MADRAS WATER-WORKS.

REPORT OF THE COMMITTEE

APPOINTED IN

G. O. No. 1576 I., 15TH SEPTEMBER [illegible]

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1918.

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OFFICE OF THE SANITARY COMMISSIONER,
MADRAS, *dated* 29*th April* 1918.

From

MAJOR W. A. JUSTICE, M.B., C.M., D.P.H., I.M.S.,
Sanitary Commissioner for the Government of Madras,

To

THE SECRETARY TO GOVERNMENT,
LOCAL AND MUNICIPAL DEPARTMENT.

SIR,

With reference to G.O. No. 1576 M. of the 15th September 1917, appointing a committee 'to inspect and report on the water-works and the supply to the City generally,' I am directed by the Committee to forward to you their report. The report is accompanied by five plans and thirty appendices as detailed in a separate list.

The Committee would invite the attention of Government to their conclusions and general remarks at the end of their report and would state that in the body of the report they have given in sufficient detail their reasons and arguments on which their conclusions are based.

The Committee regret the inability of the Hon'ble Surgeon-General Bannerman, C.S.I., I.M.S., their President, to continue with them as an active member owing to illness, but from time to time they have had the benefit of his advice.

I have the honour to be,
Sir,
Your most obedient servant,

W. A. JUSTICE, Major, I.M.S.,
Sanitary Commissioner for the Govt. of Madras.

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OF THE

MADRAS WATER-WORKS COMMITTEE.

GENERAL.

I.—APPOINTMENT OF THE COMMITTEE AND TERMS OF REFERENCE.

1. The Committee was appointed by the Government of Madras in their order No. 1576 M., dated 15th September 1917, which was as follows :—

The Government appoint a Committee consisting of Surgeon-General Bannerman (President) and the Sanitary Commissioner and the Sanitary Engineer to inspect and report on the water-works and the supply to the City generally. The Committee should examine carefully the defects of the present system and suggest remedies where necessary.

This committee met on the 22nd September 1917 at Ootacamund. The Hon'ble Surgeon-General W. B. Bannerman, M.D., C.S.I., I.M.S., presided. The Committee considered that before proceeding to inspect the water-works they should be put in possession of the following information :—

(1) A report on the water-works as originally designed.

(2) A report on the water-works as executed, with special reference to any important alterations made during execution.

(3) A report on the working of the water-works since the date of opening, with statements showing the number of filter-beds in use, date when each was brought into use, the duration of working of each filter, results of the analysis of water from each filter during its working period, the amount of water passed through each filter and rate of filtration adopted.

(4) A copy of the rules in force for working the filters.

(5) A report on the analyses of water made from time to time at the King Institute of Preventive Medicine, by whom the samples were taken, by what method they were taken and at what places.

(6) A report of the average quantity of water supplied to the town from time to time, and the quantity of unfiltered water added and by what process this was effected.

(7) A statement of the rate per head per day of supply of water, as compared with the rate contemplated in the original scheme, and an explanation of excess variation, if any.

(8) A copy of the rules for the guidance of the staff at the pumping station, with reference to the quantity of water pumped daily.

(9) A copy of the rules for the guidance of the staff in supervising the distribution system.

(10) A statement of the staff employed on the water-works with their duties.

On receipt this information was circulated amongst the members of the Committee.

2. The next meeting of the Committee was held at the King Institute, Guindy, on 2nd November. Owing to illness the President, the Hon'ble Surgeon-General W. B. Bannerman, was unable to attend. The remaining members considered the results of the analyses and arranged for additional samples being taken from certain places.

3. The Committee met on 20th November 1918 at King Institute of Preventive Medicine, Guindy, and considered the results of the samples ordered to be taken at their last meeting, the President again being absent owing to illness. As it appeared likely that Surgeon-General Bannerman would be unable to attend meetings for some time, the Committee decided to place the matter before Government and ask for their directions. In the meantime the Committee resolved to inspect the water-works as early as possible and to carry out the wishes of Government pending further orders.

Government orders were subsequently received to carry on. The order of Government was as follows :—

In modification of G.O. No. 1576 W., dated 15th September 1917, the Government direct that the Committee appointed therein to inspect and report on the Madras water-supply shall consist of Major W. A. Justice, I.M.S., and Mr. W. Hutton, A.M.I.C.E.

4. The two members of the Committee have carried out the inspection of the water-works and have held meetings to consider the evidence obtained by them after inspection and from inquiries.

During their inspections they received every assistance from the Corporation executive, and they desire to express their obligations to Dr. Maitland Gibson and the staff at the King Institute who have carried out the heavy additional duties involved in the taking and examinations of numerous samples of the water and to Dr. J. L. Simonsen and Mr. Bainbrigge Fletcher.

5. With reference to the time taken by the Committee in submitting their report the Committee would point out that the reference was not one which could be answered in a short time. The reference involved the inspection of works in detail located over a large area, the analyses of numerous samples of water, the determination of defects and the progress step by step from the discovery of a defect and its remedy to the next until the preliminary defects had been determined and their bearing on the problem before the Committee decided on. It was impossible to hurry such investigation. It should not be overlooked that the members of the Committee had in addition to the work required by this important reference to carry on their own responsible duties at the same time. The Committee are of opinion that while all defects in the system cannot be said to have been discovered by them, such major defects as affect the quality of the water and its supply to the City will have been found to be brought to light in their report and if the works are managed in the future in the manner pointed out by the Committee they see no reason why the Madras water-works should not be entirely successful.

6. A printed memorandum on the Madras water-supply and alleged defects was forwarded to the Committee by Mr. K. C. Desika Achariyar, a Municipal Commissioner. The Committee have given this memorandum their careful consideration and think that the points brought to notice will be found to have been dealt with in the various sub-heads of the Committee's report.

7. The Committee would specially desire to bring to notice of Government their deep regret at the absence of their President Surgeon-General Bannerman through illness, but they desire to thank him for his advice which he freely gave them from time to time when the state of his health permitted.

II. SHORT DESCRIPTION OF THE MADRAS WATER-WORKS.

(1) POPULATION FOR WHICH THE SCHEME HAS BEEN DESIGNED.

The new water-works were designed for a population of 660,000, and the rate of supply was fixed at 25 gallons per head per day.

The supply is intended to be constant.

(2) RED HILLS TANK.

The source of supply of drinking-water for the City of Madras is the Red Hills tank or lake which is situated about nine miles north-west of the centre of the City. This tank is fed from its own catchment area of 23 square miles and in addition it receives a supply from a channel which takes off from the River Korttalaiyar, and after passing through another tank called Cholavaram, falls into the Red Hills tank.

The capacity of the Red Hills tank when full is at present 2,000,000,000 (two thousand millions) cubic feet. The whole of this water is not available for supply to the City as the Red Hills tank is primarily an irrigation tank, irrigating some five thousand acres. The Government of Madras have, however, arranged that when the level of the water in the tank falls to 6·67 feet below full tank level the supply for irrigation is stopped and the City has the first claim on the remaining water. The Red Hills tank covers the large area of 6 square miles when full and forms a suitable reservoir for the supply of water to the City. The catchment area is composed of agricultural, grazing and waste land. There are no large villages or towns within the area, but undoubted contamination takes place due to the scattered inhabitants and animals within the area. This contamination is more evident in the rainy season as in the dry weather the tank, owing to its large extent, forms a suitable sedimentation and sunning basin. At these times the water is comparatively pure bacteriologically, but at other times filtration is undoubtedly essential.

The rainfall over this area is less than 40 inches per annum and proposals are under consideration for increasing the capacity of the tank by raising its full tank level by 18 inches to avoid failure of supply to the City.

The Government charge the Corporation for the supply of water to the City at the rate of 1 rupee per thousand cubic yards, or one-tenth of an anna per 1,000 gallons. The total amount now paid by the City for water is approximately thirty thousand rupees per annum.

(3) OUTLET TOWER.

To enable the water to be drawn off from the lake an outlet tower has been built at its deepest part. This tower is provided with two vertical stand pipes twenty-four inches each in diameter and each stand pipe has three inlets on it placed at different levels so that water nearest the surface can be drawn off as the level of water in the lake falls. The two 24-inch stand pipes pass under the embankment or bund of the tank and discharge into a roughing filter. On the line of both 24-inch mains there is a valve house provided with sluice valves so that either the one or the other or both lines of pipes can be used for supplying the roughing filter. Adjoining the sluice valves and on the tank side of them there are 6-inch scour pipes, one on each 24-inch main.

(4) ROUGHING FILTER.

This consists of a basin divided into two parts by a central wall. Each of the two compartments measures 108′ × 72′ × 7′ deep.

The water on entering the roughing filter passes through two triangular screening chambers and enters the roughing filter at floor level, passes upwards through a layer of broken stone and discharges over a weir into the conduit which leads to the City. The depth of water passing over the weir is measured by a patent automatic recorder.

(5) CONDUIT.

The conduit is of brick masonry with a concrete floor lined with brick on edge. The roof is a brick arch of two rings thick. The inside is plastered with ¾ inch cement mortar ; outside with ¾ inch lime mortar containing in addition a small proportion of cement.

At places where the conduit is more than 11 feet below ground the thickness of the masonry is suitably increased. The dimensions are 5 feet wide and 4 feet deep. The floor is dished to the extent of 3 inches and the rise of the arch is 1 foot 6 inches so that the total height at the middle of the cross section of the conduit is 5 feet 9 inches. The side walls are 18 inches and the floor is 18 inches thick.

The total length of the conduit is 37,000 feet, or over 7 miles. In its length of 37,000 feet the conduit falls in level 8·28 feet so that its gradient is 1 in 4,470 feet.

The present depth of water to supply 523,000 people is 3 feet and with the fall available gives a velocity of 1·7. The velocity is satisfactory and prevents deposit in the conduit as has been found by examination.

For a length of nearly a mile the conduit passes through the bed of the tank and at this place the masonry is made thicker to stand the increased pressure. At three places on the conduit it has to pass streams which is accomplished by using in one place steel pipes 4 feet in diameter and in the other two cases by using masonry drop syphons.

