if no fresh floods occur the sea gradually reforms the bar once more across the opening and closes up the river's mouth. The following table shows the dates of opening and closing the Cooum bar for the past twelve years:—

DATES of Opening and Closing the Cooum Bar from 1880 to 1891, inclusive.

Year.	Date.	Particulars.	Number of Days open.	Remarks.
1880	4th November	Opened	59	
1881	1st January	Closed		
,,	12th November	Opened	40	
,,	21st December	Closed		
1882	16th November	Opened	62	
1883	16th January	Closed		
,,	16th October	Opened	99	
1884	22nd January	Closed		
,,	19th October	Opened	95	
1885	21st January	Closed		
,,	16th November	Opened	31	
,,	16th December	Closed		
1886	9th November	Opened	30	
,,	8th December	Closed		
1887	28th October	Opened	86	
1888	21st January	Closed		
,,	30th October	Opened	82	
1889	19th January	Closed		
,,	15th October	Opened	15	
,,	19th ,, ...	Closed		
,,	18th December	Opened		
,,	27th ,, ...	Closed		
1890	.. ..	..	..	No floods, bar not opened. An attempt made in November to let in water, but without effect.
1891	22nd October	Opened	29	
,,	5th November	Closed		
,,	15th ,, ...	Opened		
,,	23th ,, ...	Closed		

From the preceding table it will be seen that for a period of about nine months in every year the Cooum lies as a lagoon, filled with an admixture of fresh and salt water, in the centre of the town. It is in indirect communication with the sea by the Buckingham Canal and the Junction Canal when the bars at Ennore and Adyar are respectively open, but, owing to the slight rise of the tide and the distance the water has to travel in both cases, the influence upon the Cooum river is so minute that it may be omitted in all calculations. It is but seldom that any appreciable quantity of fresh water is received by the river during the long time it is cut off from the sea, but a considerable addition is made to its contents, and also to the contents of the Buckingham and Junction Canals, by the discharge of large quantities of sewage which is poured into them daily from a great number of sewers and overflow sewers. It is estimated by Mr. Jones that over one million gallons of sewage is poured every day into this stagnant brackish pool, but, from my own observations, I am of opinion that this large volume is often exceeded.

Condition of the River.—The solid contents of the sewage settle to the bed of the river and form layer upon layer of horrible deposit, whilst the fluid portion emits the stench which has gained for the river its unenviable notoriety. As the hot weather increases the river gains in potency until the noxious exhalations are apparent at a considerable distance.

2078/A

The nuisance and inconvenience which must result for the numerous dwellers upon or near the banks must be very great; many large buildings, such as Government House, the Government Offices, the Senate House, and the Penitentiary, are near it; whilst the effects upon the inmates of the General Hospital and the Women's and Children's Hospital are matters for grave consideration. The river also breeds myriads of organisms, and is credited with producing the plagues of mosquitoes which at times infest Madras. In this cesspool of stagnant filth men may be seen every day fishing, and doubtless the results of their labours are vended for human consumption. Thus the river in its present condition is a standing menace to the health of the inhabitants of Madras, during the time it remains a motionless pool in the centre of the town; even when tidal it is a source of great danger under the present conditions, inasmuch as the decomposed and decomposing deposits on the bed of the river are disturbed by the action of the tidal water, and thus permitted to freely throw off obnoxious gases. The greater part of this sediment would doubtless be removed when the river is in flood and flowing freely outwards to the sea, but this may only occur for two or three months in each year; for the remaining nine or ten months the mouth of the river is blocked by the bar, and the matters held in suspension once more deposited.

Very early in my observations I came to the conclusion that no scheme of drainage for the town of Madras would be in the remotest degree satisfactory unless it provided for the total elimination of all sewage matter from the River Cooum.

With this object kept prominently before me, I have designed the system which will be found fully detailed in this report.

There is appended also the description of a scheme I have prepared for keeping up a permanent connection between the sea and the river, in the manner shown by the plans and sections which accompany this report. I have no hesitation whatever in affirming that, if these two schemes are carried out in their entirety, the river will soon assume a condition of purity and healthy freshness to which it has long been a stranger. Instead of being a source of danger to the health of Madras, it would become a beneficial "lung" to the town—a potent factor towards increasing the salubrity of the district. With the removal of all offensive odours and sources of danger to health the river would become, to a much greater extent than at present, a centre for recreation and resort, and, instead of being regarded with the feeling of abhorrence which it now excites, would earn the gratitude of all for its beneficial influence upon the sanitary condition of the several districts in its neighbourhood.

MYLAPORE AND ST. THOME.

Description of the District.—This district is bounded on the north by Triplicane, on the east by the sea, south by the River Adyar, and west by Brodies Road. It has a surface sloping inland from the sea, the highest portion being that surrounding St. Thomé Cathedral, where it is about 20 feet above mean sea-level. Towards the sea it falls abruptly, but on the western side slopes gradually away in all directions.

Present System of Drainage.—The open-channel system prevails at this time in this district, but in many parts in a very imperfect condition. The general contour of the ground permits the surface drainage being conducted in three different directions, which radiate from the high ground near the Cathedral. The sewage flowing towards the north tends towards the low-lying portion of land which is to the north of Corna Easwarer Covil Street. Here a small stream, which has its origin near the Mylapore tank, flows into the sea when in flood. As this event happens approximately about the same time that the River Cooum discharges its waters, it follows that for a large portion of the year the water lies as a shallow pool, constantly augmented by the sewage which it receives from a considerable portion of Mylapore. It forms one of the evil-smelling spots in which, unfortunately, Madras is so rich, and its proximity to the South Beach Road, the healthiest drive in Madras, makes its purification a matter of the utmost importance.

The swampy land here is now being considerably raised above its former level by the deposit of large quantities of town refuse, which the conservancy carts are bringing. Care is being taken, however, to preserve a channel for the flood waters. When

this improvement is completed, and the sewage is diverted from its present channel, this portion of Madras will become much improved from a sanitary point of view.

The Junction Canal.—The Junction Canal passes round a portion of the north and west of Mylapore and St. Thomé. It receives the contents of a considerable number of small open drains, and, as it has practically no current, the effect is to foul its waters with sewage to such a degree as to render it an object of the greatest aversion, both to sight and smell, and a danger to the health of the inhabitants who live in the districts through which it passes. There can be no doubt that one of the most important objects in the efficient sanitation of the town of Madras should be the purification and cleansing of the waters of this canal. The River Adyar receives directly or indirectly the major part of the sewage of the southern portions of Mylapore and St. Thomé, but in parts of this district no drainage whatever is provided; the fouled water in these cases stand as a pool near the dwelling from which it has proceeded, and, except when heavy rainfall occurs, is allowed to evaporate, or is absorbed into the subsoil. The stench which rises from the constant fermentation of the successive deposits in these miniature cess-pools is, at times, simply unbearable.

Triplicane.

Surface of the District.—This district has a most irregular surface, rising and falling continually within small areas. For all drainage purposes it may be considered as a plain, with an elevation of 10 feet or 11 feet above the mean sea level.

Royapettah Sewage Farm.—The sewage of this extensive and populous part of Madras is disposed of, under the present system, chiefly by utilization on sewage farms, or is discharged into the Junction Canal. A portion of Royapettah, that which lies to the south-west, is drained by gravitation towards a small sewage farm lying off the Bazaar Road, where it is lifted on to the land by a picottah.

The remaining portion of Royapettah, and a considerable part of the south of Triplicane proper, drains by open channels towards the Ice House Road, down the sides of which two open drains of considerable size run towards the sea coast. Shortly after passing the junction of Triplicane High Road with Ice House Road they unite; the single large drain thus formed traverses a bye-road for a short distance, and then discharges the sewage either into a small stream, which, in times of flood, empties its waters into the sea, at a point in the South Beach Road, between the Ice House Road and Edward Elliott's Road, or it is utilised upon the Triplicane Sewage Farm, which lies adjacent.

From the other portion of the district of Triplicane, and from that populous part of Chepauk which lies to the east of Tholasinga Perumal Covil Street, the sewage flows by open channels and a few short covered drains to Pycroft's Road. Near the eastern extremity of this road it branches off, by a large open channel, towards the Triplicane Pumping Station, which is situated on the western side of the Junction Canal.

Triplicane Sewage Farm.—The sewage is received here into a well, from which it is lifted by a 4-inch centrifugal pump into a 12-inch pipe, which conveys the sewage for some distance on to the sewage farm which lies to the south of Ice House Road. Here it is discharged into a large pool, at one end of which is erected a second pumping station, which lifts the sewage again for distribution on the land. The overflow finds its way directly into the Junction Canal, and also into the stream before mentioned.

Triplicane Drain.—The remaining parts of Triplicane and Chepauk are drained, on the open-channel system, towards Chella Pilliar Covil Street, Bungaroo Naick Street and Tana Saib Street. Through the latter street an old drain, nearly square in section, is laid, which passes under Messrs. Misquith's premises and the Mount Road towards the sewage farm in Napier Park, the overflow passing on to the River Cooum, where it discharges in close proximity to Government Bridge. The sewage from the Mount Road district finds its way, by means of a large drain, into the River Cooum, a small portion of it being used upon a sewage farm, which is situated a short distance above Harris's Bridge.

2078/B

Chintadripettah.

Surface of the District.—This district is almost surrounded by the River Cooum, which here makes a quick bend. It may be looked upon as the half of a spoon-like hollow, the surface sloping from the western parts, where it is about 9 feet above mean sea level inwards, towards the centre, where it is in some parts but 4 feet or 5 feet above mean sea level. That portion of Chintadripettah which lies to the east of Sawmy Naick Street is drained by open channels towards the River Cooum, where it is intercepted by a larger channel, which carries it eastwards for a short distance; the sewage is then lifted by picottahs into a channel, which conducts it on to the Napier Park Sewage Farm; when the picottahs are not at work and the well fills it overflows into the river.

Napier Park Sewage Farm.—The pump at the Napier Park Sewage Farm is an 8-inch centrifugal pump, and works generally for about 5 hours out of the 24; when pumping operations are suspended, and the two wells fill, they overflow into two sewers, one of which discharges into the River Cooum a short distance below Harris's Bridge, and the other in close proximity to the overflow of the Triplicane sewer, on the western side of Government Bridge.

The large volume of sewage from the remaining portion of Chintadripettah finds its way into the river direct by eight open drains, which occur at intervals along the right bank.

Egmore and Elemboor.

Surface of the District.—Egmore lies to the west of Chintadripettah, being separated from it by the River Cooum, whilst still further to the west is the village of Elemboor. The surface of the ground falls steadily from west to east.

Egmore Sewage Farm.—One division of Egmore, which is known by the name of Poodoopett, is drained by gravitation towards a small sewage farm, which lies adjacent to the grounds of Egmore Police Court. The whole of the sewage from the remainder of this district finds its way into the River Cooum by nine drains on the left bank of the river.

The Elemboor sewage is utilised upon a small sewage farm situated near the Male Asylum Road.

Purrewaukum.

Surface of the District.—This populous district stretches from the People's Park towards the west. The ground rises steadily in that direction, and at the same time forms a wide valley, whose sides ascend to the north and south. The levels range from 15 feet in the upper portions to 3 feet only above mean sea level in the lowest parts of the valley.

De Mellow's Road Sewage Farm.—The major part of this district is drained towards a sewage farm at Nadumbarai, known as De Mellow's Road Farm. An underground sewer conducts the sewage along Perambore Barracks Road, when, near the water at the sepoy lines, it is lifted by picottahs into a high level channel, which terminates at the sewage farm. An old open 3-feet drain, leading to the same farm, runs parallel to Choolay Bazaar Road until Sydenham Road is reached; here a 12-inch pipe receives the sewage, and conducts it to the pump at the farm.

Peoples' Park Sewage Farm.—An overflow from this drain runs across open land towards one of the small sewage farms in the Peoples' Park. Here it is augmented by the sewage from the Choolay district; a picottah raises it and passes it on towards the second sewage farm near the Penitentiary, receiving *en route* the Vepery High Road drain. A large overflow drain discharges the surplus sewage into the River Cooum, in close proximity to the Penitentiary.

Black Town.

Surface of the District.—This district contains two well-defined ridges, which run parallel to each other and to the coast line. The land rises gradually from the sea, until it culminates in a ridge in Thumboo Chetty Street, and then descends to the

first valley, which is occupied by Popham's Broadway. Rising again, the second ridge is reached at Mint Street, the ground then falls to the valley through which runs the Buckingham Canal. The land near Fort St. George slopes inland from the sea.

Open channel system.—The present Black Town drainage exhibits, in the highest form to be found in Madras, the open-channel system, combined with an arrangement of covered sewers. The open channels, which are constructed in all parts of this congested district, deliver their contents into one or other of the four main arteries which traverse the town.

The present sewers—The Old Main Drain.—These are known respectively as Nos. 1, 2 and 3 sewers, and the Old Main Drain. The latter is undoubtedly one of the most extraordinary abortions of incompetent sanitary science that can be found in any part of the world.

The drain has a width of no less than 10 feet and a height of 5¼ feet. It has a shape similar to the longitudinal section of a barrel; the sides and covering arch are of brickwork, and the floor of granite slabs. It is laid with a very slight gradient, and can only discharge at low water; hence, for a large portion of the 24 hours, the liquid contents are stagnant, and deposit their solid contents with ease. The accumulated silt in this huge underground receptacle must of necessity be always in a putrescent condition, and there can be no reasonable doubt but that the Old Main Drain is responsible to a very large extent for a great portion of the high death-rate which prevails in this part of Madras. Formerly, it received nearly the whole of the sewage from the dense population occupying the centre of Black Town, and consequently had a fair fall by reason of the head given to it by the volume of sewage, but at the present time it is merely the receptacle for the overflow of No. 1 sewer, and a small number of drains. This is not sufficient to give it any appreciable flush, and the contents remain practically stagnant—a hideous hidden danger to the health of all around. It extends along Umpherson's and Davidson's Streets and part of Popham's Broadway, one end runs parallel to Old Jail Street and Ibramjee Saib Street to its outlet into the sea near the North Pier of the Harbour; the other end, for it discharges in two directions, extends to a piece of land near the Fort.