There are 54 manholes altogether in the length of 37,000 feet. The manholes are not more than 1,000 feet apart and in addition there are manholes at each change of direction. The tops of the manholes are raised $2\frac{1}{2}$ feet above ground level and they are alternately fitted with air inlets and ventilating shaft outlets.

(6) SAND FILTERS.

Fourteen slow sand filters are provided for filtering the water and it is intended to provide seven more when the increase of population of the City requires it. The size of each is 200′ × 100′. The side walls are $7\frac{1}{2}$ feet high and the outside walls of the filters have a parapet wall around them to keep out frogs, etc. The filters are filled with 28 inches of fine sand which passed through a screen of 1/30th inch mesh and is retained on a screen of 1/50th inch mesh (see however Appendix S_1). Below this layer of fine sand there is a layer of coarse sand two inches thick and below this two layers each 2 inches thick of broken stone varying in size from $\frac{3}{8}$ to $\frac{3}{4}$ of an inch. Below this stone there are two layers of bricks which form collecting drains leading to a main drain 24 inches wide in the centre of the floor of the filter bed. This main drain is connected to a filter outlet chamber in which is placed a Glenfield Jones Regulator, which is intended to maintain a constant rate of filtration through the filter bed. The filtered water from these chambers passes into a conduit which conveys it to three storage reservoirs. When the works were executed the broken stone and brick collecting drains were only carried to within three feet of the side walls of the filter and this space 3 feet wide around the inside walls of the filters was filled with the fine sand with the object of preventing 'creep' of unfiltered water past or down the surface of the inside walls. Arrangements are provided for scouring out the filter beds and for filling them with filtered water from below when the beds have to be re-started after cleaning. Overflows are also provided at the termination of the inlet conduit.

(7) CLEAR WATER RESERVOIRS.

There are three clear water reservoirs constructed under ground to store the filtered water. Space is reserved for a fourth to be constructed when required. Each reservoir measures 150′ × 150′ and 10′ deep. The capacity of each reservoir is 1,400,000 gallons. The four reservoirs together will provide one-third of a day's supply.

(8) PUMPING STATION.

From the clear water reservoirs the filtered water is led by a conduit to a suction culvert which is situated below the floor of the pumping station. In the pumping station there are three Worthington pumping engines each capable of pumping 12,000 gallons of water per minute to a total height of 80 feet. The water is discharged through a 48-inch steel main to the town.

(9) STEEL TANK.

A balancing tank constructed of steel plates and with a diameter of 104 feet and 28 feet deep and a capacity of $1\frac{1}{2}$ million gallons is directly connected to the 48-inch steel main. The bottom of the tank is 38 feet above ground and its capacity is equal to two hours' supply to the population for which the scheme has been designed.

(10) DISTRIBUTION SYSTEM.

At a distance of 4,000 feet from the pumping station the 48-inch steel main is connected to the old pipe distribution of the City. As the old system was inadequate for the new supply provision has been made for extending it. The extension has not yet been completed but sufficient has been done to ensure a fairly satisfactory supply to all parts of the City.

(11) COST OF WORKS.

The cost of the works for supply of water to the City which have been completed is 29 lakhs of rupees and the improvements to the distribution works when completed are estimated to cost 33 lakhs of rupees.

III.—DETAILED DESCRIPTION OF THE MADRAS WATER-WORKS AS FOUND ON INSPECTION BY THE COMMITTEE.

A. HEADWORKS.

(1) RED HILLS TANK.

Red Hills tank.—This tank, a large irrigation tank, is fed by a channel, $2\frac{1}{2}$ miles long, from another irrigation tank called Cholavaram which is supplied by a channel, 8 miles long, from the Tamarapak anicut on the Korttalaiyar river at a distance of $23\frac{1}{2}$ miles from Madras. The catchment area of the Korttalaiyar river is of the usual description in the Carnatic, that is to say, it contains large areas of cultivated land and numerous villages. The upper reaches of the river and its tributaries have their source in the hilly country forming the Karvetnagar zamindari in the North Arcot district and in the jungles on the slopes of Nagari Hill.

The average rainfall on the catchment basin may be taken at about 37 inches. The river is in flood during the north-east monsoon, and in an average year is said to run in full flood for four or five days only. For a month more the flow in the river is about 3 feet and after that period there is a small perennial stream. The normal breadth of the river is about 500 feet, but the anicut is 624 feet long. The channel from the anicut to the Cholavaram tank and the channel from this tank to the Red Hills tank have a section of 30 feet bottom width and side slopes $1\frac{1}{2}$ to 1. Depth of ordinary flow is $2\frac{1}{2}$ feet. The bedfall of the channel is about 2 feet per mile and that of the river is $3\frac{1}{2}$ feet per mile. This gives an ordinary discharge of 940 cubic feet per second for the channel.

The protection of this river catchment area is a matter of impossibility at present owing to its extent. The area draining into the supply channel to the Cholavaram tank is also of large extent and contains a number of villages. It is equally impossible to deal with this catchment area in the matter of protection. Fortunately for the City before the water of these two catchment areas arrives at the Red Hills tank the water has to pass through the Cholavaram tank, the capacity of which when full amounts to nearly 600,000,000 cubic feet where it obtains a considerable amount of sedimentation and sunning and so gets a certain amount of natural purification. The water from this tank passes by a supply channel about $2\frac{1}{2}$ miles in length to the Red Hills tank. In addition to the supply from this channel the Red Hills tank has an independent catchment of 23 square miles. The Committee have inspected this catchment and find it contains cultivated lands and hamlets. They have come to the conclusion that an area of land along the margin of the waterspread within a distance of 1,000 feet from the water margin at full tank level should be acquired and that an inspection path or road should be made through this land from the Tiruvallūr trunk road to the bund on the right flank of the tank. This path is in their opinion absolutely necessary in order to have effective control over the margin of the tank. It is also essential in their opinion that the water which has undergone a certain amount of purification by sedimentation and sunning in the Cholavaram tank should not be contaminated in its passage through the supply channel to the Red Hills tank and for this purpose both banks of this supply channel should be effectively fenced with barbed wire fencing on stone posts and all traffic across the channel through the water absolutely prevented. This channel after being fenced must be patrolled efficiently by the Red Hills patrolling staff and to enable this to be done and checked it is necessary to provide an inspection path on one bank. The Committee were struck by the evidence of the fouling of this supply channel where the Tiruvallūr trunk road crosses it. It is apparently customary for pedestrians on this road to use the water here for their purposes. We consider that this source of contamination can be easily eliminated. Similar barbed wire fences will be required here and efficient patrol and checking of the same. Further east in the catchment area between the Tiruvallūr road, the Red Hills village and the tank, there is an area of land which is freely used by buffaloes and other cattle and is used as a short cut to Tiruvallūr road by travellers. This area must be acquired and enclosed and all traffic prevented.

On the south of the bund of the tank there is the village of Kannadipalaiyam. This village has been provided with a well in an endeavour to prevent the villagers resorting to the tank for water. The Committee think that this village should be removed further south. There was distinct evidence that the people resort to the tank probably for bathing. The watching staff is apparently useless in dealing with this matter. In the first place they should have distinct uniforms which should show the number of the watcher. If this has already been done we would remark that the uniforms are not maintained. We consider the watchmen should be regularly mustered and their efficiency tested. In the event of it being found impossible at present to remove this village we consider that it should be fenced on three sides to exclude the villagers from the tank. In connexion with the water-supply to the municipal bungalow we suggest a well should be constructed to prevent the servants entering the lake. It would be advisable also to place a fence between the lake and this well and of sufficient length to prevent access to the lake from the bungalow. With the exception of these points there is no contamination of the lake on the southern side except from stray cattle and grass cutters— the Committee would remark that these are surely points within the cognizance of the watching staff and there is no reason why they should be allowed to continue.

(2) OUTLET TOWER.

This outlet tower is fitted with six draw-off valves operated by gearing from the tower. These draw-off valves are located at different levels with the object of drawing off water from the tank as near the surface as possible. Three of the draw-off valves are connected with one 24-inch cast iron main which passes under the bund of the tank to a valve chamber, thence to a roughing filter at entrance to the conduit. As a stand by against accident to this arrangement, which might involve the cutting off of water-supply to the City, a duplicate set of valves, mains, etc., is provided. The whole arrangement is such that water can be

drawn from three different levels which for simplicity the Committee will refer to hereafter as the upper, the middle and the lower valves. On the day of inspection (30th November 1917) the Committee found that the lower valve was fully opened and the middle valve to the extent of 6 inches; whereas in ordinary circumstances the upper valve should have been fully opened and the middle valve 6 inches, or more if necessary, to provide the desired supply.

The reason assigned for using the lower valve instead of the upper valve was that a less amount of floating weeds, leaves, etc., was drawn in from the water in the lake. The Committee would observe that it is an accepted fact, which has been proved by analyses of samples of water in other water-supplies, that the upper layers of water within 4—5 feet of the surface are purer than the layers of water at a greater depth and at times when the tank water is turbid the difference in this respect would be greater. This being so the Committee consider that the usual practice of drawing water off from the tank 4 or 5 feet below the surface should be followed in future and that a lower valve should not be opened unless the supply from the upper valve is deficient in quantity. They would point out, however, that the upper valve should not be used when the depth of water above it is less than 3 to 4 feet. The entry of leaves, weeds, etc., into the valve in use can be prevented by the provision of screens circular or octagonal and of mesh suitable for the purpose desired. The Committee observed a number of old casuarina trees below the tank bund near the outlet tower and were informed that when the prevailing wind (south-east) is blowing, a large number of casuarina needles are blown into the water near the outlet tower and find thier way through the valves to the roughing filters tending to choke the screens of these filters. These trees are in charge of the Public Works Department and we do not doubt that that department when the nuisance is brought to their notice, would remove those casuarina trees on each side of the outlet tower for a distance of 100 yards.

The Committee would also recommend as a precaution that the proper designation of each valve should be clearly painted on the valve head so that mistakes in operating may be avoided, as they noticed that the staff appeared to hesitate when called on to state which valve was open or shut and whether the upper, lower or middle valve was open or shut.

(3) VALVE HOUSE.

This house is situated below the bund and contains two 24-inch sluice valves, one on each of the 24-inch mains from the outlet tower. Immediately adjoining the sluice valves and between them and the outlet tower are two scour pipes each provided with a sluice valve. These pipes are intended to scour the 24-inch mains from the outlet tower to the valve house. As the 24-inch mains are about 6 feet below ground level and the outlets of the scour pipes are above ground level and as the scour pipes are only 6 inches in diameter the effect of them on the scouring of 24-inch mains must only be local. The last samples of water analysed (see appendix 4) indicated the presence of silt or other source of deterioration in these 24-inch mains and to verify this the Committee had the scour valves opened in their presence. The south scour pipe was found to be choked but the north scour pipe disclosed the presence of a considerable amount of black silt. The Committee requested that taps for taking samples should be fixed on each 24-inch main on the lake side of the valves in the valve house with the object of detecting any variation in quality of the water occurring in that section of the 24-inch mains.

Samples of water were taken on 4th December 1917 and the results of the bacteriological analysis of these samples is given in Appendix 5. It will be observed that the sample of the lake water 5 feet 5 inches below the surface showed total colonies per c.c. 380 and lactose fermenters present in 60 c.c. and no vibrios according to the vibrio test. The sample from the south 24-inch main from the new tap fixed on the suggestion of the Committee gave the result 610 colonies and lactose fermenters present in 30 c.c., while the tap in the north main gave 460 colonies and lactose fermenters present in 30 c.c. No vibrios in both cases.

This confirmed the Committee's opinion that the two 6-inch scours on these were ineffectual as the quality of the water was reduced two-fold. Referring to the same appendix it will be observed that at the end of the 24-inch mains where they discharge into the inlet to the roughing filters the sample of water taken shows a further deterioration which is partly due in the Committee's opinion to deposit in the pipe and partly to diffusion of contaminated water from the roughing filter. The Committee are of opinion that no part of the system of water-works should be so constructed as to prevent periodical cleaning. In the present instance the 24-inch mains can only be partly cleaned by two small inefficient scour branches. In order that this section of the 24-inch mains may be cleaned out periodically the valve house and the valves should be shifted to a position as near as possible to the inlets to the roughing filters and two 14-inch scour pipes should be provided on these mains. Until this alteration is made the two 6-inch scours should be frequently opened, say, at least once a week.

(4) ROUGHING FILTERS.

In paragraph II (4) these are described generally.

The water from the 24-inch main enters the roughing filters from below and passes upwards through a layer of broken stone which varies in size from 1½ inches to ⅜ of an inch. In passing through this layer of broken stone the water will deposit matter both suspended and otherwise which will gradually accumulate and in the end the filter will become completely choked. The Committee found on inspection that from the end of 1914 to the date of their inspection the roughing filters had never been cleaned. They found however that preparations were being made for cleaning them. The Committee's attention was directed to the deterioration which occurred in the lake water after passing through the roughing filter and refer to the analyses taken from 25th September to 11th October 1917, Appendix (1). They accordingly at the 2nd November Meeting of Committee, directed that in addition to the places where samples had been taken in the previous examination, samples should be taken at the entrance to the roughing filter so that a comparison might be made with a sample from the outlet.

The new series of samples, Appendix 4, were taken on 7th November 1917 and showed the water after passing through the roughing filter was 60 fold worse than the lake water. The Committee were still not satisfied and further samples were taken on 4th December 1917. The Committee took the opportunity of one of the compartments being then empty for cleaning to ask the President not to have this compartment re-filled with stone, so that the Committee could ascertain the difference in quality of the water in passing through an open sedimentation and sun-ning basin as compared with the other compartment of the roughing filter which was filled with broken stone and had not been cleaned for three years. The results of the examination of water are shown in Appendix 5. These show that the tank water from a point 5′ 5″ below the surface gave 380 colonies per c.c. and lactose fermenters present in 60 c.c and no vibrios thus indicating a high degree of purity of the lake water. Be-tween the outlet tower and the valve house this water showed a two-fold deterioration in quality due in our opinion to the presence of deposit in the pipe. At the inlets to the roughing filter the quality of the water further deteriorated in all probability due to a similar cause. In passing through the unclean filter the water became 12 fold worse than the tank water but in passing through the cleaned filter the water improved in quality again almost attaining the purity of the lake water.

This is not surprising as an inspection of the material removed from one compartment of the roughing filter showed that it was particularly offensive being impregnated with black silt.

The Committee are not in a position to experiment with a roughing filter containing clean broken stone and they did not consider it advisable to recommend that the Corporation should replace the stone after cleaning.

The Committee are impressed with the fact that even if the roughing filter is cleaned every six months there will still be considerable deposit on the stones of the filter and such deposit is seen to affect the quality of the drinking water and form foci for the breeding of larvæ, etc. (which will be referred to under the next paragraph). The Committee would mention that roughing filters are commonly used for the purification of sewage but when applied to water-supplies, such as the Red Hills they are more likely to adversely affect the quality of the water than otherwise because the broken stone is never aerated at the Red Hills and consequently the multiplication of the requisite number of bacteria for purification purposes is not facilitated. The Committee consider that the basins as constructed are suitable as sunning and sedimentation tanks and the materials from them which consists of broken stone can be usefully employed in improving the paths and roadways in the enclosure at the headworks. The Committee consider that the roughing filters should be emptied of material, and thoroughly cleaned of all deposit on the walls and floor. Each should be cement washed and the iron work repainted. In future the roughing filters should only be used as sunning and sedimentation basins.

(5) OUTLET FROM ROUGHING FILTER.

In Appendix 5 and from the results of previous analyses the Committee noticed a further deterioration in the water before it entered the conduit.

The Committee inspected the outlet of the roughing filter on 12th January 1918. To enable them to do so the outlet sluices of roughing filter were closed and the water was lowered so that the Committee could enter the basin. A certain amount of moss was found growing on the walls especially inside the two semi-circular culverts. It was obvious that the growth of the moss was encouraged by light and the Committee considered that the openings into these culverts should be closed by teakwood shutters which would also prevent the diffusion of water from these culverts into the outlet basin. A similar shutter should be placed at the entrance to the conduit, but this should only dip two or three inches into the water. On the floor of the outlet basin of the roughing filter there was a certain amount of deposit apparently consisting of lime shells and small pieces of gravel in which there were larvæ like life. In manhole No. 1 of the conduit a piece of rope found attached to one of the foot-rests was impregnated with these larvæ. Samples of these were taken and submitted to Mr. Bainbrigge Fletcher, Imperial Entomologist, and his report is given in Appendix P_1. The Committee are of opinion—the presence of these larvæ is due in part to the deposit in the roughing filters and that they will be eliminated by the proposed conversion of the roughing filter into sunning and sedimentation basins. They are also of opinion that no deposit such as lime shells, gravel, loose bricks to which larvæ might cling, should be placed in or allowed to remain in the inlet basin of the conduit. The Committee were informed that the lime shells were introduced for the purpose of purifying the water by the addition of slaked lime ; apparently a considerable number of underburnt shells were introduced at the same time. When it is proposed to introduce slaked lime into water the Committee would point out that this is best done by adding lime water drop by drop, the solution being made by mixing slaked lime in powder form with water.

The Committee support the view that environment is important in obtaining from the staff employed on a water-work the best possible results. They recognize that this has been obtained at the pumping station at Kilpauk but they are not satisfied with appearance of the compound at the roughing filters. The Committee would remark that the compound at the headworks is not in the state which is desirable for a water-work. They would recommend that the low places should be filled up, surplus stones and material removed, necessary roads and paths made and such sanitary conveniences provided as may be required by the staff at the headworks. The compound should be fenced or preferably a compound wall should be constructed with necessary gate or gates and the growing of ornamental shrubs encouraged. The Committee noticed on one occasion that water was drawn from the roughing filter basin for the use of the staff. If the tank margin is to be conserved there is all the more reason why this practice should be prevented and the Committee would suggest the provision of a small service pipe from the 24-inch main on the outlet tower side of the sluice valve. If there is any difficulty in providing this the service pipe may be fitted as a syphon pipe from the tank.

B. CONDUIT.

Early in the investigation the Committee noted a regrettable deterioration in quality of the water in passing from the Red Hills to Kilpauk, see Appendices (1), (4) and (5). The Committee therefore decided as no explanation of this could be given on the surface after inspection to inspect the inside of the conduit. This was done on 12th January 1918. At the request of the Committee the water was shut off from the conduit and they proceeded to inspect the inside of the conduit as far as the second manhole. When the water ceased to flow it was found the weir had been recently cleaned and cement washed. The conduit was found to be water-tight. In the first length of it there was a deposit of shells the result of using slaked lime as an experiment to purify the water. This deposit contained large quantities of the larvæ mentioned above and the samples gave off an offensive smell. The Committee found that brownish coloured moss grew on the sides and floor of the conduit ; there was none on the roof. The moss was more evident near the ventilating openings through which a certain amount of light entered. Some bricks, stones and other debris were gathered 'en route' and taken out of the conduit for closer inspection. These were found covered with cocoons and their hatched out larvæ.

As the conduit was found to be water-tight and apart from the above-mentioned deposits in very good order the Committee did not consider it necessary to interrupt the supply to the city any further than had been already done for their inspection. Water was then turned on and the remainder of the conduit and the manholes on it were inspected from the surface. The Committee found that the manholes on the conduit were arranged alternately as air inlet and air outlet manholes. The air inlet arrangement was however in the Committee's opinion of faulty design and its simplicity was an inducement to tamper with it. It consisted of a cast-iron grating cover hinged at one side ; this cover could easily be lifted with one hand disclosing a 6-inch diameter opening vertically over the water in the conduit. The Committee will refer further on to manholes where evidence of this tampering was found.