The Fort Pumping Station.—Here a pumping-station is erected which lifts the contents into No. 3 sewer. The pump is a 10-inch centrifugal, and works on an average about 10 hours daily. During the remaining part of the day the sewage accumulates in the shallow well, then backs up in the sewer, and ultimately overflows into the River Cooum by the scoop drain in the Esplanade.

No. 1 Sewer (Black Town).—No. 1 Sewer begins in China Bazaar Street, and runs the whole length of Popham's Broadway; it then turns down Old Jail Street to the pumping station at Ráyapuram. An overflow for this sewer is formed from China Bazaar Street by the scoop drain in the Esplanade, which conveys the sewage to the River Cooum.

No. 2 Sewer.—No. 2 Sewer commences near the Central Railway Station, and for a part of its course traverses Wall Tax Road; near Elephant Gate Bridge it strikes off from the road and passes through cocoanut topes to Old Jail Street, which it traverses to its junction with No. 1 Sewer, at the end of Popham's Broadway. Seven overflows occur for No. 2 Sewer, all occasionally discharging sewage into the Buckingham Canal.

No. 3 Sewer.—No. 3 Sewer begins, as has been stated, at the Fort Pumping Station; it receives sewage from the Old Main Drain, and then runs along North Beach Road. Near the North Pier of the Harbour it has an overflow into the sea, the sewer being continued up Ibramjee Saib Street to Ráyapuram Pumping Station.

Rayapuram Pumping Station.—This station contains three 15-inch centrifugal pumps and three 4-inch pumps of the same description. The working time is upon an average 22½ hours daily, the sewage raised in that period being about three million gallons.

The overflow.—The overflow from the pumping well is discharged into the Old Main Drain, by which it finds exit to the sea.

7878
-9

The pumping main.—The pumping main is a 24-inch iron pipe; it extends northwards for a distance of about 5,000 feet, where it terminates in an open channel, which conveys the sewage by gravitation to the Black Town Sewage Farm.

Rayapuram and Tondiarpett.

Surface of the Districts.—These two districts lie to the north of Black Town, and are separated physically from each other by a ridge of land some 15 feet above mean sea level; this is a prolongation of the second Black Town Ridge, and runs north and south midway between the Buckingham Canal and the sea coast.

The drainage of Ráyapuram and Tondiarpett has apparently received but slight attention, and is generally in a much neglected condition.

In Ráyapuram the sewage is collected by open channels, and conducted to the sea by two covered drains.

Robinson's Park Sewage Farm.—The portion of Tondiarpett which lies immediately to the west of Monegar Choultry Road, known as Tinnevelly Settlement and Sunjeevarain Pettah, is drained, first towards a 12-inch pipe, and then towards an open channel, which terminates at a well in Robinson's Park. Here the sewage is lifted by picottahs on to the land, the overflow finding its way into the Old Main Drain of Black Town.

The populous district of Washermanpettah, and the villages lying to the west of Thiruvottiyur High Road, appear to have no very definite destinations for their sewage; the low-lying land between them and Coorookoopettah doubtless receives the major portion of it.

DESCRIPTION OF THE PROPOSED DRAINAGE SCHEME.

During the past thirty or forty years various schemes for the drainage of Madras have been proposed.

Amongst the earliest was that of Major Tulloch, R.E., now Chief Engineer to the Local Government Board in England, who collected a large and valuable amount of topographical, meteorological, and physiographical information relative to Madras.

Of this information, so far as it deals with geology, contour, rainfall, tides, sea-currents, &c., I have gladly availed myself, and, where observations have been taken in the course of my investigations, I have found them coincide in every particular with those left by him.

Additional reports.—Subsequently reports have been furnished by Mr. Clark, Mr. Lee, Mr. Jones, and various committees from time to time, as stated in the earlier part of this Report, but, with the exception of the drainage of Black Town on the open-channel system, nothing appears to have been done to improve the drainage of the town.

In devising the scheme for the drainage of the district, which I now have the honour to submit, I have had before me two necessary conditions, viz., efficiency, combined with economy. I have therefore designed the sizes and gradients of the sewers with a view to their carrying off the sewage only, together with a portion of the rain-water which may fall on the backyards of dwelling-houses, and a small amount of subsoil water, which, with every precaution to exclude, will always find its way into sewers, but have excluded all storm-water falling upon the roads, streets, &c.

The large area to be drained.—The large and scattered areas of the populous parts of Madras requiring to be drained and included in this scheme, the low level of the various districts, and the subsoil water lying at no great depth below the surface, are all elements of cost in carrying out a proper system of sewers for the drainage of the district. I have therefore, after most careful consideration of the whole subject, decided to recommend that the district be divided into four separate systems, one division having a gravitating system, and in the other three divisions the sewage to be pumped on to land at present used as a sewage farm for Black Town, and such

additional land adjoining as may be required for the purpose of dealing with the increased amount of sewage.

Proposed divisions of the drainage scheme.—The proposed divisions are as follows:—

(1) Mylapore and St. Thomé to be drained by gravitation into the sea.
(2) Royapettah, Triplicane, Chepauk, part of Nungumbaukum, Chintadripettah, Egmore, Elemboor, Pursewaukum, Vepery, Choolay, the Fort, and part of Black Town to be drained to a pumping station in Sydenham's Road, from this point the sewage to be pumped to the Black Town Sewage Farm.
(3) Ráyapuram and the remainder of Black Town to be drained to the present Ráyapuram Pumping Station, the tank accommodation of which to be enlarged and deepened, the sewage being pumped as at present to the Black Town Sewage Farm.
(4) Tondiarpett and Washermanpettah to be drained to a small pumping station to be erected on land adjoining Monappah Moodelly Street, the sewage to be pumped to the Black Town Sewage Farm.

GENERAL DESCRIPTION OF PROPOSED SEWERS.

Mylapore and St. Thomé.

This district will have two main sewers, into which the whole of the sewage will eventually fall. No. 1 Sewer commences in Brodie's Road, a short distance to the north of Kabaleswarer Pagoda Tank. It traverses Brodie's Road, Mandavully Street, Madah Church Street, and the continuation of the same from the South Beach Road, to the Beach. No. 2 Sewer commences near the Junction Canal, in Mandagaum-meumnen Covil Street; it traverses Natsubraya Moodelly Road, part of Bazaar Road, Corna Easwarer Covil Road, and then runs along South Beach Road, to its junction with No. 1 Sewer at the junction of Madah Church Street with South Beach Road.

At the termination of No. 1 Sewer at the beach a manhole is placed, which is provided with a storm-water overflow. From this manhole a 15-inch steel tube is carried for a considerable distance out to sea, where it discharges the sewage at the level of low water from a trumpet mouth. The tube to be constructed of ⅜-inch steel boiler plates firmly riveted together in 10-feet lengths, having special socket joints so as to allow the joint of each length being made above low-water level, and afterwards dropped into position. The tube to be carried on strong iron girders resting on collars projecting from the screw piles at such level as to correspond with the gradient of the tubes, another and lighter girder to be placed on top, and the whole secured to the screw piles.

By carrying the outlet well out to sea the sewage will mix with and become so largely diluted with sea water that, in all probability, hardly any manifestations of its presence will be apparent. When sewage enters sea-water it meets with various salts which quickly precipitate it, and it is questionable whether any trace whatever of the sewage will be found even at a short distance from the outlet.

The sewage of this district could be discharged on to suitable land on the south side of the River Adyar for irrigation purposes, but, as it would have to be pumped, the cost of doing this would be prohibitory.

Triplicane.

This district, though undulating in surface, must, for drainage purposes, be considered as a plain, having an average elevation of about 11 feet above mean sea-level. The intercepting sewer for the drainage of this district commences in the Bazaar Road, Royapettah; it is continued through Royapettah High Road and Ice House Road until it returns into the Triplicane High Road; it receives a number of small sewers on its course, and at this point two sewers join, one from Barber's Bridge Road, and another from the eastern part of the Ice House Road. The intercepting sewer traverses Triplicane High Road and Wallajah Road, to the termination of the

2078/20.

drainage district of Triplicane at the Round Tannah in Mount Road. The most important subsidiary drains received in this part of its course are those from Pycroft's Road, Venteatasa Moodelly Street, which brings the sewage from a large part of south-east Triplicane, and the two sewers which serve the Chella Pilliar Covil Street district and Bell's Road district respectively. From the Round Tannah the same intercepting sewer is continued through Chintadripettah, to the pumping station in Sydenham Road.

Chintadripettah.

The intercepting sewer for this district is a continuation of the same sewer which serves Triplicane.

It enters the drainage district of Chintadripettah at the Round Tannah in Mount Road, and traverses the district, by way of Mount Road, Waller's Road, and Sawny Naick Street, to the crossing of the River Cooum (the short lengths of the sewers and the good gradients which are to be obtained in this district allow of small sized pipes being freely used).

From the end of Sawny Naick Street the intercepting sewer which has served the districts of Triplicane and Chintadripettah is continued through the bed of the River Cooum, in a direct line with Sawny Naick street, to the piece of land between the Penitentiary boundary wall and the river; it turns to the west to the end of Laws bridge, and then proceeds in a northerly direction along Sydenham Road to the proposed pumping station.

The river crossing.—The river crossing will consist of two iron pipes, 2 feet 6 inches in diameter, laid side by side paralled to each other, and placed at such a level that they will not interfere with the improvements to the river bed as recommended by Mr. Jones.

The necessary plans and sections of the special manholes which are required on either side of the river are furnished with this report.

Egmore.

The chief sewer in Egmore will be one which follows the course of the river Cooum from a point above Harris's bridge to Laws Bridge, where it will discharge into the intercepting sewer which has crossed the river from Chintadripettah and proceeds to Sydenham Road Pumping Station. The Egmore sewer intercepts five branch sewers, the two most important being one from Marshall's Road, and another from Mangappah Moodelly Street.

Elemboor.

The principal sewer for the drainage of this district commences in Gengoo Reddy Road, and passes, by way of Egmore High Road, Male Asylum Road, Wannell's Road, and the Poonamallee Road, to its junction with the intercepting sewer in Sydenham Road.

Pursewaukum.

The intercepting sewer which passes along Sydenham Road from the north end of Laws Bridge to Sydenham Road Pumping Station, receives a portion of the drainage of Pursewaukum by seven branch sewers. The remaining portion of this district is served by an intercepting sewer, which commences in Veneithertha Moodelly Street. It passes through Poonamallee Road, Condappah Moodelly High Road, and thence by the side of the water to the junction of Vadavenayargar Road, during which part of it course 24 branch sewers discharge their contents into it, the most important being one which brings the sewage from the district of Kosapett by the Padavettummen Covil Road. From the junction of Vadavenayargar Road, where it receives the drainage of the district to the north of the Sepoy Parade Grounds, the intercepting sewer is continued through Vencatasbutheen Street (or Aslaboogum Street), Vijaga Vignaswarer Covil Road, and Choolay Bazaar Road to the proposed pumping station in Sydenham Road. It receives nine branch sewers in this part of its course.

Black Town.

I have thought it advisable, for drainage purposes, to divide this district into two unequal portions, the smaller of which takes in the south-west part of Black Town, draining to the proposed pumping station in Sydenham Road, and the larger to the present pumping station at Ráyapuram, where some slight alterations and additions must be made.

First intercepting sewer for Black Town.—The first intercepting Black Town sewer is intended for the drainage of the smaller divisions; it is laid through a part of Maloo Perumal Street and China Bazaar Street (or Mandavully Street), to the junction of Eresappa Maistry Street, and in this section receives four branch sewers, the most important being one from the western portion of Mandavully Street.

It is then continued through Eresappa Maistry Street, Evening Bazaar Road, and Naneappa Naick Street, to the junction of the latter with the General Hospital Road; it receives five branch drains in this section, and is joined by the Fort Sewer at the south end of Naneappa Naick Street. The first intercepting Black Town sewer is continued through the western part of General Hospital Road, through Wall Tax Road, Elephant Gate Road, and Sydenham Road, to the proposed pumping station in Sydenham Road. It receives 18 branch sewers in this part of its course, and passes through the bed of the Buckingham Canal, at a short distance, to the south of Elephant Gate Bridge.

Second intercepting sewer for Black Town.—For the larger division of Black Town three intercepting sewers are necessary. The westernmost, or second intercepting sewer for Black Town, commences in Perumal Pagoda Garden Street, and passes through a series of streets to Old Jail Street, down which it is carried to its junction with the third intercepting sewer coming from Popham's Broadway. It receives 12 branch sewers in its course.

Third intercepting sewer for Black Town.—The central or third intercepting sewer for Black Town begins in Mandavully Street, and from thence, to the junction of Mandavully Street with Popham's Broadway, receives three branch sewers.

From this junction, where a branch sewer joins it from the eastern part of Mandavully Street, the third intercepting sewer passes through the whole length of Popham's Broadway to Old Jail Street.

In the Broadway it receives 15 branch sewers, the most important being one from Moorgoonulla Moodoo Chetty Street. From the junction of Popham's Broadway with Old Jail Street this intercepting sewer passes along Ibramjee Saib Street, and discharges its contents into the well at the Ráyapuram Pumping Station.