The air outlet arrangement consisted of a 6-inch vertical pipe provided with a Creegan's patent ventilating outlet. These in the Committee's opinion were quite satisfactory. The Committee found in the case especially of the inlet ventilators that large quantities of insects, flying ants, etc., were entering the conduit through the gratings. This is an undoubted disadvantage and can be overcome by the new design of inlet recommended by the Committee later on.

On February 26th the Committee proceeded to inspect the conduit starting from Kilpauk. Within 300 yards of the filters the Committee found that manhole No. 54 on the conduit was being regularly used to provide

water for washing clothes. The ventilator was turned back fully opened. It was impregnated with silt and had obviously been in this position for a considerable time. Water was apparently withdrawn from the conduit through the open ventilator and the granite stone on the top of the manhole had been smoothed by constant use as a dhobis' stone. The ground around the manhole was a quagmire in which there was evidence of soap being used to wash the clothes and further evidence of prolonged use of this manhole by the people was the luxuriant crop of grass in the neighbourhood.

After all the precautions for preventing contamination of the Red Hills water and the provision of a closed conduit therefrom it is surprising to find this loophole of possible contamination existing close to the sand filters. An outbreak of cholera in the village might under such conditions involve the city in an epidemic.

Between manholes Nos. 33 and 54 referred to in the minutes of sixteenth meeting a drop syphon is required at this place.

At manhole No. 52 the ventilator was found open and there was evidence of water having been recently drawn out of it, and so also at manhole No. 50, evidence that ventilator had been opened and used by dhobis in the past. Between manholes Nos. 48 and 49 there is a pipe syphon. At the inlet of manhole No. 48 the water in the conduit was dirty ; the scour pipe connected to this manhole was found had not been used. It was found by examination that there were at least 3 inches of silt deposited in the conduit at the manhole. From the evidence the Committee consider that the pipe syphon probably contains an undesirable quantity of silt affecting the quality of water ultimately. At manhole No. 47 the cover was off the opening. Between manholes Nos. 45 and 46 the Cuddapah slab covering of a temporary manhole was found out of place and the manhole open. The Committee noticed that the conduit passes through a number of swamps, the water of which stands in many places against the walls of the conduit. They think it is advisable that a bank should be formed on the sides of the conduit in order to prevent this and they are further of opinion that the bank over the conduit should be made up, levelled, and maintained as a suitable inspection path.

Sulurpet village is near manhole No. 16. It was observed that the people of the village were taking water from a filthy pond which receives the drainage of the village. Villagers are said to have a prescriptive right to water from the Red Hills tank as their village tank was abandoned when the Red Hills tank was constructed. They formerly obtained water from a small pond near the open channel. It is intended to provide two wells for this village and another village on the other side of the conduit to be supplied with water from the conduit. This provision will prevent possible interference with manhole No. 16.

At manhole No. 20 there is a village called Puttavaram. The Committee consider that the villagers help themselves to water from the ventilator of this manhole and it would be better to provide a small well similar to that proposed for Sulurpet. Between manholes Nos. 21 and 22 there is a short length of drop syphon which passes the conduit across a depression at this place. There are no arrangements made for scouring this syphon and as it has not been cleaned since the opening of the works it is almost certain to contain a considerable amount of deposit. Similarly there is a syphon arrangement between manholes Nos. 29 and 30. The above remarks apply to this arrangement also. At manhole No. 31 there was evidence of water having been taken from the ventilator as the top of the manhole was wet and there was water in the seating of the ventilator while it was observed ventilators at other manholes were quite dry.

During the inspection of the conduit the Committee noticed that there was no silt in the bed of the conduit itself due in their opinion to the satisfactory velocity with which the water passes down the conduit. At drop syphons in the length of the conduit evidence was obtained of the existence of the deposit of silt ; this is not surprising as these drop syphons act as catch pits and from their nature they retain sediment which in the straight lengths of conduit is carried on by the current. This deposit must take place in the syphons owing to the reduction in velocity of the water in passing through them.

In fortunate circumstances this deposit of silt could be removed from the syphons through sufficiently large scour branches. Owing, however, to the flatness of the country through which the conduit passes the requisite fall for these branches is not available.

The only means under the existing conditions of clearing out the deposit from these drop syphons is by stopping the flow of water in the conduit, pumping out the water in the drop syphons and clearing out the deposit by hand labour. As this operation would interfere with the supply to the City, the Committee would advise the provision of drop syphons in duplicate so that one could be cleaned while the other supplied the City. As the syphons are limited in length the cost of supplying duplicates would not be great. An alternative to providing duplicate syphons is the provision of syphons for the three cross drainages under which the present drop syphons are built. The advantage of this would be the elimination altogether of drop syphons on the conduit itself and the avoidance of periodical cleaning out of such syphons.

The Committee would remark that although the water of the conduit is filtered at Kilpauk there is no reason why it should be liable to deterioration during its passage ; for the purer the water is delivered at Kilpauk the less strain is thrown on the filters and the less liability of obtaining an unsatisfactory filtrate.

The Committee are of opinion that the most important improvement required for the conduit is the provision of suitable air inlets which cannot be tampered with.

The present ventilators would not have been so easily tampered with if they had been screwed down ; a simple stud screwing into the casing would have required the use of a spanner and considerable effort to open the ventilator and such tampering would have been promptly detected if the conduit had been regularly inspected. However, these ventilators allow light and insects to enter. The water can easily be contaminated through the opening of the ventilators as the flowing water is vertically below. Owing to these disadvantages we propose the institution of ventilators similar to the outlet pipe Creegan ventilator but of shorter length. If necessary the outlet ventilator can be increased in height by an amount equal to the height of the new inlet pipe ventilator. The Committee consider the iron manhole covers in use fastened down from inside the conduit necessitates the entrance of men into the conduit in order to open them and this can be avoided by a simple arrangement whereby the nut can be unscrewed from the outside. There are certain temporary manholes in the conduit provided with Cuddapah slab loose covers. These should be built up. As a regular inspection of the conduit is absolutely necessary the bank over the conduit should be kept in order so that it may be traversed from the Red Hills to Kilpauk without detour caused by obstructions such as swamps. The watchmen should inspect the conduit once daily ; the overseer once a week and a member of the superior staff once a month.

C. KILPAUK WORKS.

(1) INLET CONDUIT.

From the end of the supply conduit from Red Hills an inlet conduit is taken around the filter beds which are in two batteries of seven each. This inlet conduit measures inside 5×4 feet and is built of brick in mortar walls, 18 inches thick, with a flat concrete floor ; the roof is made of re-inforced concrete, 4 inches thick. The Committee from perusal of Appendix 10 are inclined to think that analyses of the inlet chamber

water shows deterioration as it passes to the last filter bed No. 2. It will be noticed that the water in the Red Hills conduit deteriorates from lactose fermenters in 10 c.c. to lactose fermenters in ·1 c.c. in bed No. 2 inlet. There are only two manholes in this conduit one at each corner. The Committee inspected their condition and found evidence of deposit. The water is sometimes stagnant or nearly so in it and deposit is more than likely. For example, say the last three or four filter beds connected with the inlet conduit are under cleaning and the inlet valves are shut, the water in the conduit opposite these filter beds will be stagnant.

The inlet conduit should have facilities for cleaning and the scour valve at the end should be frequently used. There should be a valve at the beginning of the inlet conduit and the end of conduit from the Red Hills to regulate the flow in the inlet conduit and prevent surplusing from the end of the inlet conduit into the scour conduit.

(2) FILTER BEDS.

(*a*) *Construction.*

There are fourteen filters completed at Kilpauk arranged in two rows of seven each. These filter beds are surrounded on three sides by a conduit which supplies them with water. Space has been left at Kilpauk for seven additional filters which will be constructed adjoining one of the rows of seven already in use, so that the inlet conduit will pass between these two rows.

Each filter bed measures 200 feet long $\times$ 100 feet wide and it is constructed of brick in mortar walls with a concrete floor. The walls and floor are plastered inside with cement plaster to give the walls a smooth surface. The floor of a filter is arranged to have a slope of three inches between the side walls and a central collecting drain. This drain is one foot deep at the beginning and two feet deep at the outlet end and it has a fall of one in two hundred. It is two feet wide throughout and is covered with Cuddapah slabs three inches thick. These slabs rest on a layer of bricks on edge laid in longitudinal lines from the side wall to the central collecting drain. The space between the lines of bricks is equal to the width of a brick. This is how the lines of bricks were originally intended to be but during construction the bricks were stopped at a distance of three feet from the walls of the filter. The spaces between the lines of bricks form channels for the conveyance of filtered water to the central collecting drain. Over these lines of bricks there is a second layer of bricks placed flat without mortar. The combined depth of the brick layer is six inches. Resting on the bricks there is a layer of broken stone two inches thick of $\frac{3}{4}$ inch gauge and above this another two inches layer of broken stone of $\frac{3}{8}$ of an inch gauge. Over this layer there is a layer of coarse sand and above it a fine sand layer twenty-eight inches thick. When a filter is first brought into use the depth of water above the fine sand layer is three feet nine inches. The depth of the division walls of a filter was designed to be seven feet eight inches thus leaving a margin of seven inches and all these walls have been constructed with an inside batter. Surrounding each battery of seven filters there is a parapet wall two feet six inches high which prevents the entrance of frogs, etc., and also storm water.

The broken stone and brick collecting drains and coarse sand layer in the Madras filters do not extend to the walls of the filter but a space three feet wide from the walls is filled with fine sand similar to two feet four inches sand layer. The Committee remark that this is not the customary way of filling in a filter bed. They were informed that it was done with the object 'to prevent short circuiting of the unfiltered water by creeping down the walls.' See plan No. 4.