Fourth intercepting sewer for Black Town.—The eastern or fourth intercepting sewer for Black Town traverses Arbuthnot Lane and North Beach Street, and receives four branch sewers; at the junction of North Beach Street with Ibramjee Saib Street the sewer joins it which carries the whole of the sewage of Ráyapuram.

From this junction the fourth intercepting sewer is carried through Ibramjee Saib Street to the Ráyapuram Pumping Station, receiving in this section of its course nine branch sewers.

Fort St. George.

For the advantage of the Fort two sewers will be laid, so as to encircle the whole of the inner portion of the Fort, and into these seven branch sewers will fall. The two sewers will unite at the main entrance to the Fort, on the west side, and the sewage carried through the ditches by iron pipes, and thence by one sewer through the General Hospital Road to the junction of Naneappa Naick Street, where it will be discharged into the first intercepting sewer for Black Town, which will convey it to the proposed pumping station in Sydenham Road.

Rayapuram and Part of Tondiarpet.

The intercepting sewer for Ráyapuram commences in Soorea Narraina Chetty Street, and passes through Cullmantapum Road, East Madah Church Road, and

North Beach Street, to its junction with the fourth Black Town main sewer at the junction of Ibramjee Saib Street with North Beach Street, by which the sewage is conveyed to the Ráyapuram Pumping Station. The sewers in the other parts of this district are chiefly pipe sewers, discharging by 17 junctions into the first described main sewer.

Part of Tondiarpett, Corgookoopettah, and Washermanpettah.

For these districts a separate system has been devised. The locality is isolated from the greater part of Ráyapuram by the high ridge of land which runs throughout this portion of Madras from north to south.

The sewage will gravitate towards the low-lying lands in the vicinity of Monappah Moodelly Street, where a pumping station will be constructed to lift and discharge the sewage into the iron gravitating main from the proposed Sydenham Road Pumping Station, which passes through the Theruvottiyur High Road on its way to the Black Town Sewage Farm.

The chief sewer in Tondiarpett commences in Gumballumen Covil Road; it runs through Ramanuja Iyer Street to the junction with the Theruvottiyur High Road, and then passes down Soobrayaloo Naick Street to the pumping station situated on a piece of land adjacent to Monappah Moodelly Street.

Rayapuram Pumping Station.

The present pumping station at Ráyapuram, which has six centrifugal pumps and engines, three of them each 20 H.-P., and three pumps for condensers equal to 8 H.-P., and four boilers equal to 90 H.-P., and also the present pumping main and open channel leading to the Black Town Sewage Farm, to be utilised for dealing with the sewage of Ráyapuram, part of Tondiarpett, and part of Black Town. The present population which would be drained to this pumping station is estimated at 110,766.

ADDITIONAL PUMPING STATIONS.

Sydenham Road Pumping Station.

A pumping station to be erected adjoining the east end of Sydenham Road, which will receive the drainage of Mylapore, Triplicane, Chepauk, Chintadripettah, Vepery, Egmore, Elemboor, Pursewaukum, part of Black Town, and Fort St. George.

The sewage from these districts will flow by gravitation to the pump well, from which it will be lifted into a gravitating tank erected 78 feet above the bottom of the well, or 72 feet above the level of the invert of the sewers.

The estimated present population of this district is 220,269, which, taken at 20 gallons per head, and on the assumption that one half of this sewage may flow off in eight hours, is equal to 4,588 gallons per minute.

Engines.—I would recommend that three of the "Davey" triple compound differential condensing pumping engines be erected at this station, each capable of raising 2,500 gallons of sewage per minute 78 feet high, working at 12½ strokes per minute, with 90 lb. boiler pressure.

Sewage pumps.—Each engine to have two sewage pumps, each having a plunger 30 inches diameter and 4 feet stroke; the pumps to be provided with special suction and delivery valves, having a very large waterway. The rising mains from the pumps to be 20 inches diameter, to extend to and be connected with one common air vessel of large size.

Each pair of pumps to have a separate suction pipe, 20 inches diameter, and a vacuum vessel.

Boilers.—Three improved high-pressure steel boilers to be fixed, each 26 feet long by 6 ft. 6 in. diameter, with one flue through each, having a fire-grate arranged for burning either coal or wood. The boilers to be capable of sustaining a working pressure of 100 lb. per square inch, and to be tested to 160 lb. per square inch.

Tank—Gravitating Main.—A tank to be erected 72 feet above the level of the main intercepting sewer at this station, made in accordance with the drawings, with ⅜ inch boiler plates, well riveted and stayed together with 1-inch iron tie-rods, into which the sewage will be pumped, and from which a cast-iron main 33 inches in diameter, having an effective gradient of 1 in 378, will convey the sewage along Sydenham Road, Basin Bridge Road, crossing the Buckingham Canal at Basin Bridge, thence along North Wall Road, Theruvottiyur High Road, where it is increased to 36 inches diameter; it then passes along Ramanuja Iyer Street, Gumballumen Covil Road, and from thence into a brick culvert 3 ft. 6 in. by 3 ft. 6 in., near to the commencement of the present open channel carrying the Black Town sewage to the sewage farm, and having a gradient of 1 in 1,224.

Tondiarpett Pumping Station.

A pumping station to be erected on a piece of land opposite Soobrayaloo Naick Street, to deal with the sewage of part of Tondiarpett, Corookoopettah, and Washermanpettah. The sewage from these districts will flow to the pump well, from which it will be lifted into a gravitating tank 43 feet above the bottom of the well.

The estimated present population of the districts is 48,917, which, taken at 20 gallons per head, and assuming that one half may flow off in eight hours, is equal to 1,019 gallons per minute.

Engines.—This station to be provided with two pumping engines, of the same description as those recommended for the Sydenham Road Pumping Station, each engine to be capable of raising 1,100 gallons of sewage per minute, 43 feet high, at 16 strokes per minute, with 90 lb. boiler pressure.

Sewage Pumps.—Each engine to have two sewage pumps, each pump to have a plunger, 22 inches diameter, with 2 ft. 6 in. stroke. The rising mains from the pumps to be 13 inches diameter, and connected with one common air vessel; the suction pipes to be 13 inches in diameter with all necessary fittings.

Boilers.—To fix two boilers and fittings of the same description as those for the Sydenham Road Station, each boiler to be 20 feet long by 5 ft. 6 in. diameter, and to be tested to 160 lb. per square inch.

Tank.—The sewage tank at this station to be similar to the tank at Sydenham Road, and to be 43 feet above the level of the well; from the bottom of this tank will be carried an 18-inch cast-iron pipe, which will join the gravitating main from Sydenham Road Station in Theruvottiyur High Road, having an effective gradient of 1 in 378.

Discharging capacity of sewers.—In designing the sizes of the sewers, I have so arranged them as to be sufficient to meet the requirements of the future estimated increase of population, varying in the several districts from 10 to about 50 per cent.

Additional pumping machinery may hereafter be required to meet any great increase in the population, and also additional land for the treatment of the sewage at the outfall.

Pipe sewers.—The whole of the pipes for the sewers to be thoroughly glazed outside and inside with salt or other vitreous glaze, impervious to water, and well burnt throughout their thickness.

The joints to be made practically watertight; this may be done, when there is no great depth of subsoil water, with Stanford's joint. Doulton's patent self-adjusting joint, Hassall's patent double joint, or Sykes' patent joint to be used in situations where the pipes would be laid any great depth below the level of subsoil water.

Brick and concrete sewers.—Amongst the drawings accompanying this report will be found sections of different forms of brick sewers, and combinations of brick and Portland cement concrete sewers; also of concrete and concrete block sewers. The different kinds may be used according to the description of the soil in which they may have to be laid, the whole of them to be made practically watertight. The

2078
-12-

9-inch brick sewers to have ½-inch cement collar joint between the two rings, so as to make them watertight. The trenches to be kept free from water sufficiently long after the sewers have been laid, to allow the cement to properly set.

Graduation of sewers.—The brick or concrete sewers will be graduated in sizes varying from 3 ft. 2 in. × 4 ft. 9 in. to 1 ft. 8 in. × 2 ft. 6 in., and the pipe sewers from 18 inches down to 6 inches in diameter; these will be laid with such gradients as will ensure their being self cleansing, aided by means of flushing chambers and flushing gates.

Surface and storm-water.—The surface and storm-water to pass off by the present open channels and culverts. It will be necessary to make a few slight alterations to some of the old culverts in Black Town, so as to cut off their connection with the present pumping stations, and also to some of the old drains in that part of Black Town which is now liable to be flooded during heavy rains.

Ventilation of sewers.—The proper ventilation of sewers is of the greatest importance and various methods have been adopted for this purpose. For the ventilation of the sewers of Madras, I would recommend that each manhole and inspection shaft should act as a ventilator, and that, in addition to these, special ornamental ventilating shafts or ornamental iron columns be erected in suitable open positions; these should be carried up to a height of from 30 to 40 feet; or hollow iron telegraph poles may be used for this purpose.

Flushing sewers.—Provision is made for the automatic flushing of sewers wherever this is desirable, and also by means of flushing gates fixed in manholes, and all other manholes will have a groove left in the invert and sides of the shaft, into which half sluice gates can be fixed whenever any particular length of sewer may require flushing. The flushing in this case would be done with the sewage.

Works to be first proceeded with.—With a view of diverting the sewage from flowing into the River Cooum, I would recommend that the first work proceeded with should be the erection of the Sydenham Road Pumping Station; the cast iron gravitating main from it to the present open sewer leading to the Black Town Farm, where a temporary connection will be made with it; the construction of the Sydenham Road main sewer between the pumping station and the river, and the sewers abutting on both sides of the river, into which the whole of the sewage now discharged into the Cooum could be intercepted, and diverted on to the Black Town Sewage Farm.

House drainage.—It is a necessity, in carrying out a system of sewerage, that properly constructed drains should be laid, with self-cleansing gradients from every house, and connected with the sewer in the street, and, when laid underneath houses, they should be surrounded with not less than six inches of cement concrete.

There should be a simple description of intercepting syphon, placed upon the pipe between the outside of the house and the sewer.

The water-closets for the use of the Natives may be of several forms, having a simple trap, which can be easily got at to clear out any improper things which may be put into them; the discharge from the pan into the drain should not exceed three inches in diameter; such closets to be flushed with bath and sink water.

A better class water-closet would be a plain pedestal with trap, no valves, and supplied with water by means of simple description of waste preventing cisterns.

As a means of reducing the cost of the private drainage, I would recommend that, wherever it is possible, the drainage of rows of houses should be connected to one joint drain, passing along the backs of houses and connected with the sewer, either in the front or side street, and flushed with one automatic flushing tank, placed at the highest part of the drain.

The appearance of the streets will be considerably improved by the abolition of the present repulsive spectacle of the termination of the house drains, and by the open side drains, now conveying sewage which, in future, if a covered sewerage system be adopted, will run only with rain-water during the wet seasons, and be perfectly dry at other times.

Importance of good workmanship in house drains.—Perhaps the most important part of a drainage scheme is that relating to the manner in which the house drains are constructed and connected with the public sewers. I would recommend, and recommend strongly, that the house drains and connections should, in all cases, be made by men in the employ of the Municipality. These men should be trained to the work, and should give positive proof of their intelligent efficiency before being fully entrusted with carrying out this important part of the work, for there are many points where an incompetent workman may easily go wrong, and construct the house connections in such a way as to be a permanent danger to the occupiers of the house.

Public latrines.—These should be connected with the public sewers, and supplied with automatic flush tanks; they may be constructed with or without seats. *See* drawings accompanying this Report.

The following is a detailed estimate of the cost of carrying out the whole of the sewerage works as recommended :—

Estimated Cost of Sewerage Works.