From the inlet conduit water is led on to a filter through a fourteen-inch cast iron pipe the supply being regulated by a sluice valve. The end of the fourteen-inch pipe discharges horizontally into a semi-circular receiving chamber of five feet radius. The top of the wall of the receiving chamber is above the sand level. This wall is intended to prevent scouring of the surface of the sand when a filter is being restarted after cleaning and as an additional precaution a layer of bricks is placed on the surface of the sand around the outside of the receiving chamber. In actual construction the walls of this semi-circular chamber where they abut on the filter bed walls have been cut down to the level of the sand. When water enters this chamber it passes through these cuts into the filter beds with appreciable velocity and the surface of the filter bed is thereby scoured into depressions. The Committee will propose improvements to this arrangement including the provision of a screen at this chamber to prevent the entry into the filter bed of frogs, crabs, fish and other foreign bodies. Filtered water from the collecting drain of the filter passes directly into an outlet regulator chamber in which it rises to a height depending on the degree of clogging of the filter bed. In this regulator chamber is placed a Glenfield-Jones patent regulator which on being set fixes the rate of flow of water through the filter bed to that amount which has been decided on. The water passes down the patent regulator pipe and through a fourteen-inch cast iron pipe provided with a sluice valve to the filtered water conduit which has been built between the two batteries each of seven filters. From the end of the collecting drain a scour pipe provided with a sluice valve is arranged for the emptying of the filter bed when required. This scour pipe discharges into a fifteen-inch scour outlet which is common to all the filters.

In the filter beds as originally designed the filling was made up as follows :—

The first layer consisted of bricks laid flat and dry on the cemented floor from the side walls to the central collecting drain, spaces the width of a brick being left between the lines to serve as channels for the flow of water. Over this a second layer of bricks was laid dry and transversely to the first layer. This second layer was laid as close together as possible thus converting the spaces in the lower layer into covered drains which discharged into the central collecting drain.

On the top layer of bricks there were six inches of broken stone $\frac{3}{4}$ inch to two inches. Above this four inches of broken stone $\frac{3}{8}$ inch to $\frac{3}{4}$ inch and above this layer four inches of broken stone, $\frac{1}{8}$ inch to $\frac{3}{8}$ inch gauge. On this was placed four inches of coarse sand and above this was placed a filtering layer of two and half feet of fine sand. The total depth of materials in the filter was therefore four feet six inches. The scheme as originally designed contemplated a depth of water on the sand of two feet when a filter was first brought into use. The height of the side wall of the filter was to be seven feet eight inches which under the above conditions gave one foot two inches of wall above water level. Arrangements were made to fill the filter with filtered water from below prior to starting a filter. Both in the scheme as designed and in the scheme as executed the fine sand to be used for filtering purposes was such as would pass through a sieve of thirty meshes to a lineal inch and be retained on a sieve of fifty meshes to the lineal inch. That is to say the largest grain of sand used was less than ·71 millimeters and no grain of sand was smaller than ·39 millimeters.

In the scheme as designed thirty of Walker's patent sand washers were included in the estimate with the object the Committee understand of washing the sand prior to its first use in the filter beds. In carrying out the works these sand washers were not obtained. In Appendices A and B will be found copies of correspondence which has passed between the Committee and the President of the Corporation on the subject of the sand and stone filling of the filter beds. It will be noted that the sand and the bricks used in all the filters were not washed before being placed in the filters.

(*b*) *Method of working.*

The Committee made their first general inspection of the filter beds on the 14th January in order to obtain some general idea of the arrangements and the working of the filters. Of the fourteen filter beds ten were working, two were under cleaning operations and two which had been cleaned were ready for starting. The filter beds were in charge of an Overseer on eighty rupees per mensem. This Overseer stated he was a passed lower subordinate of the College of Engineering, Madras, and had been in charge since the opening of the filter beds in December 1914. He stated that he had an assistant who had passed some of the technical examinations, but possessed no other qualifications. The Overseer stated that six months after the filter beds were opened they became clogged and the top nine inches of sand was dug up. This sand was dug up with mamuties so as to allow the water to pass through the sand. This practice continued up to July 1917 and was apparently permitted by rule 7 of the new rules issued for the working of the filters, dated 25th October 1915 (Appendix R). Since July 1917 the filters have been worked in the manner described in the rules omitting the digging up of the surface of the sand with mamuties or rakes. The Committee were informed that twenty-four hours' settlement had been fixed from the results of the bacteriological examination of the water. They were also informed that no attempt had ever been made to determine the presence and uniform distribution of the filtering skin. The rules in force provide for the test of an efficient filtering skin by bacteriological examination of the filtered water but this cannot be done in case of every filter prior to starting because a bacteriological examination even if such staff were on the spot to carry out this duty would take forty-eight hours at least to complete the examination and during that time the filtered water would have to be run to waste.

On page 17, paragraph (*d*), the Committee will give a practical way of determining the formation of a filtering skin which can be carried out without having resource to a bacteriological examination of the water.

The top layer of sand which had remained in the beds from December 1914 till August 1917, and which had been periodically dug up with mamuties was removed for the first time after the latter date. This sand was then washed and replaced in some beds. This operation is proceeding. There was one mechanical sand washer in use which was being experimented with. The Committee observed that the sand obtained from this washer was too coarse in size—the silt and much of the finer sand was washed away in the sand-washing machine and a modification of the method adopted with this washer will be required. A brick platform which had been used for sand washing was inspected. This platform is not now in use.

The quantity of water from each filter is determined from the depth flowing over each of the two eighteen-inch weirs of the patent regulator in the outlet chamber. In the original scheme the quantity of water fixed on as obtainable from each filter was based on the rate of 450 gallons per square yard per day. This corresponds to a depth on the two weirs of $3\frac{1}{2}$ inches. At the date of the Committee's inspection the depth of water passing over the weirs was found to be three inches this amount having been fixed on six months ago. Formerly a depth of four inches and sometimes five inches was allowed. The filter bed is worked according to rule 4 which states that when it is no longer possible to get a greater rate of filtration of three vertical inches per hour the filter is stopped. The Committee would remark that this is a very vague rule to leave in the hands of an Overseer and that the usual way of judging when a filter bed is clogged is to observe the loss of filtering head as shown by the gauges in the filter water chamber and the usual standard fixed for waterworks in the Madras Presidency is when the head reaches twenty-four inches the filter is thrown out of action. This is a simple rule which is easily understood by the subordinate staff.

The method of cleaning a filter is described in paragraph 5 of the rules, Appendix R, and the Committee found that method was being followed at the time of their inspection. When the filtering sand gets reduced in depth beyond the amount given in rule 11, i.e., fifteen inches, the original depth is made up with washed sand. This depth in the opinion of the Committee is too little and the washed sand now being replaced is too coarse. Their recommendations on the subject will be found in sub-heading (4), page 45.

When anything unusual occurs in the rate of flow of filtered water from a filter in other words when the filtering head falls rapidly instead of rising the Overseer reports the matter to the Assistant Engineer who informs him to stop the filter and examine for defects. The Committee would remark that this is not a satisfactory way of dealing with this emergent situation. The official in charge of the filters should have the power to immediately put such a filter out of action without waiting for instructions.

During the working of the filters such breaks have occurred due to the action of frogs, crabs, fish, etc. These accidents in the Committee's opinion are not surprising considering that the inlet chamber of each filter is not provided with a screen.

It is more than possible that the break in the filtering head which occurs is due to the disturbance of the filtering skin, in addition to the above possibilities, by the presence of gas underneath the skin. This gas, as subsequently pointed out, is formed in the interior of the bed from the chemical action on the iron contents of the sand. In practice it is found that the filtering head gradually increases as observed up to about 20 inches when a break occurs the head being reduced to 10 inches. When the head is gradually increasing, say from 0 to 20 inches, we consider that during this period gas bubbles are probably forming under certain patches of the filtering skin and when a sufficient number has been formed to overcome the resistance of the skin, patches of the skin are lifted bodily off the sand by the upward pressure of the gas and through the bare patches of sand thus formed water passes more freely thus reducing the filtering head. When a break occurs in a filter bed—the bed should be immediately stopped—the filtering skin reformed by three days settlement and the bed restarted in the usual way. At this time special attention should be paid to the examination of samples of water bacteriologically and to the evidence of sulphuretted hydrogen in the filter outlet chamber.

The Committee observed that the garden staff drew water from the filters in earthenware pots to water the grass and shrubs in the compound. As precautions are taken to prevent contamination of the unfiltered supply in the Red Hills tank and in the conduit en route to the filters this method of obtaining water for the garden should be prohibited. A line of pipes can be provided for this purpose.

(c) *Results obtained.*

Each bed at the rate of 450 gallons per square yard per day filters 999,999 gallons daily. For the sake of simplicity this may be taken as 1,000,000 gallons. If the area of the regulating outlet chamber and the inlet chamber are taken into account the effective area of the bed will be decreased from 20,000 square feet to 19,880 square feet. A very slight increase in the rate of filtration per square yard will give the quantity filtered by each filter bed equal to a round million gallons daily. This is the rate for which the filter beds were designed by the original designer of the scheme. Since the beds were brought into use in December 1914 they have been worked at different rates varying from the standard rate of 4 lineal inches per hour to a maximum rate of 5 inches and even to $5\frac{5}{8}$ inches per hour, i.e., the filters have been worked to approximately 40 per cent more than they were designed for and more than the standard

usually adopted in the Madras Presidency for mufassal filters. This increase was brought about by the demand for water by the city. Instead of limiting the supply to the city to the quantity which the filter beds were intended to produce the system was forced in the endeavour to comply with the city's demands. The bacteriological results obtained from the analyses of the Madras filters were not only variable but also unsatisfactory, in many instances the results were worse than those obtained from unfiltered water showing clearly that the filters were inefficient. The Director of the King Institute of Preventive Medicine carried out a series of analyses on beds eight and twelve. They gave fair but varying results. The filters were worked on lines laid down by the Director of the King Institute and the period embraced was from the 5th February till September 1916. Prior to that regular experiments were conducted on beds thirteen and fourteen from the 8th November 1915 till 4th February 1916. The Committee do not think it will serve any useful purpose to examine in detail the results of the workings of these filters at this date. If there is one thing which has impressed the Committee more than any other ; it is the fact that in carrying out the experiments there was no proper co-ordination between physical inspection of the filter beds and scientific examination of the samples of water.

The results obtained from the analyses of the remaining filters were so unsatisfactory that at the request of the Corporation for enquiry the Government appointed the present Committee to report on the defects of the water-works and to show how these defects should be remedied.

(d) *Defects observed and proposals for improvement.*

At their inspection of the filter beds on 14th January 1918 the Committee observed ten filters had water in them and in the remaining four the sand was exposed to view. The Committee thereupon requested in the first instance that one of the sand filters should be excavated at one corner to the full depth so that inspection could be made of the floor, the bricks, the broken stone and the sand. This pit was dug in bed No. 4. Bed No. 13 which was being scraped was inspected and it was noticed that the filtering skin was not uniform but in patches. In filter bed No. 10 which was being filled with water it was found that the inlet chamber wall had been cut at the sides adjoining the filter bed wall. (Paragraph 2 (*a*) construction.) Evidence of the scouring action was observed in bed No. 4 and in other beds as they became empty.

At the request of the Committee arrangements were made to lower the water in a filter bed which was intended to be brought into use so that the Committee could decide by actual inspection of the surface of the sand whether a sedimentation of 24 hours was sufficient or not to form a proper filtering skin. They also brought to notice that this was the method to be adopted in determining the condition of the filtering skin of the bed and that bacteriological examination of the filtered water should follow in the usual course and that the actual starting of a bed should not await the result of the bacteriological examination. The bed under examination was prepared for starting in the usual way as given in rules for the working of filters, rule 2 of Appendix R. This rule, the Committee would point out, is unworkable. After the water was lowered in this bed the surface of the sand was inspected by the Committee and it was found that the filtering skin was unsatisfactory showing that a settlement of 24 hours was insufficient. It was thought that running off the water at the rate of $\frac{1}{2}$ inch per hour would not be so satisfactory as settlement for a longer period than 24 hours without running off. We would point out that the running of water through a sand filter bed prior to the formation of a satisfactory filtering skin is likely to spoil the subsequent filtration results because the contamination in the water is liable to penetrate deep into the sand of the filter bed. Instructions were therefore given that the filter bed should be filled to the usual height with unfiltered water and that this water should remain quiescent in the bed for a period of three days. An inspection at the end of this period showed that the filtering skin was now satisfactory and instructions were therefore given for this bed to be brought into use. The analyses of the filtered water from this No. 4 bed are given in Appendix 10.

This bed was brought into action and four days afterwards on 17th March the following bacteriological result was obtained:—

Unfiltered water.	Filtered water.
Colonies per c.c. 1,830	Colonies per c.c. 790
Lactose fermenters. Present in 5 c.c.	Lactose fermenters. Present in 20 c.c.
No vibrios in 100 c.c.	No vibrios in 100 c.c.

Twelve days later on 29th March 1918 (Appendix 10) it gave the following :—

Unfiltered.	Filtered.
Colonies 460	140
Lactose fermenters in 5 c.c.	None in 60 c.c.
No vibrios in 100 c.c.	No vibrios in 100 c.c.

Nine days later the following result was obtained (Appendix 12).

Unfiltered.	Filtered water.
Colonies per c.c. 1,350	160
Lactose fermenters in 1 c.c.	None in 60 c.c.
No vibrios in 100 c.c.	No vibrios in 100 c.c.

The Committee would remark that apart from other defects this bed experimented on by the Committee gave efficient results in purification of the water. From their study of the Madras filter beds the Committee have come to the conclusion that the principal reason why efficient results are not obtained from the filter beds is due in part to the unsatisfactory formation of the filtering skin on the surface of the sand of the filter bed. The operation of forming a filtering skin on a filter bed is one which requires the greatest care and the operation should not be left to the subordinate staff. Instructions for the future working of the filter beds are given in sub-heading (4), page 46.

One of the defects from the starting of the works has been the persistence of the smell of sulphuretted hydrogen in the filtrate. It is believed that every endeavour had been made to find out the cause of this and no definite conclusion had been arrived at prior to the appointment of the Committee. The problem of this defect confronted the Committee and at first sight no easy solution seemed forthcoming. They determined to examine the filters in detail and leave no part unexamined. To carry out this several of the filter beds were excavated down to floor level and the contents examined. It was found that to a depth of 3 inches the sand lying in the floor of bed No. 4 in one of the corners had become impregnated with black silt. This silt smelt strongly of sulphuretted hydrogen and apparently extended uniformly round the filter bed to a breadth of three feet, i.e., the width of the floor not provided with bricks and broken stone. No such silt was found in the sand overlying the broken stone and bricks nor in the latter in this pit. Several pits were dug in bed No. 13 and the same conditions were observed. The bricks and stones in the filter bed were found to be quite clean. In a pit in the centre of bed No. 13 black silt was found to a depth of $2\frac{7}{8}$ inches. This silt was not so concentrated as in the marginal pits. In other filter beds this silt was not found in the centre but was always present in the margin. Samples of the black silt were taken and were sent to Dr. Simonsen who examined them. His report will be found in Appendix S_3.

It will be noticed that the silt sample contained 'a relatively considerable quantity of sulphide' and that there is 'the merest trace of sulphate in the sand from the centre of the beds and no sulphide the

black specimens contain sulphate especially after exposure to sunlight and air.' In paragraph 2 of his report Dr. Simonsen states 'from these experiments it would appear that lack of aeration is the cause of the black colour and it would disappear if there were no dead ends.' Dr. Simonsen was kind enough to examine a sample of the filtered and unfiltered water, his report is given in Appendix S_4. The general conclusions to be made from Dr. Simonsen's experiments are that the sulphur from the organic matter acts on the iron in the sand contained in the filter bed to form black sulphide of iron. In the centre of the bed this sulphide becomes oxidised into ferrous sulphate which is readily soluable in water and which passes away in the filtered water. At dead ends, i.e., when there is not free draw off of water by the under drains, the water is retarded by the fineness of the sand there present, and the black sulphide of iron accumulates to form the deposit found at our inspection.

We consider this stagnation of water is caused by the unusual construction of the Madras filter beds. Instead of extending the broken stones and brick underdrains to the walls of the filter bed these underdrains and the stones have been stopped three feet from the walls and water in order to escape has to pass through this additional thickness of fine sand before reaching the underdrains. The flow of the water here is therefore retarded or in other words there is stagnation as compared with the other parts of the filter bed. This peculiar construction of the Madras filter beds was, we understand, intended to prevent creep of unfiltered water down the walls of the filter beds. In a filter bed where a filtering skin is carefully formed and preserved there can be no creep down the side walls. Experiments were conducted at the experimental filters at the King Institute of Preventive Medicine to test the amount of creep if any which occurs in a filter bed. The experiments showed that this did not occur and we think the possibility of creep of unfiltered water in a filter bed is a problem which has never been proved to exist in a well-regulated filter bed and which the King Institute experiment has disproved.

The Committee are of opinion that if the broken stone and brick underdrains are extended to the walls of the filter an important step will have been taken to solve the problem of eliminating the smell of sulphuretted hydrogen from the filtered water.

The thickness of the layer of broken stone in the Madras filter beds including a coarse sand layer of 4 inches was 18 inches in the original scheme. See plan No. 3. In the scheme as executed this provision has been cut down to 6 inches including a coarse sand layer of 2 inches. See plan No. 4. We are aware that the trend of opinion of the proper thickness of broken stone layer in a sand filter bed is in favour of reducing it to a minimum on the plea that this layer serves only the purpose of supporting the superimposed fine sand filtering layer. While admitting that this is an important function of the broken stone layer we are convinced that another important function of this layer is to facilitate the passage of filtered water from the sand layer to the underdrains and that consequently the thickness of this broken stone layer cannot be unduly reduced ; especially is this so with the treatment of a water like the Madras water which contains a high organic matter content. We consider that the extension of the brick drains and broken stone layer to the walls of the filter is immediately essential removing at the same time the sand impregnated with black silt and substituting clean sand. In addition when all the sand of a filter bed is removed for periodical renewal it would be advisable to increase the thickness of the broken stone 6 inches. The increased thickness should be composed of stone $1\frac{1}{2}$ inches to $\frac{3}{4}$ inch. See plan No. 5.

When the recommendations above mentioned are given effect to, we think that in all probability the presence of crenothrix growth which is a feature in the filtered water and the unpleasant smell of sulphuretted hydrogen will disappear.

(e) Note on the interpretation of results.

The Committee desire to remove a misapprehension which seems to exist amongst Municipal Commissioners and the general public with reference to the interpretation of the results of bacteriological analyses and the numbers of bacteria present in the Madras drinking water.

Bacteria are of two kinds—pathogenic and non-pathogenic, that is, harmful and harmless. There are two diseases of the first kind, enteric and cholera, of which there is evidence that contaminated drinking-water is the cause. Observers all over the world have proved by experiment that waters containing many bacteria are more deadly to typhoid and cholera germs than those with few microbes. In the former—the Red Hills waters is one of these—typhoid bacilli survive for 9 to 13 days, while in deep well waters which contain few bacteria they may live as long as 39 days. Thus in the presence of these harmless bacteria in surface waters or at any rate under the conditions concomitant with the presence of bacteria in surface waters, powerful agencies are at work, limiting the longevity of pathogenic bacteria. So the presence of these harmless bacteria play an important part in water purification. No standard can therefore be set up as to the quality of a water based on the *number* of bacteria which the water contains. In recent experiments at the King Institute it has been shown that 98 per cent of the bacteria which pass through a sand filter are spore bearing. There are no spore bearing microbes associated with intestinal diseases, therefore these microbes are harmless. Further in water containing lactose fermenters in over .5 c.c. and upwards and a total count of under 1,000 colonies per c.c. the isolated organisms are nearly always of the comparatively inoccuous type.

Lactose fermenters are found in the discharges of man and animals and are therefore used as indicators of pollution of the water by intestinal microbes. At present we are unable to distinguish between water which has been contaminated by sewage and water which has been simply in contact with agricultural land and this must be remembered when results of analyses are being interpreted.

Filtration is not merely a mechanical straining, it is much more than this, for the efficiency of a filter depends on the formation of a filtering skin on the surface of the sand which holds back the bacteria.