			Total.
			Rs. A. P.
Mylapore and St. Thomé.			
Lin. yds.	ANNAS.		
241 of 6-inch pipe sewers, laid at an average depth of 5 feet ..	27	406 11 0	
508 „ 6 „ „ „ „ 6 „ ..	29	920 3 0	
456 „ 6 „ „ „ „ 9 „ ..	34	969 0 0	
333 „ 9 „ „ „ „ 5 „ ..	43	894 15 0	
1,981 „ 9 „ „ „ „ 6 „ ..	45	5,371 9 0	
8,284 „ 9 „ „ „ „ 7 „ ..	45½	23,557 10 0	
1,916 „ 9 „ „ „ „ 8 „ ..	48	5,748 0 0	
656 „ 9 „ „ „ „ 10 „ ..	52½	2,152 8 0	
1,905 „ 12 „ „ „ „ 8 „ ..	71	8,453 7 0	
	Rs. A. P.		
1,423 „ brick sewer, 1 ft. 10 in. × 2 ft. 9 in., laid at an average depth of 13 feet	13 6 6	19,077 1 0	
1,216 „ brick sewer, 1 ft. 10 in. × 2 ft. 9 in., laid at an average depth of 14 feet	13 9 6	16,530 0 0	
No.			
62 manholes and ventilating shafts, on 6 and 9 inch pipe sewers, at an average depth of 7 feet	146 12 0	9,098 8 0	
12 ditto, on 12-inch ditto, ditto 8 feet	151 1 0	1,812 12 0	
21 ditto, on 1 ft. 10 in. × 2 ft. 9 in. ditto, ditto 13 feet	187 13 0	3,944 1 0	
32 lampholes and ventilating shafts, on 6 and 9 inch pipes, at an average depth of 7 feet	50 5 0	1,610 0 0	
4 ditto, on 12-inch ditto, ditto 8 feet	50 12 0	203 0 0	
4 ditto, on 1 ft. 10 in. × 2 ft. 9 in. ditto, ditto 13 feet	55 11 0	222 12 0	
13 automatic flushing chambers, on 6 and 9 inch pipe sewers, at an average depth of 4 feet	.. ..	4,621 10 0	
3 ditto, on 1 ft. 10 in. × 2 ft. 9 in. ditto, ditto 10 feet	418 2 0	1,254 6 0	
Lin. yds.			
107 of outfall sewer, constructed with steel tubes, including 82 screw piles, iron girders, and other works complete ..	..	73,494 0 0	
Contingencies, engineering and supervision	..	27,091 15 0	
			2,07,704 0 0
Triplicane.			
Lin yds.	ANNAS.		
1,041 of 6-inch pipe sewers laid at an average depth of 5 feet ..	27	1,756 11 0	
330 „ 6 „ „ „ „ 7 „ ..	29½	608 7 0	
481 „ 6 „ „ „ „ 8 „ ..	32	962 0 0	
200 „ 9 „ „ „ „ 4 „ ..	41	512 8 0	
320 „ 9 „ „ „ „ 5 „ ..	43	860 0 0	
29,025 „ 9 „ „ „ „ 6 „ ..	45	81,632 13 0	
473 „ 9 „ „ „ „ 7 „ ..	45½	1,345 1 0	
8,493 „ 9 „ „ „ „ 8 „ ..	48	25,479 15 0	
783 „ 9 „ „ „ „ 9 „ ..	50	2,446 14 0	
1,601 „ 9 „ „ „ „ 10 „ ..	52½	5,253 4 0	
225 „ 9 „ „ „ „ 11 „ ..	56½	794 9 6	
270 „ 12 „ „ „ „ 6 „ ..	68	1,147 8 0	
1,406 „ 12 „ „ „ „ 8 „ ..	71	6,239 2 0	
176 „ 12 „ „ „ „ 9 „ ..	73	803 0 0	
586 „ 12 „ „ „ „ 10 „ ..	77½	2,750 6 0	
955 „ 12 „ „ „ „ 12 „ ..	81½	4,854 8 6	
510 „ 15 „ „ „ „ 5 „ ..	113	3,601 14 0	
642 „ 15 „ „ „ „ 6 „ ..	115	4,614 6 0	
653 „ 15 „ „ „ „ 9 „ ..	120	4,897 8 0	
500 „ 18 „ „ „ „ 6 „ ..	159	4,968 12 0	
573 „ 18 „ „ „ „ 10 „ ..	168½	6,043 5 0	
578 „ 18 „ „ „ „ 13 „ ..	172½	6,231 9 0	
	Rs. A. P.		
750 „ brick sewer, 2 ft. 2 in. × 3 ft. 3 in., laid at an average depth of 12 feet	15 0 0	11,250 0 0	
956 ditto, 2 ft. 4 in. × 3 ft. 6 in. ditto, ditto 14 feet	15 14 6	15,206 6 0	
250 ditto, 3 ft. × 4 ft. 6 in. ditto, ditto 14 feet	17 14 6	5,013 12 0	

			Total.
			Rs. A. P.
Triplicane—cont.			
No.	Rs. A. P.		
130 manholes and ventilating shafts, on 6 and 9 inch pipe sewers, laid at an average depth of 6 ft.	142 7 0	18,516 14 0	
86 ditto, on 9-inch ditto, ditto 8 feet	151 1 0	12,991 6 0	
17 ditto, on 12-inch ditto, ditto 10 feet	159 11 0	2,714 11 0	
14 ditto, on 15-inch ditto, ditto 8 feet	151 1 0	2,114 14 0	
22 ditto, on 18-inch ditto, ditto 10 feet	159 11 0	3,513 2 0	
8 ditto, on 2 ft. 2 in. + 3 ft. 3 in. brick sewers, ditto 12 feet ..	183 8 0	1,468 0 0	
14 ditto, on 2 ft. 4 in. × 3 ft. 6 in. ditto, ditto 14 feet	192 2 0	2,689 12 0	
3 ditto, on 3 ft. × 4 ft. 6 in. ditto, ditto 14 feet	192 2 0	576 6 0	
116 lampholes and ventilating shafts, on 6 and 9 inch pipe sewers, laid at an average depth of 6 feet	49 14 0	5,785 8 0	
34 ditto, on 9-inch ditto, ditto 8 feet	50 12 0	1,725 8 0	
10 ditto, on 12-inch ditto, ditto 10 feet	51 10 0	516 4 0	
4 ditto, on 15-inch ditto, ditto 8 feet	50 12 0	203 0 0	
5 ditto, on 18-inch ditto, ditto 10 feet	51 10 0	258 2 0	
2 ditto, on 2 ft. 4 in. × 3 ft. 6 in. brick sewers, ditto 14 feet ..	56 6 0	112 12 0	
13 automatic flushing chambers, on 6 and 9 inch pipe sewers, laid at an average depth of 4 ft.	..	4,567 10 0	
Contingencies, engineering and supervision	..	38,555 0 0	
			2,95,593 0 0
Chintadripettah.			
Lin. yds.	ANNAS.		
941 of 6-inch pipe sewers laid at an average depth of 5 feet ..	27	1,589 0 0	
1,012 „ 6 „ „ „ „ 7 „ ..	29¼	1,865 14 0	
481 „ 6 „ „ „ „ 8 „ ..	32	962 0 0	
5,363 „ 9 „ „ „ „ 6 „ ..	45	15,083 7 0	
1,260 „ 9 „ „ „ „ 10 „ ..	52½	4,134 6 0	
270 „ 12 „ „ „ „ 6 „ ..	68	1,147 8 0	
1,406 „ 12 „ „ „ „ 8 „ ..	71	6,239 2 0	
1,725 „ brick sewer, 3 ft. × 4 ft. 6 in., laid at an average depth of 14 feet	Rs. A. P. 17 14 6	30,388 4 6	
No.			
47 manholes and ventilating shafts, on 6 and 9 inch pipe sewers, laid at an average depth of 6 feet	142 7 0	6,994 9 0	
6 ditto, on 9-inch ditto, ditto 10 feet	159 11 0	958 2 0	
10 ditto, on 3 ft. × 4 ft. 6 in. brick sewers, ditto 14 feet	192 2 0	1,921 4 0	
2 special ditto, on ditto, ditto 14 feet	..	400 0 0	
26 lampholes and ventilating shafts, on 6 and 9 inch pipe sewers, laid at an average depth of 6 feet	49 14 0	1,296 12 0	
5 ditto, on 9-inch ditto, ditto 10 feet	51 10 0	258 2 0	
5 ditto, on 12-inch ditto, ditto 7 feet	50 5 0	251 9 0	
6 ditto, on 3 ft. × 4 ft. 6 in. brick sewers, ditto 14 feet	56 6 0	338 4 0	
5 automatic flushing chambers, laid on 6-inch pipe sewers, at an average depth of 4 feet	294 2 0	1,470 10 0	
1 ditto, laid on 12-inch ditto, ditto 5 feet	520 0 0	520 0 0	
Lin. yds.			
303 of 30-inch cast-iron pipes, laid through bed of River Cooum ..	42 6 0	12,966 12 2	
Contingencies, engineering and supervision	..	13,567 14 6	
			1,04,021 0 0
Egmore.			
Lin. yds.	ANNAS.		
3,206 of 6-inch pipe sewer, laid at an average depth of 6 feet ..	29	5,810 14 0	
256 „ 9 „ „ „ „ 5 „ ..	43	688 0 0	
383 „ 9 „ „ „ „ 6 „ ..	45	1,077 3 0	
1,013 „ 9 „ „ „ „ 7 „ ..	45½	2,880 11 0	
468 „ 9 „ „ „ „ 8 „ ..	48	1,404 0 0	
466 „ 12 „ „ „ „ 7 „ ..	69	2,010 4 0	
580 „ 12 „ „ „ „ 9 „ ..	73	2,646 4 0	
635 „ 12 „ „ „ „ 10 „ ..	77¼	3,085 11 0	
306 „ 12 „ „ „ „ 11 „ ..	80	1,530 0 0	
	Rs. A. P.		
1,695 „ brick sewer, 1 ft. 8 in. × 2 ft. 6 in., laid at an average depth of 11 feet	12 13 0	21,717 3 0	
116 „ 3 ft. + 4 ft. 6 in., laid at an average depth of 17 feet ..	18 13 3	2,184 1 0	
No.			
15 manholes and ventilating shafts, on 6-inch pipe sewers, laid at an average depth of 6 feet	142 7 0	2,136 9 0	
14 ditto, on 9-inch ditto, ditto 7 feet	146 12 0	2,054 8 0	
15 ditto, on 12-inch ditto, ditto 9 feet	155 6 0	2,330 10 0	
17 lampholes and ventilating shafts, on 6-inch pipe sewers, laid at an average depth of 6 feet	49 14 0	847 14 0	
5 ditto, on 9-inch ditto, ditto 7 feet	50 5 0	251 9 0	
9 ditto, on 12-inch ditto, ditto 9 feet	51 3 0	460 11 0	
6 manholes and ventilating shafts, on brick sewers, 1 ft. 8 in. × 2 ft. 6 in., laid at an average depth of 17 feet	205 1 0	1,230 6 0	
5 lampholes and ventilating shafts, on ditto ditto, 17 feet ..	58 7 0	292 3 0	
4 automatic flushing chambers	418 2 0	1,672 8 0	
Contingencies, engineering and supervision	..	8,446 15 0	
			64,758 8 0

				Total.
				Rs. A. P.
Elemboor.				
Lin. yds.		ANNAS.		
733 of 6-inch pipe sewers, laid at an average depth of 8 feet		29	1,328 9 0	
586 „ 9 „ „ „ „ 6 „		45	1,648 2 0	
560 „ 9 „ „ „ „ 7 „		45½	1,592 8 0	
130 „ 12 „ „ „ „ 8 „		72	576 14 0	
1,100 „ 15 „ „ „ „ 8 „		118	8,112 8 0	
833 „ 18 „ „ „ „ 11 „		171	8,902 11 0	
No.		Rs. A. P.		
3 manholes and ventilating shafts, on 6-inch pipe sewers, laid at an average depth of 6 feet		142 7 0	427 5 0	
6 ditto, on 9-inch ditto, ditto 7 feet		146 12 0	880 8 0	
1 ditto, on 12-inch ditto, ditto 8 feet		151 1 0	151 1 0	
4 ditto, on 15-inch ditto, ditto 8 feet		151 1 0	604 4 0	
7 ditto, on 18-inch ditto, ditto 11 feet		164 0 0	1,148 0 0	
No.				
11 lampholes and ventilating shafts, on 6 and 9 inch pipe sewers, laid at an average depth of 6 ft. 6 in.			550 13 0	
1 ditto, on 12-inch ditto, ditto 8 feet		50 12 0	50 12 0	
3 ditto, on 15-inch ditto, ditto 8 feet		50 12 0	152 4 0	
1 ditto, on 18-inch ditto, ditto 11 feet		52 1 0	52 1 0	
1 automatic flushing chamber, on 9-inch pipe, laid at an average depth of 4 feet		418 2 0	418 2 0	
Contingencies, engineering and supervision			3,989 10 0	
				30,586 0 0
Pursewaickum.				
Lin. yds.		ANNAS.		
500 of 6-inch pipe sewers, laid at an average depth of 7 feet		29½	921 14 0	
2,500 „ 6 „ „ „ „ 8 „		32	5,000 0 0	
690 „ 6 „ „ „ „ 9 „		34	1,466 4 0	
340 „ 9 „ „ „ „ 6 „		43	913 12 0	
673 „ 9 „ „ „ „ 6 „		45	1,892 15 0	
2,416 „ 9 „ „ „ „ 7 „		45½	6,870 8 0	
20,166 „ 9 „ „ „ „ 8 „		48	60,485 1 0	
1,583 „ 9 „ „ „ „ 9 „		50	4,946 14 0	
843 „ 12 „ „ „ „ 7 „		69	3,635 7 0	
826 „ 12 „ „ „ „ 8 „		71	3,665 6 0	
593 „ 12 „ „ „ „ 11 „		80	2,965 0 0	
783 „ 15 „ „ „ „ 7 „		116	5,676 2 0	
1,296 „ 15 „ „ „ „ 10 „		124¾	10,104 12 0	
		Rs. A. P.		
1,464 „ 1 ft. 8 in. × 2 ft. 6 in., brick sewers „ 16 „		14 1 0	20,587 8 0	
1,293 „ 3 ft. 2 in. × 4 ft. 9 in. „ „ „ 16 „		19 9 0	25,300 13 0	
No.				
121 manholes and ventilating shafts, on 6 and 9 inch pipe sewers, laid at an average depth of 8 feet		151 1 0	18,278 9 0	
15 ditto, on 12-inch ditto, ditto 8 feet		151 1 0	2,265 15 0	
26 ditto, on 15-inch ditto, ditto 8 feet		151 1 0	3,927 10 0	
11 ditto, on 1 ft. 8 in. × 2 ft. 6 in. brick sewers, ditto 16 feet		200 12 0	2,208 4 0	
8 ditto, on 3 ft. 2 in. × 4 ft. 9 in. ditto, ditto 16 feet		200 12 0	1,606 0 0	
103 lampholes and ventilating shafts, on 6 and 9 inch pipe sewers, laid at an average depth of 8 feet		50 12 0	5,227 4 0	
4 ditto, on 12-inch ditto, ditto 8 feet		50 12 0	203 0 0	
5 ditto, on 15-inch ditto, ditto 8 feet		50 12 0	253 12 0	
3 ditto, on 1 ft. 8 in. × 2 ft. 6 in. brick sewers, ditto 16 feet		57 12 0	173 4 0	
2 ditto, on 3 ft. 2 in. × 4 ft. 9 in. ditto, ditto 16 feet		57 12 0	115 8 0	
1 automatic flushing chamber, on 6-inch pipe sewer, laid at an average depth of 4 feet		294 2 0	294 2 0	
7 ditto, on 9-inch ditto, ditto 8 feet		418 2 0	2,926 14 0	
Contingencies, engineering and supervision			28,786 5 9	
				2,20,699 0 0
Black Town.				
Lin. yds.		ANNAS.		
116 of 6-inch pipe sewers, laid at an average depth of 5 feet		27	195 12 0	
1,553 „ 6 „ „ „ „ 7 „		29½	2,863 5 0	
1,176 „ 6 „ „ „ „ 8 „		32	2,352 0 0	
1,218 „ 6 „ „ „ „ 9 „		34	2,588 4 0	
2,226 „ 9 „ „ „ „ 5 „		43	5,982 6 0	
35,863 „ 9 „ „ „ „ 6 „		45	1,00,864 11 0	
370 „ 9 „ „ „ „ 7 „		45½	1,052 3 0	
13,876 „ 9 „ „ „ „ 8 „		48	41,628 0 0	
613 „ 9 „ „ „ „ 9 „		50	1,915 10 0	
1,508 „ 9 „ „ „ „ 10 „		52½	4,948 2 0	
1,381 „ 9 „ „ „ „ 11 „		56½	4,876 10 0	
803 „ 9 „ „ „ „ 12 „		59½	2,986 2 0	
925 „ 12 „ „ „ „ 7 „		69	3,989 1 0	
571 „ 12 „ „ „ „ 9 „		73	2,605 3 0	
638 „ 12 „ „ „ „ 10 „		77¾	3,100 4 0	
1,063 „ 12 „ „ „ „ 13 „		85	5,647 11 0	
825 „ 16 „ „ „ „ 18 „		158½	8,172 10 0	
3,540 „ 1 ft. 8 in. × 2 ft. 6 in. brick sewer „ 15 „		13 12 9	48,840 15 0	
445 „ „ „ „ „ 18 „		14 10 3	6,515 1 0	
523 „ „ „ „ „ 21 „		15 8 0	8,106 8 0	