By bacteriological analyses we can state definitely whether this filtering skin is working, i.e., whether it is holding back these lactose fermenters or intestinal germs efficiently or not.

If the reduction in numbers of intestinal germs is satisfactory we say the filters are efficient and should any accidental pollution such as cholera or typhoid germs gain access to the water and should they survive the natural forces at work in the Red Hills lake, they would ultimately get entangled and destroyed in an efficient filter.

Bacteriological tests showing unsatisfactory results indicate that something is wrong and that an investigation is necessary. The bacteriological analysis shows whether and to what extent bacteria have been removed from the water by filtration; and the proportion of lactose fermenters present is the indication of the degree of purification that has taken place.

The Committee are of opinion that it would be well if in future such terms as foecal bacilli, lactose fermenters and number of colonies per c.c. were not issued in statements which are intended for the public. The degree of purification obtained by filtration such as two-fold, three-fold, etc., might be given by the Director, King Institute, Guindy, and a statement whether the water was fit for drinking purposes or not. Nothing else is required by the public.

The bacteriological analyses ordered at intervals by the Committee were undertaken with a view to find where deterioration in the water occurred and to verify defects observed on inspection. It will be seen on reference to the minutes of the Committee's meetings that on more than one occasion their anticipations in this respect were justified by subsequent analyses. The Committee would emphasise the importance of inspection as well as bacteriological analyses. The former in itself supplies information which need not require a bacteriological expert opinion, whereas a single bacteriological examination is of little value without an inspection.

A bacteriological analyses to be of service must be taken daily throughout long periods as climatic and other conditions vary from day to day.

Last year some hundreds of samples of the water-supply of Madras were taken and examined at the King Institute but had they been accompanied by a close inspection of the water-supply system, some of the defects the Committee have now brought to notice would have been detected.

Vibrio test.—The recent researches of Major Greig, I.M.S., have proved that more than one species of vibrio produces Asiatic cholera and that at least one species of an initially harmless water-vibrio has been found under certain favourable conditions to become pathogenic in character. The vibrios reported as occurring at the beginning of our investigations have not been found in the Madras water since our inspections started nor have they been discovered since. No untoward or unexplained outbreak of epidemic disease occurred in the city during the time they were reported to be present in the water. The period synchronised with a time when the water at the Red Hills was showing a high standard of purity (see Appendices 1 and 2). This leads us to think that the vibrios found were of the harmless kind. Under the circumstances, however, the Committee do not feel they are in a position to give a decided opinion on the value of the vibrio test, but they would point out that biological conditions that favour the presence of one sort of vibrio may be equally favourable to the propagation of the cholera vibrio. The necessity of filtration which keeps back such vibrios is therefore evident.

(f) Filtering sand.

The sand used in the Madras filter beds is stated to have been screened to pass through a sieve of $\frac{1}{30}$ inch mesh and to be retained on a $\frac{1}{50}$ inch mesh.

In Appendices S1 and S2 will be found the results of the mechanical analyses of the sand actually in use in bed No. 6 and also of the sand which is now being filled in the beds after washing. These analyses do not agree with the statement given above. A perusal of the results will show that only 38 per cent of the sand in use passed through a screen of 30 meshes to the lineal inch instead of 100 per cent. The sand is therefore coarser than it was intended to be and the Committee would remark that the relative fineness of sand used in slow sand filtration is of great importance in waters like the Madras Red Hills water where the raw water receives good sedimentation so that the water passing on to a filter bed is comparatively clear. It will therefore be necessary in order to achieve the best results to screen the sand again and remove from it the coarser sand which is retained on the mesh of $\frac{1}{30}$ inch before the sand is replaced in the filters.

The sand used apparently came from the bed of the river Cooum opposite the seventh milestone on the Poonamallee Road. We do not think that it is desirable to take sand from such a place, as the river bed is liable to pollution. It is necessary in all cases to wash sand which is intended to be used in a filter bed. From a letter received by the Committee and attached to this report it is observed that only "a small quantity of the sand was washed at Kilpauk and that no appreciable benefit was obtained." "The only washing most of the sand received was before the filters were first put into use, when the water was allowed to run through them until it was perfectly clear." The Committee have noted this statement with surprise and they observe that it is not a question of the clearness of the filtered water in this case, but a question of the washing of the sand of all impurities prior to its use in a filter bed. Unfortunately the sand used contained a small percentage of iron and owing to the high albuminoid ammonia content of the Red Hills water this has been prejudicial to the working of the beds. The Committee do not think that it has been anywhere usual in the past to chemically analyse the sand proposed to be used in a filter bed but from this study of the Madras water conditions they recommend that this analyses should invariably be carried out for all water-works in future and the results should be studied side by side with the chemical analyses of the raw water proposed to be used and it should then be decided whether any metals or salts exist in the sand or in the water which on contact would form an undesirable combination. More especially is this desirable if facilities for deposit exist such as "dead ends" causing or likely to cause accumulations of silt in the system.

Appendix S_5 gives the chemical analyses of two samples of sand from one of the filter beds. This sand which is of a reddish brown tint contains an appreciable amount of oxide of iron which is acted on by the sulphur from the albuminoid nitrogen to form sulphide of iron which is of a dense black colour. This black colour fades away if exposed to air and this explains the reason why the sulphide is absent as a rule from the middle of the bed but exists in the "dead ends".

It has been found by experiment that the sulphide turns to sulphate on exposure to air but is liable to return to sulphide in dead ends.

As it would cost a considerable amount to replace all the sand in the filter beds we think that opportunity should be taken when rescreening the sand, which we have already advised, to have it thoroughly washed so as to clear it as much as possible from the remaining iron oxide left in it. The sand required to replace loss due to screening operations, etc., should be such as contains little or no iron oxide and the Committee would point to the white sand of Tiruvottiyur as being a suitable source. The Committee recommend that sand washers of the type included in the original scheme should be obtained and fitted up.

During their inspection the Committee noticed that the heaps of spare sand were not well arranged with reference to the size of the compound and the location of the filter beds. They would recommend that as the operation of washing and screening sand is an important one, that the washers and heaps of sand should be so located as to be easily manipulated, and to facilitate the transport of the unwashed and washed sand, a regular and complete system of tramways should be laid down so that the unwashed sand can be transported to the washers and then returned and deposited in the beds with the minimum of labour.

The Committee note that the broken stone layers were washed before being placed in the filter beds, but that the bricks were not washed. After this lapse of time they do not think it necessary to wash the bricks now, but if any filter bed is at any time completely replaced with filtering material all such material should be carefully washed or re-washed before being placed in the bed.

(g) *Inlet Chamber to filter beds.*

This chamber consists of a semi-circular cistern, 5 feet radius and 5 feet deep. Water enters this chamber by a 14-inch horizontal cast-iron pipe provided with a sluice valve. In the original design the wall of the inlet chamber was level throughout, but subsequently this wall was cut down to the level of this 14-inch pipe at the junction of the wall with the filter bed wall on each side. It was noticed that owing to the velocity of approach of the water the surface of the sand in the filter bed was scoured and consequently the filtering skin must be disturbed when this scouring takes place. It is understood these two cuts at the ends of the chamber

were made with the object of overcoming the weir action of the water as it fell on the sand during the filling of a filter bed. The Committee consider that the arrangement of the inlet chamber should be modified as follows: The level of the top of the wall of this chamber should not be higher than 6 inches above the level of the sand of a filter bed when it is first brought into use and in starting a filter it should be filled to the level of the top of this wall with filtered water from below. As the level of the inlet pipe to the chamber is unusually high as it is near the level of the top of the chamber wall the velocity of approach of the unfiltered water into the chamber is not sufficiently reduced by contact with the wall owing to the insufficient height of the latter.

To overcome this defect the Committee consider that a right angle bend pointing downwards should be placed on the inlet pipe. The result of this will be that the force of the water will be broken on the floor of the chamber and the water will rise evenly without apparent velocity over the whole area of the inlet chamber and will enter a filter bed without disturbing the surface of the sand.

The Committee are of opinion that a number of frogs, crabs, fish, etc., obtain entrance into the filter beds with the raw water through the inlet chamber and that it is essential to provide suitable screens on the top of the wall of the inlet chamber throughout its whole length. These screens must be kept in thorough order.

(3) OUTLET CHAMBER AND CONDUIT.

The filtered water drain in the floor of the bed passes into the outlet chamber and the water rises in this chamber to the same level as the water in the filter bed when this is first brought into use. In this chamber there is a patent regulator (Glenfield-Jones). This is provided with two floats supporting a weir box containing two 18-inch weir plates one on opposite sides of the box. A brass pipe is attached to the bottom of the box and this pipe slides vertically inside a fixed pipe connected to the filtered water conduit. There is a screw arrangement for adjusting the depth of the edge of the plate of the weir below the water level in the chamber. This depth is adjusted in inches so as to give a predetermined rate of discharge from the filter bed. As the thickness of the filtering skin increases, the height of water in the outlet chamber falls. As this water level falls the floats of the regulators also fall simultaneously so that the depth of the edge of the weir plate below the water level remains constant. The rate of discharge of a filter bed is thus automatically controlled. The filter beds were intended to be thrown out of action when the filtering head increased to 2 feet. The Committee found that this depth was not being adhered to and that the filters had been worked to much greater depth. They advised that the depth of 2 feet should not be exceeded.

If any undue friction occurs in the telescopic pipe or in the guide rods of the weir box and the guide pulleys connected therewith, the weir level does not accurately fall as intended by the designers of the patent. The usual faults found with this arrangement are want of care in erection, resulting in telescopic arrangement, guide rods and pulleys being "out of plumb" causing undue friction and "sticking" of the apparatus. Evidence of these defects was found by the Committee in some outlet chambers and owing to presence of water in the chambers further investigation was not possible. These defects should be corrected.