			Total.
	Rs. A. P.	Rs. A. P.	Rs. A. P.
Black Town—cont.			
No.			
233 manholes and ventilating shafts, on 6 and 9 inch pipe sewers		34,067 11 0	
15 ditto, on 12-inch ditto, laid at an average depth of 9 feet	155 6 0	2,330 10 0	
3 ditto, on 15-inch ditto, ditto 18 feet	194 3 0	582 9 0	
31 ditto, on 1 ft. 8 in. × 2 ft. 6 in. brick sewers, ditto 16 feet	200 12 0	6,223 4 0	
301 lampholes and ventilating shafts, on 6 and 9 inch pipe sewers		15,127 0 0	
16 ditto, on 12-inch ditto, laid at an average depth of 9 feet	51 3 0	819 0 0	
5 ditto, on 15-inch ditto, ditto 18 feet	55 2 0	276 10 0	
17 ditto, on 1 ft. 8 in. × 2 ft. 6 in. brick sewers, ditto 16 feet	57 12 0	981 12 0	
20 automatic flushing chambers	300 0 0	6,000 0 0	
Contingencies, engineering and supervision		48,846 2 0	
			3,74,483 0 0
The Fort.			
Lin. yds.	ANNAS.		
3,443 of 9-inch pipe sewers, laid at an average depth of 6 feet	45	9,683 7 0	
	Rs. A. P.		
473 „ 1 ft. 8 in. × 2 ft. 6 in. brick sewers, ditto 11 feet	12 13 0	6,060 5 0	
No.			
15 manholes and ventilating shafts, on 9-inch pipe sewers, laid at an average depth of 6 feet	142 7 0	2,136 9 0	
2 ditto, on 1 ft. 8 in. × 2 ft. 6 in. brick sewers, ditto 11 feet	179 3 0	358 6 0	
16 lampholes and ventilating shafts, on 9-inch pipe sewers, laid at an average depth of 6 feet	49 14 0	798 0 0	
2 ditto, on 1 ft. 8 in. × 2 ft. 6 in. brick sewers, ditto 11 feet	54 5 0	108 10 0	
1 automatic flushing chamber, on 9-inch pipe sewer, laid at an average depth of 4 feet	418 2 0	418 2 0	
Lin. yds.			
36 of 9-inch cast-iron pipes, laid and jointed	10 0 0	360 0 0	
Contingencies, engineering and supervision		2,988 9 0	
			22,912 0 0
Tondiarpett.			
Lin. yds.	ANNAS.		
2,526 of 6-inch pipe sewers, laid at an average depth of 6 feet	29	4,578 6 0	
745 „ 9 „ „ „ „ 7 „	45½	2,118 9 6	
6,060 „ 9 „ „ „ „ 8 „	48	18,180 0 0	
1,358 „ 9 „ „ „ „ 10 „	52½	4,455 15 0	
516 „ 12 „ „ „ „ 12 „	81½	2,528 6 0	
706 „ 12 „ „ „ „ 13 „	85	3,750 10 0	
396 „ 16 „ „ „ „ 13 „	132	3,267 0 0	
No.	Rs. A. P.		
4 manholes and ventilating shafts, on 6-inch pipe sewers, laid at an average depth of 6 feet	142 7 0	569 12 0	
28 ditto, on 9-inch ditto, ditto 8 feet	151 1 0	4,229 12 0	
9 ditto, on 12-inch ditto, ditto 12 feet	168 5 0	1,514 13 0	
4 ditto, on 15-inch ditto, ditto 13 feet	172 10 0	690 8 0	
39 lampholes and ventilating shafts, on 6 and 9 inch pipe sewers	50 0 0	1,950 0 0	
8 ditto, on 12-inch ditto, laid at an average depth of 12 feet	52 8 0	420 0 0	
2 ditto, on 15-inch ditto, ditto 13 feet	52 15 0	105 14 0	
10 automatic flushing chambers	300 0 0	3,000 0 0	
Contingencies, engineering and supervision		7,718 6 6	
			59,178 0 0
Rayapuram.			
Lin. yds.	ANNAS.		
4,666 of 6-inch pipe sewers, laid at an average depth of 6 feet	29	8,457 12 0	
680 „ 9 „ „ „ „ 7 „	45½	1,933 12 0	
5,355 „ 9 „ „ „ „ 8 „	48	16,065 0 0	
423 „ 12 „ „ „ „ 11 „	80	2,115 10 0	
675 „ 12 „ „ „ „ 12 „	81½	3,438 4 6	
	Rs. A. P.		
1,670 „ 1 ft. 8 in. × 2 ft. 6 in. brick sewer „ 13 „	13 3 3	22,049 3 6	
No.			
14 manholes and ventilating shafts, on 6-inch pipe sewers, laid at an average depth of 6 feet	142 7 0	1,994 2 0	
13 ditto, on 9-inch ditto, ditto 8 feet	151 1 0	1,963 13 0	
36 ditto, on 12-inch ditto, ditto 12 feet	168 5 0	6,059 4 0	
7 ditto, on 1 ft. 8 in. × 2 ft. 6 in. brick sewers, ditto 13 feet	187 13 0	1,314 11 0	
11 lampholes and ventilating shafts, on 6-inch pipe sewers, laid at an average depth of 6 feet	49 14 0	548 10 0	
18 ditto, on 9-inch ditto, ditto 8 feet	50 12 0	913 8 0	
7 ditto, on 12-inch ditto, ditto 12 feet	52 8 0	367 8 0	
8 ditto, on 1 ft. 8 in. × 2 ft. 6 in. brick sewers, ditto 13 feet	55 11 0	445 8 0	
10 automatic flushing chambers	300 0 0	3,000 0 0	
Contingencies, engineering and supervision		10,599 6 0	
			81,266 0 0

	Rs. A. P.	Rs. A. P.	Total. Rs. A. P.
Cast Iron Delivery Mains, Overflow Sewers, &c.			
Lin. yds.			
3,750 of cast-iron delivery main, 33 inches diameter	46 11 0	1,75,078 0 0	
1,453 ,, ,, ,, 36 ,, ,, ...	51 0 0	74,103 0 0	
433 ,, ,, ,, 18 ,, ,, ...	28 8 0	12,340 8 0	
2,530 ,, 18-inch overflow sewers into sea, including canal crossing	..	18,975 0 0	
2,533 ,, brick culvert, 3 ft. 6 in. × 3 ft. 6 in., with concrete blocks to farm	15 1 0	38,301 6 0	
Contingencies, engineering and supervision	..	47,819 10 0	
			3,66,617 8 0
Sydenham Road Pumping Station.			
Three "Davey's" triple compound differential condensing engines, each capable of raising 2,500 gallons of sewage per minute, 78 feet high, at 12½ strokes per minute, with 90 lbs. boiler pressure; cylinders to be 17½-inch, 26-inch, and 40-inch diameter, by 4-feet stroke. Each engine to have two sewage pumps, with plungers, 30-inch diameter by 4-feet stroke. Three steel boilers, each 26 feet long by 6 feet 6 inch in diameter, with one flue for a working pressure of 100 lbs. per square inch, with fittings and pipe work to sewage pressure tank. Engine and boiler house, sewage well, and pressure tank.	..	3,39,540 0 0	
Contingencies, engineering and supervision	..	50,931 0 0	
			3,90,471 0 0
Tondiarpett Pumping Station.			
Two "Davey's" triple compound differential condensing engines, each capable of raising 1,100 gallons of sewage per minute, 43 feet high, at 16 strokes per minute; cylinders to be 10½-inch, 15-inch, and 22-inch, by 2 feet 6 inch stroke. Each engine to have two sewage pumps, with plungers, 22-inch in diameter, by 2 feet 6 inch stroke. Two steel boilers, each 20 feet long by 5 feet 6 inch diameter, with one flue for a working pressure of 100 lbs. per square inch, with mountings and fittings, and all pipe work, both on suction and delivery side to sewage pressure tank. Engine and boiler house, sewage well, and sewage pressure tank ..	..	1,04,250 0 0	
Contingencies, engineering and superintendence	..	15,637 8 0	
			1,19,887 8 0
Total Cost of Sewerage Works ..	..	..	23,38,176 0 0

Note.—This estimate is based upon the joints of the pipe sewers being made with Stanford's joints.

Whenever it is found necessary (owing to the depth at which the pipes may have to be laid below the level of subsoil water) to use either Doulton's improved joint, Hassell's double joint, or Sykes's joint, it will increase the cost of such pipes by about 25 per cent.

THE IMPROVEMENT OF AND THE PURIFICATION OF THE RIVER COOUM.

The urgent necessity that exists for the improvement of the River Coum within the limits of Madras has been a subject which has occupied the careful attention of the authorities for many years.

Schemes for the river's improvement.—Of the various schemes which have been proposed for its improvement, those of Mr. Standish Lee in 1874, Mr. Clarke in 1875, and Mr. Jones in 1890, have dealt the most comprehensively with the subject.

Mr. Lee.—Mr. Lee proposed that the entire bed of the river should be filled up so that the Coum would cease to exist, the flood waters being utilised for the purpose of carrying down sufficient detritus to effect this object.

Mr. Clarke.—Mr. Clarke believed that the action of the tidal water passing in and out four times a day would be sufficient to keep the channel open, if suitable groynes were erected to confine the current to a defined channel.

Mr. Jones.—Mr. Jones has undoubtedly presented the most thorough and comprehensive scheme for the river's improvement; stated briefly, his proposals are—

(1) To filter the sewage before permitting it to enter the river.

(2) To remove the banks of sewage matter which have been deposited by the river on either side.

(3) To restore the river banks where eroded.

(4) To deepen, level and resection the river.

(5) To erect training walls, groynes, &c., to train the river.

(6) To erect wharves for the landing of goods.

(7) To restore, improve, resection and turf the existing banks.

(8) To fill up the north branch of the river.

(9) To erect groynes at the mouth of the river so as to ensure its being permanently open.

As an alternative scheme to No. (9) he proposes—

(10) To construct a canal from the harbour to the river, joining it to the east of the Medical College.

Colonel Pennycuick.—Colonel Pennycuick, the Chief Engineer to Government, stated on 16th March 1891 that he could not agree to the proposal to keep the mouth of the Cooum open by groynes, as he did not think they would be effective. He also demurred to a few other points, but recommended the scheme as a whole. Mr. Jones replied to this, defending the position he had taken up, and Colonel Pennycuick commented upon the reply; this was the condition of affairs when I received my appointment to proceed to India.

During the period of my residence in Madras I was fortunate enough to see the mouth of the River Cooum opened and closed twice.

Recent opening of the bar.—The rains which attended the burst of the north-east monsoon caused the river to rise to flood level. The bar was cut on 22nd October 1891 and closed by the action of the sea on 5th November. It was again cut on 15th November and finally closed on the 28th of that month.

During these periods I lost no opportunity of being personally on the spot, so as to make myself conversant with the varied actions of the sea winds and floods, in bringing about the changes at the mouth of the river. When the flood waters have passed off into the sea, having scoured a more or less considerable channel through the bar, the River Cooum becomes in every respect a salt lagoon, rising and falling with the tide. If the inrush of the water and it subsequent exit were the only forces at work the mouth of the river would possibly be open the whole year round, but when the amount of water entering and leaving the river is the same, that is when the backwater has ceased to flow, the mouth at once begins to close up. The north-east monsoon was blowing during the times of opening and closing the bar, as stated above; the sea current, as a consequence, set towards the south.

Action of the currents, &c., on the bar.—The passage of the water along the coast being to a certain extent hindered by the inrush and exit of the water of the Cooum, the sand held in suspension by the water was deposited on the north side of the river's mouth. This sand accumulated and a tongue formed with great rapidity, travelling past the mouth of the river towards the south, in a direction parallel with the shore. This action caused the tidal water to erode the southern part of the river mouth, and the consequent movement of the mouth towards the south; at the same time the breakers dashing over the bar gradually heaped up sufficient sand to close the river.

Condition of the discharged water.—The water which issued from the Cooum when the bar was first breached was filthy and disgusting beyond description.

As it had not been discharged the previous year it held the accumulated sewage of nearly two years; it darkened the sea for a considerable distance along the coast, and strewed the shore with marine organisms which had been killed by the foul liquid.

Futility of groynes to keep the river mouth open.—From my observations of the mouth of the Cooum, and of the sea-shore in general, I am convinced that the erection of groynes, or any structures of a similar nature which would tend to cause accumulation of sand or erosion of the foreshore in the neighbourhood of the river's mouth,

would be a risky and dangerous experiment. So many elements, the majority of which are utterly unreliable, would tend to make or mar the scheme.

Very early in my observations I was led to the conclusion that no scheme for discharging the waters of the Coonm and allowing free entry to the sea-water would be effective if it interfered in any way with the natural action of the waves and the shifting sand of the shore. As an underground culvert was the only reliable means for fulfilling these obligations, I had a careful survey of the district made, and many levels taken, both on shore and out to sea. A steady fall from high-water mark was found in going seawards for a distance of about 150 feet, then an abrupt rise occurs when the well-known bar of sand is reached, upon which the breakers are generally seen. Upon the upper part of this a depth of only 7 feet is found, but immediately beyond the see rapidly deepens. I was for a time doubtful whether to terminate the steel tubes inside the bar by reducing the gradient or to continue them to the outside, but finally decided that the advantages obtained by carrying them through the bar and discharging freely into deep water would fully compensate for the extra cost.

Details of the proposed scheme.—The proposed culverts consist of two portions, the first to be of laterite or cement concrete masonry, and the second steel tubing. The masonry culverts commence at the seaward side of the southern end of Napier Bridge, at a point a few feet from the face of the groyne at the south of the river's mouth.

The culverts described.—There will be two culverts, each 10 feet in width, by 6 feet 6 inches high; in the centre they are divided from each other by a wall 3 feet thick. The inverts of the two culverts are placed at 16·5 above datum.

The masonry culvert is continued for about 520 feet through the sand in a south-easterly direction, when it curves to due east, and terminates at about low-water mark. The two openings terminate in the western wall of a masonry chamber.

Steel tubes.—From the opposite or eastern wall the steel tubes are led off, their inverts at the commencement being at the same level as the masonry culvert. They are six in number, and circular, each 3 feet diameter, and to be constructed of half-inch steel plates firmly riveted together, and carried on strong iron girders, resting on collars projecting from the screw piles at such level as to correspond with the gradient of the tubes; another and lighter girder to be placed on top of the tubes, and the whole secured to the screw piles.

The tubes to be constructed in 10 feet lengths, having special socket joints, so as to allow the joint of each length being made above low-water level, and afterwards dropped into position. These tubes are carried out to sea until they project from the farther side of the sand bar for a distance of about 25 feet, and there terminate in a downward direction, so as to prevent the deposit of sand in the tubes. The length of the steel tubes is about 220 feet; the total length from the river entrance to the discharge at sea is about 740 feet.

The inverts of the steel tubes at their termination at sea are at a level of 11 feet above datum, the fall in the tubes being about 5 feet.

At the river entrance there will be fixed iron gratings, to prevent floating objects getting into the culverts, and quick opening and closing gates for flushing the culvert and tubes periodically.

Capacity of the culvert.—I estimate that about 12 million gallons of water will be discharged from the river and replaced from the sea each tide, and if the harbour canal be constructed, about double this quantity will be discharged from the river each tide.

As by the scheme for sewering the town the whole of the sewage matter now poured daily into the river will be entirely diverted from it, I fully believe that it will, under this constant change of water, purify itself of its present fouled contents, and rise and fall with the tide as a body of clear sea-water.

The penstocks or sluices are introduced with a view to clearing the culvert of any deposit tending to silt up either end; thus, in the event of sand settling in the seaward

2098/16

portion, the river-water could be confined by the penstocks at high-water, and opened at or near low-water. The rush of water would effectually remove any obstruction of such a nature as sand.

The same operation reversed would remove any silt at the river end of the culvert. I believe, however, with the great rush of water which will occur every tide, both in and out, no deposit will occur to form an obstruction.

Flood waters.—It is obvious that the culvert is not constructed with a view to the removal of flood waters; at such times I would recommend that the penstocks be closed, and that the bar be cut as at present, to set free the pent up waters. As soon as these have subsided the penstocks might be raised, and the ordinary action of the culvert recommenced.

I estimate the cost of constructing the proposed works for connecting the River Coonm with the sea in the manner I have described, and as shown on the drawings accompanying this report, at Rs. 3,07,876.

The proposed canal.—I am of opinion that the canal between the north branch of the Coonm and the harbour might be carried out with great advantage to the town.

It is probable that if such a means of communication were opened up between the harbour and the Buckingham and Junction Canals, by way of the Coonm, a large carrying trade would be created, to the general advantage of the population. It would also be of great value as a secondary means for purifying and flushing the river.

I do not think it will be necessary to construct locks at the north part of the Junction Canal, as the current induced by the discharge through the culvert at the Coonm mouth will not be sufficient to create any inconvenience to boats in the canal, whilst the sanitary advantages accruing from the free entry and exit of water in the canal cannot be over estimated.

If the proposed canal to the harbour be constructed, the lock gates at St. Mary's Bridge will be necessary, and the consequent damming up of the waters of the Buckingham Canal be unavoidable; but I would advocate, as an important sanitary measure, that as much circulation and change as is possible should be afforded to the water in the river and canal.

Deepening the river: disposal of soil.—One of the proposals of Mr. Jones's scheme is to deepen, level, and resection the tidal portion of the river; but very great care will have to be taken respecting the disposal of the soil which is recovered first from the bed of the river, containing as it does the accumulated solid deposit of the sewage. Its free exposure to the atmosphere might produce an epidemic.

I think the bed of the river should not be touched until it has been well flushed by storm water, and until the culvert has been constructed and in operation for a time. When this has occurred, I would advocate its complete removal by way of the sea, sooner than its utilization in raising the level of the Island, or any other part of the river. With respect to the project for filling up the north branch of the river, I do not see that any material benefit will accrue to the town or the inhabitants if this work is carried out. It would entail long and expensive operations, with a doubtful future advantage. Under the conditions which exists at the present time, its removal would undoubtedly be a blessing, as lessening the bulk of foul stagnant water in the river; but if by the drainage system the sewage be eliminated, and by the culvert and proposed canal the sea-water be constantly renewed, the necessity for its removal at once disappears.

The river banks, &c.—The proposal of Mr. Jones to restore the river banks, build training walls and groynes, erect wharves, &c., fall readily under the heading of Town Improvements, and do not come within the province of a sanitary report; but I should like to fully endorse his recommendations as to their desirability or probable usefulness.

Weir at Harris's Bridge.—Colonel Pennycuick's suggestions regarding the weir at Harris's Bridge appear to me to be sound. I also entirely concur in his remarks relating to the weirs further up the river.

LIST OF DRAWINGS ACCOMPANYING DRAINAGE REPORT.

		Number of sheets.	Number of drawings.
General plan showing proposed system of sewerage		1	1
Sections of sewers in Mylapore and St. Thomé		1	18
Do. do.	Triplicane, Chintadripettah, Elemboor and Egmore	1	25
Do. do.	Pursewaukum and Vepery	1	18
Do. do.	Black Town and Fort St. George ..	1	28
Do. do.	Tondiarpett, Washermanpettah and Coorookoopettah	1	7
Section of intercepting main sewer from Royapettah to Sydenham Road Pumping Station and gravitating main		1	1
Do.	present open sewer and proposed covered sewer from end of iron gravitating main to Black Town Farm	1	5
Do.	overflow sewer from main, Sydenham Road, to the sea	1	1
Sections of proposed intercepting sewers on both sides of the River Coum		2	2
Detail drawing of outfall sewer, St. Thomé		1	6
Do.	of brick and concrete sewers	1	12
Do.	of automatic flushing chambers	1	5
Do.	of sample manholes and lampholes on pipe sewers	1	9
Do.	of manholes on brick sewers	1	6
Do.	of river crossing	1	6
Do.	of pumping machinery, boilers, and tank, Sydenham Road Pumping Station ..	1	3
Do.	of Tondiarpett Pumping Station	1	3
Plan and section of house drains		1	2
Do.	showing drainage of blocks of houses ..	1	2
Do.	of public latrines	1	3
Plan, sections, and detail drawings of proposed sea outlet from River Coum		2	7
	Total ..	24	170

THE WATER-SUPPLY OF MADRAS.

The sources of supply before the present scheme.—The desirability of supplying such a large and populous town as Madras with an abundance of pure water has occupied the attention of the Madras Government for many years past. The health of a town or district depends to a very large extent upon the quality of the water which is used for domestic purposes, and doubtless much of the mortality which obtained in Madras before the present waterworks were constructed was attributable to the impure quality of the drinking water.

Shallow Wells.—Previous to 1854 the only supply was from the very large number of wells which were sunk in all parts of the town and district, many of which are in existence, and some even in use at the present day. When the porous nature of the soil on which the town is built is considered, it will be understood how readily the water in these shallow wells would become contaminated and rendered unfit for drinking purposes by the deposits of filth of all descriptions upon the surface, more especially during the monsoons, when the rain water in penetrating the soil would carry down the impurities with it.

Previous Reports—Colonel O'Connell's Report.—Colonel O'Connell, by desire of the Government, prepared a scheme which was published in 1855; it was not adopted, although subsequently reported upon by Mr. Roberts, C.E., in 1862.

Mr. Fraser's report.—Five years later, in 1867, a report was submitted by Mr. Fraser, C.E., the general design of which was as follows:—

(1) To place a dam across the Kortalayar River at a point which would give a fall of 2 feet per mile to Cholavaram Lake.

(2) To cut a supply channel to that lake, $8\frac{1}{2}$ miles in length.

(3) To enlarge Cholaveram Lake.

(4) To connect the lake with the Red Hills Lake by a channel $2\frac{3}{4}$ miles in length, and having a fall of 3 feet per mile.

(5) To enlarge Red Hills Lake.

(6) To cut a delivery channel from this lake to Madras, terminating at the Spur Tank, part of which would be used as a last settling reservoir. The water then to be filtered, raised by pumping, and then distributed.

This scheme met with the approval of the Government; they adopted it, and it was carried out, with various modifications, from the Kortalayar River to the Red Hills Lake. When the question of distribution arose, however, it was decided to effect it by means of gravitation, as being less expensive than by pumping. This necessitated the delivery channel being taken off at a higher point than had been arranged, and consequently the sacrifice of a large quantity of water still remaining in the lake below the take-off.

The Open Channel.—An open channel, running chiefly in the upper part of an earth embankment, was therefore constructed, which delivers the water into a tower at Kilpauk, from whence it is distributed by the mains to the town. When the water in the Red Hills Lake falls to about 35·50 above M.S.L. pumping has to be resorted to to give the present supply at Madras.

Mr. Jones's First Report, 1877.—In 1877 Mr. J. A. Jones, C.E., submitted a report for the improvement of the water-supply, the necessity for which he stated as follows:—

"The water is at present conveyed to Madras from the Red Hills Lake by means of an open channel, which was calculated to deliver 24 gallons per head per day for a population of 545,000. When designed it was supposed that the channel would have a good current, and the growth of vegetation be thus prevented. These expectations, I regret to say, have not been fulfilled, and at present it is most difficult to keep the channel clear of weeds. This may partly be caused by the intermittent system of supply which we have been of late forced to adopt, and by which method the water is as it were dammed up, and allowed to rest in the channel for a period of six hours during the day and 12 hours during the night. There is also another evil arising from this, and that is, that the channel having been made into a settling tank, it is getting silted up, and will in time (if allowed) become so much so as to be unable to deliver the necessary quantity to the town. The cleaning of the channel either causes the water supply to be shut off from the town or the delivery of water unfit for drinking."

Mr. Jones's Second Report, 1885.—Mr. Jones's scheme was held in abeyance until 1885, in which year he presented a new water-supply scheme, the main features of which were as follows:—

(1) The building of a tower in one part of the lake, where the water could be tapped at a level of 22·00 above M.S.L., or 9 feet lower than the present off-take.

(2) Pumping the water to a high level at Red Hills, settling and filtering it there, and storing it in a service reservoir.

(3) Delivering it by an iron main to Madras at the rate of 6,000,000 gallons per day. A part of this scheme, viz., No. 1, has been carried out; the tower has been built, and two iron supply pipes, each 24 inches in diameter, carried from it through the bank.

Colonel Pennycuick's Committee, 1890.—No further progress was, however, made, and in 1890 a Committee was formed, with Colonel Pennicuick, R.E., as President, to consider the question as to how expenditure could be most advantageously incurred on the water-supply of Madras.

In the report of this Committee they say that "the present water-supply is defective as to the quality of the water, owing to the absence of filtration, and the liability of pollution in the tank and in the open channel leading from it; it is

defective also as regards quantity of water and regularity of supply, the pressure available not being sufficient to deliver it at the rate necessary for the requirements of the town."

The chief recommendations in this report are —

(1) The construction of a masonry basin, 120 feet by 120 feet, at Red Hills, with its floor at 20·00 and the top of its walls at 32·00 above M.S.L., into which the pipes from the water tower would be discharged; this basin to act as a settling tank and from it would be conducted a masonry conduit 5 feet wide, 4 feet high, up to the springing line of the arch, the arch to have a rise of 1 foot. The sill of the conduit at the basin to be 25·00 above M.S.L., or 6 feet below that of the present municipal sluice, and to fall at 8 inches per mile to the end of the present delivery channel at Kilpauk, which it would reach at a level of about 20·00.

(2) The filtering and pumping works to be constructed at Kilpauk.

The Committee state that the conduit described above would deliver 26 cubic feet per second, or 14 million gallons of water per day, and the total cost is estimated at 20½ lakhs. They also state that—

"The water in the lake is now exposed to pollution by the existence of villages within its drainage area, and the Committee consider that means should be taken for preventing this as far as may be practicable."

Description of Existing Works.

Madras is supplied with water at the present time from the Red Hills lake (tank), which is fed by a channel from the Korttalaiyár river; this channel passes through the Cholaveram tank which forms a reserve reservoir.

The Korttalaiyár River.—The Korttalaiyár river rises in the Kávérippak tank on the left bank of the Pálár river. The tank is supplied with water by means of an anicut across the river and a supply channel, the overflow forming the source of the Korttalaiyár river. A dam is placed across the river at Kasavaram, by means of which a large portion of the water is diverted into the River Cooum. Two tributaries, the Nagari and the Tirutani, which rise in the Nagari Hills district, unite and join the main river at Kistnapuram. A dam is placed across the river at Tamarapakkam, which is 54 miles from the source of the river and about 22 from its mouth at Ennore. The area drained by the river down to this point, excluding that part whose waters are taken off by the River Cooum at the Kasavaram anicut, is 837 square miles, and the average rainfall of the district about 37 inches. (Monograph on Madras Water-supply, 1882.)

From Tamarapakkam anicut a supply channel, a little over 8 miles in length, leads to Cholaveram tank.

Cholaveram Lake.—This lake is about 2¼ miles in length, and when full contains 766 millions cubic feet of water. The total length of the bank is 2 miles 22 chains. The top of the bank is 10 feet broad. The inside slope is 1 to 1 with rough stone revetment and a parapet wall at the top. The outside slope is 1½ to 1. The head sluice to the Read Hills tank supply channel consists of 10 vents with their sills at 45·33 feet above M.S.L. The supply channel is 2 miles 5 furlongs in length and joins the Red Hills lake at its northern extremity.

The Red Hills Lake.—The lake has a length of over 3¼ miles. The present reduced full tank level is 43·31, and the greatest depth of water against the bank is over the sill of the north sluice. There are four irrigation sluices and one sluice for the municipal supply channel. (Monograph, page 3.)

The sluice of the supply channel.—The latter sluice has six pipes of 27 inches diameter which are placed at the following levels (the highest pipe has not been used since the storm water overflow has been lowered) :—

3	pipes	with	sill	at the level of	31·31 above M.S.L.
1	"	"		35·31	" "
1	"	"		39·31	" "
1	"	"		43·31	" "

The Surplus Weir or Calingula.—A surplus weir for the Red Hills lake is placed at the extreme north end of the lake. In this weir is a 10-vented surplus sluice, each vent being 6 feet by 6 feet with its sill at 31·31; by this sluice the water can be quickly lowered in times of flood, or in the event of the bank showing signs of weakness.

The Water Tower.—The water tower is an octagonal building standing on a bed of concrete 6 feet thick, the bottom of which is at 13·61 above M.S.L., or from 9 to 12 feet below the bed of the lake. There are eight branch inlets in the valve tower placed at different levels and connected to two vertical pipes; each branch has a plug valve outside of the tower and sluice valve on the inside, and by these means any of the valves or pipes can be repaired without affecting the water-supply. The inverts of the lowest of these outlet pipes in the lake are laid at a level of 23·55 above M.S.L. The tower is constructed of brickwork in cement and rises to the same level as the tank bund, to which it is intended to be connected by a foot-bridge, in two spans of 50 feet each, a pier rising from the culvert to support it midway. This bridge has not been carried out as yet. At the level of the tank bund the tower is floored over and has a verandah supported on the cantilever beams which carry the pullies for raising the outer valves. Partly above and partly below the level of the flooring is the machinery for raising and lowering the valves. The tower rises 12 feet above floor level and is covered by a brick dome, a construction which was thought the least likely to be affected by any cyclonic weather occurring in the lake. From the floor of the tower to the level of the culvert floor an iron ladder extends for the examination of the pipes and valves.

The Culverts from the Water Tower.—The culvert extends from the tower to the outer toe of the bund and is 160 feet in length and 7 feet 6 inches in breadth. It contains the two lines of 24-inch pipes from the lake. At the toe of the slope there will be a second valve house, with two sluice valves and two scour branches, and valves to enable the pipes to be cleared of deposit. The valves are in position, but the house itself remains uncompleted for the present. The double line of pipes has been continued to a length of some 550 feet from the tower.

The level of the invert of the lowest outlet pipes from the lake supplying the present open channel is 31·31 above M.S.L., but to supply the quantity of water at present used in the town temporary steam pumping has to be started as soon as the water in the lake falls to the level of 35·50.

Description of Proposed Scheme.

The report upon the water supply of Madras, which I now have the honour to submit, is the result of personal examination of the whole of the existing means for the supply of the town and a careful study of the reports of Mr. Jones, Colonel Pennycuick's committee, and Mr. Ellis upon the improved water-supply.

I concur with the general recommendations of the committee that a masonry conduit should be constructed to convey the water from the Red Hills lake to Madras and that the necessary filtering and pumping works be constructed at Kilpauk.

Settling Tank, Red Hills.—I, however, differ from their recommendations with respect to the proposed settling tank at Red Hills and to the level and gradient of the conduit. I am of opinion that the proposed settling tank would be of little or no service; the small dimensions of the chamber and the constant flow of a large volume of water through it would prevent the deposit of any appreciable quantity of sediment, and if any was deposited there would be difficulty in removing it owing to the bottom of the tank being so much below the surrounding ground. I do not consider that any settling tank is required. The Red Hills lake is in itself a huge tank of that nature, and under ordinary circumstances must fulfil all the requisite conditions. During times of heavy floods the water may be somewhat turbid, but those times are rare; the water would have a considerable distance to travel from the inlets to the outlets, and before doing so would deposit nearly all the sediment it contained, after which the filtration only would be sufficient to ensure a supply of clear water.

Conduit.—The level at which the invert of the proposed masonry conduit should be placed at its commencement at the Red Hills is a subject of the greatest importance, as upon it depends the amount of storage which may be drawn from the lake without resorting to expensive temporary pumping.

The committee recommend that the sill of proposed conduit at its commencement at Red Hills should be at a level of 25·00 above M.S.L., the conduit having a fall of 8 inches per mile. It is estimated with this fall and the water running at a level with the springer line of the arch the conduit will deliver at Kilpauk 14,000,000 gallons per day; but to deliver this quantity of water through the two 24-inch pipes the water in the lake would have to be at the level of 31·14 above M.S.L., or 7·59 above the level of the inverts of outlet pipes from the lake, thus leaving a large volume of water in the lake which could not be drawn off from it at the rate of 14,000,000 gallons per day without having to resort to temporary pumping.

I recommend that the conduit be constructed, having the level of the sill at its commencement at Red Hills at 18·17 above M.S.L., and that the culvert should have a gradient of 1 in 3,979. This would allow of an additional amount of storage for the use of the town equal to about 268,859,700 cubic feet, or 115 days' supply at the rate of 14,000,000 gallons per day. This would be the discharge when the water in the lake fell to the level of 26·31 above M.S.L. and without having to resort to temporary pumping from the lake. If the conduit be constructed of the same area as that recommended by the committee, it would discharge about 19,000,000 gallons per day, sufficient to supply an increase of 67 per cent. of the present population, which, I think, is rather more than need be provided for. I would, therefore, recommend a slight reduction in the size of the conduit, and of slightly different section, capable of delivering about 16,500,000 gallons per day, which would give 25 gallons per day for a population of 660,000 inhabitants, or an increase of about 45 per cent. to the present population. The alterations which I have recommended be made to the conduit will necessitate it being laid at a greater depth than that named by the committee, but not greater than is necessary to prevent interference with existing sewers, water-courses, roads, &c., along its proposed route.

Irrigation.—I have noticed no diminution whatever in the large amount of water discharged from the lake for irrigation purposes when the level of the water in the lake has been perilously near the pumping point. This, I think, is a subject which demands attention, as, in my opinion, the water-supply to the town is of primary and paramount importance and that for irrigation purposes entirely subservient to it. I would strongly recommend that no water for irrigation should be taken from the Red Hills lake below the level of 35·50. If this course be adopted and the sill of the conduit constructed at 18·17, there could be impounded in the lake between the levels of 26·31 and 35·50 a volume of water for the sole use of the town equal to about 764,579,900 cubic feet, or about 341 days' supply, calculated at the rate of 14,000,000 gallons per day.

Filtration.—The filtration of water through sand filters mitigates the objectionable qualities of impure water. It not only removes the impurities in suspension, but partly also the organic matters in solution by oxidation during the passage of water through the sand. The slower the rate of filtration, the purer and clearer the water will be; this depends to a great extent upon the depth and character of the material used. The best results are got from a maximum rate of filtration through sand filters varying from 4 to 5 inches per hour.

I have recently inspected and tested a new method of filtration through cloth, the machinery and plant being designed by Mr. Walter George Atkins, which he calls "Scientific Filtration." I put this filter to a severe test, and the result was very satisfactory, but not so perfect as I could wish. The designer is making alterations to the plant, which he considers will enable him to filter water equal to that of sand filters and at much less cost. If he succeeds in doing so, his system has many advantages over sand filters, especially at Madras where the water would not be exposed to the action of the sun as would be the case on sand filters; and the covered reservoir for holding the filtered water could be constructed at a higher level, and

2579
-19-

would in this way reduce the lift of the pumping engines; but until this system is perfected and the result proved in every respect satisfactory, I cannot recommend it for adoption.

Amongst the drawings sent with this report will be found drawings of this system of filtration and also of the sand filters.

Filter beds.—To supply the present population of 452,518 with 25 gallons per head per day will require seven filter beds of one acre each, allowing two of these to be out of use for cleansing purposes.

The invert of the conduit at Kilpauk will finish at 8·17 above M.S.L.; the water from it will be discharged into a wide channel, from which it will flow on to the filter beds. The top layer of sand in the filter beds will be at the level of 5·67 above M.S.L., and the invert of the drains leading from the filter beds to the filtered water reservoir will be at ·33 below M.S.L.

The bottom of the filtered water reservior adjoining will be at a level of 3·33 below M.S.L.; from this reservoir the water will be pumped into a tank constructed over the engine-house at a level of 61·7 above M.S.L., which will be requisite to give a satisfactory pressure to all parts of the town.

Connecting new with present Mains.—From this last mentioned tank a 42-inch cast-iron main will be laid and connected to the existing 42-inch main leading from the present tower at the end of the open channel to the town.

Size of Mains.—I do not recommend any increase in the size of the principal distributing mains in the town. I, however, recommend that all public mains below 3 inches in diameter should be taken up and replaced with pipes of a larger size.

Engines.—I recommend that three "Davey" triple compound differential condensing pumping engines be erected, each engine to be capable of raising 294,500 gallons per hour 73 feet high, working at 17 strokes per minute with 100 lb. boiler pressure. Two of these engines will be sufficient to lift 589,000 gallons per hour to a height of 73 feet; the third engine to be in reserve.

Cylinders.—The cylinders of each engine to be three in number, viz., 21-inch, 33-inch and 46-inch in diameter, by 4 feet stroke.

Condensers.—The condensers to be of the surface type.

Pumps.—Each engine to have a pair of pumps, each to be 34 inches diameter by 4 feet stroke. Each pair of pumps to have a separate suction pipe and a separate rising main to extend direct up to the tank over the engine-room in the form of a standpipe.

Boilers.—To erect in a building adjoining the engine-room three improved high-pressure steel boilers, each boiler to be 30 feet long by 7 feet diameter, with one flue through each, having a fire-grate arranged for burning either wood or coal. The boilers to be made to sustain a daily working pressure of 100 lb. per square inch and to be tested by hydraulic force to 150 lb. per square inch.

The conduit between Red Hills lake and the town will be capable of delivering 16,500,000 gallons per day, and I have so arranged the filter beds, pumping machinery, and boilers that any future increase in the quantity of water may be conveniently provided without in any way interfering with the arrangements for supplying the present population.

The following is the estimated cost of carrying out the works as recommended:—

	Rs.	A.	P.
Conduit from Red Hills to Madras	11,17,773	12	0
Filter beds	3,14,681	12	0
Filtered water reservoir	66,111	8	0
Pumping machinery and boilers, water tower, buildings, high-service tank, and connecting the same with existing 42-inch main and sand washing chambers	3,96,191	13	0
Engineering and contingencies	1,89,475	3	0
Total ..	20,84,234	0	0

List of drawings accompanying Water-works Report.

1. General plan of proposed works.
2. ,, section of conduit, filter beds, water tower, &c.
3. Enlarged plan of pumping station.
4. Details of filter beds and clear-water reservoir.
5. ,, pumping machinery and boilers.
6. ,, entrance and ventilation of conduit.
7. General plan for W. G. Atkins' system of scientific filtration.
8. Details of do. do. do.

Before concluding these reports upon the Drainage, Water-supply, and River Cooum improvement, I should like to place on record my appreciation of the kind readiness and willingness which was evinced by all those in Madras to whom I applied for information which would help me in my investigations.

My thanks are especially due to Colonel J. Pennycuick, R.E., Chief Engineer, Public Works Department; Lieut.-Col. G. M. J. Moore, President of Municipal Commission, Madras; the Hon. John Frederick Price, Chief Secretary to Government; J. A. Jones, Esq., Sanitary Engineer to Government; R. E. Ellis, Esq., Municipal Engineer and Vice-President, Public Works Department; Surgeon-Major J. A. Laing, Sanitary Commissioner; Dr. J. Nield Cook, Health Officer, Municipal Commission, Madras; C. Michie Smith, Esq., B.Sc., Astronomer to Government; Henry Irwin, Esq., C.I.E., Consulting Architect to Government; Captain H. B. Simpson, Deputy Conservator of the Port of Madras; A. Lee Pogson, Esq., Engineer to the Harbour Trust Board; and J. J. Wilson, Esq., Engineer to the Harbour Trust Board.

To the gentlemen enumerated above and to others who favored me with information upon various points, I tender my warmest thanks.

EDWARD COUSINS.

Palace Chambers, Westminster,
1893.

APPENDIX to Mr. COUSINS' REPORT on the Drainage and Water-supply of Madras.

27, AGAMEMNON ROAD, WEST HAMPSTEAD,
LONDON, N. W., 29*th May* 1893.

[Madras Water-supply.]

Dear Sir,

Herewith I have the pleasure of handing you drawings illustrating the general arrangement of my system of scientific filtration.

I have been actively engaged in designing and carrying out various kinds of filtering arrangements for more than twenty years. This experience has proved that filtering is entirely a question of cleaning, and when studied from this point of view, very great sanitary and economic benefits result. This may be readily illustrated.

When the usual practice is followed of putting off the cleaning of a filter as long as possible, three results follow: First, the filtering medium becomes coated with impurity, and if it originally possessed any purifying power, such as is often claimed for charcoal, it becomes suppressed. Secondly, the accumulated impurities undergo serious changes and are liable to become dangerous to the health of those who drink water that has passed through them. Thirdly, in the case of sand beds and other arrangements in the open air, especially at certain times of the year, and when there is a hot sun, the matter arrested grows freely, increases to several times its original bulk, and considerably more labour is necessary to remove this than would have been the case had the cleaning been done promptly.

2078/20

But there is a further economic aspect which is very striking. Suppose water is being filtered which contains impurity which will choke a square yard of filtering surface in one hour. If it is only convenient to clean the filter once in twenty-four hours, twenty-four square yards are necessary. But, on the other hand, if it can be cleaned every three minutes, a filtering surface of 5 inches by 12 inches will suffice. These remarks will doubtless show that filtering is entirely a question of Cleaning, and the system I term Scientific Filtration has been developed upon this basis.

The filtering medium is an endless band of cotton filter cloth. This material has been selected for the following reasons:—

(1) It can be readily adapted to mechanical arrangements.
(2) It is cheap.
(3) It can be obtained of any degree of fineness and strength, according to the conditions that have to be dealt with.
(4) It will wear well, and is practically indestructible, if properly used. I submit a sample herewith, which has been in constant use for more than eighteen months, and is still in good condition.
(5) In the process of cleaning, it can, when deemed necessary, be passed through boiling water without injury, this treatment having the effect of preserving the cloth, and at the same time completely destroying all animalculæ and organic matter, from which it is very important a filtering medium should be kept free.
(6) It is easily cleaned and restored to its original condition.

The two sheets of drawings accompanying this report illustrate the general construction and arrangement of the plant I have designed for the Madras Water-supply.

Each filtering machine consists of a hollow cast-iron cylinder, 12 feet in diameter, by 11 feet 6 inches long, and is always revolving slowly. The surface, or periphery, is so formed as to present a series of separate collecting areas. An endless band of filter cloth is led on to the cylinder near the top, surrounds it, travels with it, and on again approaching the top is led off to an adjoining cleaning apparatus, or washing machine. Except the small portion at the top where the cloth is led on and off the cylinder, the latter is submerged in a cistern containing the water to be filtered. This percolates through the cloth, leaving the impurities on the outside surface, the filtered water being conveyed by the collecting areas to certain collecting pipes, arranged inside the cylinder. Each collecting pipe discharges through a valve into a hollow chamber at one end of the cylinder. From this chamber the filtered water is withdrawn by a dip-pipe, which also acts as a hollow axle, and is conveyed where required. As the cylinder revolves, the valves of those collecting pipes in connection with the two or three collecting areas which are above the level of the unfiltered water, and therefore exposed to the air, are automatically closed. The object of this arrangement is, that by attaching the suction pipe of a pump to the outlet pipe from the cylinder, any desired vacuum can be maintained on the remaining collecting areas, and the yield of filtered water greatly increased.

The cylinder revolves about once in three minutes, so that a given point or portion of the cloth is only filtering for this period, and then passes on to the washing machine. This consists of three parts; first, the cloth is brought in contact with a revolving brush which removes the bulk of the impurity, or matter which has been arrested by filtration. It then passes between a pair of wringing rolls to a washing cistern. In this cistern the water is always warm to facilitate cleaning, and the cloth passes between ribbed wood rolls, or the water may be boiling occasionally both to facilitate cleaning and to destroy any organic matter in the cloth. It again passes between wringing rolls, and then into a rinsing cistern also fitted with wood-ribbed rolls. These rolls are always travelling to and fro, revolving freely while doing so, and this gives the cloth an effectual cleaning, with very little wear and tear. On leaving this rinsing cistern the cloth for the third time passes between wringing rolls, returning to the filtering machine perfectly clean and again acts as a filtering medium.

Filtering and Cleaning are thus always proceeding; there are certain guide rolls. stretch rolls, and compensating rolls to keep the cloth in order and to its proper course, and the whole apparatus is automatic.

There are fourteen machines, viz., twelve for use and two for reserve, each capable of passing rather more than 50,000 gallons per hour, or 600,000 gallons per hour from the twelve machines. Although each cylinder will weigh perhaps ten tons with its accessories, being hollow and having the ends closed, it will float. To prevent this, there is a pipe passing through the axle at the back, so that water can at any time be admitted or withdrawn, without stopping the machine, to act as ballast. Thus its weight can be neutralized with great nicety, it will rest very lightly on the bearings, and exceedingly little power will cause it to revolve. So far as it is possible to judge, one horse power will work a filtering machine and its washing machine. I think two men can attend to the twelve machines, one man stoke the boiler, and one man attend to the engine—or four men altogether.

The working expenses of Scientific Filtration will be considerably less than those of the sand-bed system, whilst I venture to claim that the advantages are very great. Indeed, I respectfully submit that it is a practicable impossiblity to keep sand-bed filters in an efficient and sanitary state, in a climate like that of Madras. At least twelve acres of actual sand-bed area are necessary, vegetable growth will be very rapid, and as the rate of filtration must not exceed $2\frac{1}{2}$ gallons per square foot per hour, the water, being shallow, will get warm and insipid. Even the loss from evaporation will be great, much greater than when there is a considerable depth to keep the whole cool.

On the other hand, with Scientific Filtration the plant is protected from the sun by being in a building, and the surface of water exposed to the air is extremely small. Filtration is very rapid, viz., at about the rate of 250 gallons per square foot per hour, or one hundred times as fast as is possible with sand beds; there is no opportunity for the temperature of the water to rise, and the filtering medium is always in a state of perfect efficiency.

I have endeavoured to make this report as brief as possible, but trust it is sufficient to explain the drawings and general working. I shall be pleased to give any further information you require.

I am, &c.,

(Signed) WALTER GEO. ATKINS.

E. Cousins, Esq., C.E.

INDEX.

MADRAS DRAINAGE, 1893.

	Page
Appointment	3
Previous reports	5
Situation and extent of district	5
Geology and surface	5
Rainfall and surface-water	6
Meteorological records	6
Annual rainfall	6
Excessive rainfalls	6
Table of maximum rainfalls from 1861 to 1890	6
Vital statistics, birth-rate	6
Death rate	6
Table of average death-rate	7
Direction of sea currents	8
Velocity of sea currents	8
Rise and fall of the tide	8

	Page
Open-channel system of drainage	8
Existing house drains	8
River Coovum	9
Length of river	9
Cutting the bar	9
Table giving dates of opening and closing the Cooum Bar	9
Condition of river	10
Description of the district of Mylapore and St. Thomé	10
Present system of drainage	11
The Junction Canal	11
Triplicane: surface of the district	11
Royapettah Sewage Farm	11
Triplicane Sewage Farm	11
Triplicane Drain	12
Chintadripettah: surface of district	12
Napier Park Sewage Farm	12
Egmore and Elemboor: surface of district	12
Egmore Sewage Farm	12
Pursewaukum: surface of district	12
DeMellow's Road Sewage Farm	12
People's Park Sewage Farm	12
Black Town: surface of district	13
Open channel system	13
Present sewers and old main drain	13
The Fort Pumping Station	13
No 1 sewer, Black Town	13
No 2 „ „	13
No. 3 „ „	13
Rayapuram Pumping Station	14
The overflow	14
The pumping main	14
Rayapuram and Tondiarpett: surface of the district	14
Robinson's Park Sewage Farm	14
Description of the proposed drainage scheme	14
Additional reports	14
The large area to be drained	14
Proposed divisions of the drainage scheme	15
General description of proposed sewers	15
Mylapore and St. Thomé	15
Triplicane	15
Chintadripettah	16
The river crossing	16
Egmore	16
Elemboor	16
Pursewaukum	16
Black Town	16
First intercepting sewer, Black Town	16
Second „ „ „	17
Third „ „ „	17
Fourth „ „ „	17
Fort St. George	17
Rayapuram and part of Tondiarpett	17
Part of Tondiarpett, Corookoopettah and Washermenpettah	17
Rayapuram Pumping Station	18
Additional pumping stations	18
Sydenham Road Pumping Station	18
Engines, sewage pumps	18
Boilers, tank, gravitating main	18
Tondiarpett Pumping Station	19
Engines, sewage pumps, boilers, tank, &c.	19
Discharging capacity of sewers	19
Pipe sewers	19
Brick and concrete sewers	19
Graduation of sewers	19
Surface and storm water	19
Ventilation of sewers	20

	Page
Flushing of sewers	20
Works to be first proceeded with	20
House drainage	20
Importance of good workmanship	20
Public latrines	20
Estimated cost of sewerage works	21
Mylapore and St. Thomé	21
Triplicane	21
Chintadripettah	22
Egmore	22
Elemboor	22
Pursewaukum	23
Black Town	23
The Fort	24
Tondiarpett	24
Ráyapuram	24
Cast iron main, 33 inches diameter	24
Do. 36 " "	24
Do. 18 " "	24
18-inch overflow sewers into sea including canal crossing	24
Brick culvert 3 ft. 6 in. × 3 ft. 6 in. with concrete blocks	24
Sydenham Road Pumping Station	25
Toudiarpett Pumping Station	25
Total cost of works	25

IMPROVEMENT AND PURIFICATION OF THE RIVER COOUM.

	Page
Schemes for the river's improvement	25
Mr. Lee	25
Mr. Clarke	25
Mr. Jones	25
Colonel Pennycuick	26
Recent opening of the bar	26
Action of the currents, &c., on the bar	26
Condition of the discharged water	26
Futility of groynes to keep river mouth open	26
Details of the proposed scheme	27
Description of culverts	27
Do. of steel tubes	27
Capacity of the culvert	27
Flood waters	27
The proposed canal	28
Deepening the river	28
Disposal of the soil	28
River banks, &c.	28
Weir at Harris' Bridge	28
List of drawings accompanying report	28

WATER SUPPLY OF MADRAS.

	Page
Sources of supply	29
Shallow wells	29
Previous reports	29
The open channel	30
Mr. Jones' Report of 1877 and 1885	30
Colonel Pennycuick's Committee, 1890	30
Description of existing works	31
The Kortalayar River	31
Cholaveram Lake	31
Red Hills Lake	31
Supply channel sluice	31
Surplus weir	31
Water tower	31
Culvert from the water tower	32
Description of proposed scheme	32
Settling tank, Red Hills	32

	Page
Conduit	32
Irrigation	33
Filtration	33
Filter beds	33
Connecting new with present mains	34
Size of mains	34
Engines, cylinders, condensers, pumps and boilers	34
Estimate of cost	34
List of drawings	34

From the Secretary, Public Works Department, India Office, Whitehall, S.W., dated 16th June 1893.

ABSTRACT.—Informing that the drawings referred to will be forwarded by the next steamer to Madras.

ORDER—dated 2nd August 1893, No. 1000 A/m

The report by Mr. Cousins will be communicated to the Madras Municipal Commission, the Sanitary Engineer, and the Public Works Department. It will also be placed on the Editors' table.

2. A copy will be forwarded to Colonel Pennycuick (care of the India Office) with the request that he will favour Government with any general remarks he may wish to make on the report.

(True Extract.)

for *Chief Secretary.*

To the President, Municipal Commission, Madras.
" the Sanitary Engineer.
" the Public Works Department.
" Colonel Pennycuick, R.E., care of India Office.
Editors' Table.

Encl. W. J. Lewis.

P. W. CURRENT No. 7002.

19-9-13 √

17-12-20

Govt. of {1893} Madras.

LOCAL AND MUNICIPAL.

No. 2078 W, dated 12 August 1893

P.S.C

Recorded.

Issued

Recd. Enol.

Regtd. 12.8.93

G.O. 2nd August/93.

No: 1000 A.M.

4-1-93. ZC

5-1-93. 4624 C

27-4-93. 1169 W

Central Rec. B

Drainage and Water-supply.

Communicating to the Madras Municipal Commission, the Sanitary Engineer, and the Public Works Department, Mr. Cousins' report on the — of Madras and the improvement to the river Cooum, and forwarding a copy of the same to Colonel Pennycuick for remarks.

Rec'd B/8

ZC 14 W 11

I 16/8.