The regulating chambers are provided with doors and window openings, the flooring is teakwood planks. As this is a filtered water chamber the Committee would remark that the doors and window openings should not be kept constantly open but on the other hand should be kept closed unless when absolutely required to be opened for setting the valves. The door and window openings should be filled with gauze doors in teakwood frames. The gauze should be of mesh $\frac{1}{30}$ inch and these gauze doors and windows will prevent the entrance of dust while at the same time providing the necessary ventilation to the chamber. The entrance of all persons except those required to set the valves should be prohibited. The Committee noticed with surprise that in a general way all the doors of all the regulating chambers were left open and if a chamber door is opened it is left open and not closed properly. The importance of these precautions does not appear to be sufficiently realized.

The overseer in charge has daily to note the increase in the filtering head and the Committee consider this note should be made on a form on a board which should be hung up in the chamber itself so that inspecting officers can readily obtain information on this important point. The Committee would prefer that arrangements be made for reading the gauges without it being necessary for one or two men to walk over the teakwood floor of the outlet chamber. There should be no difficulty in arranging this simple precaution by fixing the gauges outside instead of inside, as at present and if this is carried out it would obviate the necessity of opening the gauze door of the regulating chamber daily.

Scour.

A 15-inch scour pipe provided with a sluice valve is provided for each filter bed in connexion with the main drain in the floor of the bed. These scour pipes discharge into a scour conduit consisting of a pipe covered with concrete.

OUTLET FILTERED WATER CONDUIT.

Filtered water from each regulator chamber passes into a filtered water conduit made of masonry of dimensions 5 feet by 4 feet. This conduit discharges into the underground clear water storage tanks. There were no means of access to inspect this conduit. The Committee would emphasise the necessity of having means of access for inspection to all parts of the works, which should be regularly examined at stated intervals for possible defects, such as leakage, deposit of silt, etc. When a masonry work intended to contain water is cleaned it should receive a coating of cement wash.

(4) CLEAR WATER RESERVOIRS.

There are three filtered water reservoirs, each $150' \times 150' \times 10'$. It was originally intended to build four, but only three have been constructed. The fourth is to be constructed when the growth of population requires it. Water from filtered water conduit enters each reservoir through a 30-inch cast-iron pipe. The outlet is from the opposite side of the reservoir through a similar pipe. The Committee observed during their inspection that the west reservoir was being supplied with unfiltered water. The central and the east reservoir are supplied with filtered water. The Committee desired to inspect one of these reservoirs and arrangements were made to have one emptied. It was found necessary to use two temporary pumping engines to do this as the main pumps were unable to do it owing to the fact that the suction pipes were too high for this purpose. On a subsequent inspection the Committee found there were still 18 inches of water in the central reservoir so that they were unable to enter the reservoir and make a detailed inspection. As far as could be seen this reservoir was quite clean. It was reported however that it had been cleaned out only three months previously. The Committee think that the main pumps should be capable of emptying any reservoir at any time when required for the removal of deposit and that there should also be a scour at a level sufficient to empty the outlet chambers from each reservoir. The necessity for cleaning out the filtered water reservoirs is proved by a glance at the results of analyses from them (Appendices 4, 7 and 10).

The Committee did not insist on emptying all the reservoirs owing to the difficulty of emptying them and the loss of filtered water to the City involved in doing so. By testing the west clear water reservoir the Committee were satisfied that this contained silt. This is not surprising as this reservoir is supplied with unfiltered water from the Red Hills conduit in which the sediment in the water must be deposited. The Committee noticed that the level of the soil on the top of the reservoir roof was the same as the level of the compound of the water-works. They consider that it is advisable to have the level of this soil raised above the compound level so as to prevent soakage of storm water. The covering should be sloped so as to lead off the storm water from the roof. Subsoil drains should have been laid when the reservoir was constructed, on the masonry roof, so as to drain away storm water penetrating the soil into the scour outlet thus preventing collection of water on the roof and the possibility of leakage into the filtered water in the reservoir. As the roof is made of jack arches supported on rolled steel beams this subsoil drainage is also required to prevent the rusting away of these beams in course of time, and also to reduce the weight on the roof.

(5) SUPPLY PIPE TO PUMPING STATION.

Water is led from the clear water reservoirs to the suction conduit of the pumping station by means of a masonry conduit into which 30-inch cast iron pipes, one from each reservoir discharge. There is a sluice valve on each of these pipes for regulating purposes.

The following are the levels from the clear water reservoirs to the pumping station :—

Level of floor of clear water reservoir	27·00
„ still of cast iron outlet pipe	25·50
„ inlet steel pipe (invert)	25·11
„ invert of suction culvert of pumping station	23·17
„ foot valve of suction pipe of pumping do.	26·17

These levels show that the conduit from the clear water reservoir and the suction culvert of the pumping station form a catch pit for the collection of deposit. For instance, as the level of the foot valve of the pump is 26·17 feet and the level of the invert of the suction culvert of the pumping station is 23·17 or 3 feet below the foot valve level there will always be 3 feet of water in this culvert and it will form a receptacle for objectionable deposit. Similarly in the supply conduit to pumping station the level is given as 25·11 and as this is less than 26·17, the level of the foot valve, there will be deposit in this conduit.

(6) SUCTION CULVERT AND SUCTION PIPES OF PUMPS.

The water from the clear water reservoirs is conveyed under the pumping station where it enters a suction culvert consisting of three compartments 10 feet apart, the connecting culvert being 5′ 6″ wide. Each of these compartments is 9′ long and 12′ 3″ wide. Each of these compartments is intended to contain a suction pipe from the Worthington pumps in the floor above. The bottom level of the suction culvert is 23·17 on the plan supplied to the Committee by the President. The level of foot valve of each suction pipe is 26·17 or 3 feet higher than the bottom of the culvert. No scour pipe has been provided to empty the suction culvert so that the lower 3 feet is likely to contain deposit. The Committee tested the central compartment for deposit and found none. The suction culvert is ventilated by two openings carried to the floor of the pumping station and provided with guard rails. The Committee would observe that the practice of providing suction chambers or pump wells underneath the floor of pumping stations is not now considered advisable since the introduction of the bacteriological analyses of water which is so delicate as to show at once even the slightest contamination. When pipes pass through masonry and are subject to vibration, cracks invariably occur at the junction of the pipe and the masonry and through this opening lubricating oil, wash water from the floor, etc., is likely to obtain access to the filtered water in the suction chamber. There is vibration of the floor caused by the large engines in use and the Committee recommend that three separate and independent pump wells, 10 feet in diameter, one for each pumping engine should be sunk outside the pumping station building where space is available for the purpose.

(7) STEEL TANK.

The capacity of the elevated steel tank is one and a half million gallons which is approximately two hours' supply for the population for which the water-works have been designed, viz., 660,000 at 25 gallons per head per day.

The tank is 104 feet in diameter and 28 feet deep and the bottom of the tank is 38 feet above ground. It is provided with an overflow and a central roof ventilator. The inlet to the tank is a 36-inch pipe branching off the 48-inch steel main to the town. The tank is intended to serve as a balancing tank to safeguard the pumps from fluctuation in pressure due to variable draw off in the town. It also serves as a small storage tank as stated above, its capacity being equal to two hours' supply.

There is no separate outlet pipe for the tank, the inlet and outlet being combined in one pipe. In order to empty the tank for examination and cleaning purposes it would be arranged to shut the inlet 36-inch valve when the water in the tank was at its lowest level. The remaining quantity of water in the tank would be run to waste through a 9-inch scour pipe which is provided for the purpose as a branch at ground level off the 36-inch inlet and outlet on the tank side of the 36-inch sluice valve. So far as the Committee could see the tank is well built and in good condition on the outside. The Committee, however, would point out a defect in its design and arrangements which might have a bad effect on the quality of the water supplied to the town. The defect is this, the tank has a level instead of a dished floor, the level of the combined inlet and outlet pipe is 78·25 and the level of the floor is 78. The difference of 3 inches cannot be run off when the tank has to be cleaned and no ordinary means can effectively remove the whole of the water remaining in this 3-inch space. If the tank had been slightly dished, say to the small amount of 6 inches at the centre and a scour pipe provided here the tank could have been drained dry during the cleaning operations. The Committee would here remark that since the bacteriological examination of water has been introduced as a standard test of the quality of water supplied to a town, it is essential that all parts of a water-works system supplied with filtered water should be periodically scoured out and that facilities for this scouring must be provided. As the tank has been constructed it is not easy now to suggest a remedy for the above defect, the Committee can only suggest that there should be six scours distributed over the flat bottom of the tank with their inlets at floor level. During cleaning operations the tank must be drained as dry as possible and water pushed towards the six scour outlets using rubber rakes. The bottom of the tank should then be disinfected using chlorinated solution, any excess of this solution being got rid off by washing out with filtered water from the inlet. The inside of the tank must be carefully watched for deterioration in the steel plates and it should be painted with bitumastic solution to preserve the plates.

When first used after painting it should be filled with water from the inlet pipe, this water should be allowed to stand for sometime then the water should be run to waste in order to get rid of the smell of the bitumastic solution. In order that the inside of the tank should be clearly visible during the periodical inspections arrangements should be made for sufficient electric lights. In this connexion the Committee would point out that when electric light is available at the pumping station portable cables and lights should be used for the thorough inspection of the inside of filter water conduit, clear water reservoir, pump wells or suction culverts and the inside of the elevated tank. The use of flares is objectionable and also ineffectual.

(8) COMPOUND.

The main entrance road is satisfactorily maintained and it has an agreeable appearance. The Committee understand that a new main road is contemplated to run between the open channel and the Lunatic Asylum on the line of the 48-inch steel main. This will afford facilities for the carting of coal to the pumping station without passing near the filter beds. In addition the traffic will be diverted from the filter beds to a great extent. Part of the compound is ear-marked as a site for seven more filter beds. The Committee have already remarked on the provision of tramways, sand washers and the keeping of the heaps of sand in a more tidy and concentrated manner. It would be well to provide stone platforms for the coal so that it could be neatly stacked. In the north-east corner there are quarters for the subordinate staff. The Committee recommend that the north-west corner should be utilized as a site for an Engineer's residence.

D. DISTRIBUTION.

(1) PIPES.

Water is delivered to the City from the Kilpauk Pumping Station through a 48-inch steel main as far as "the shaft" at the end of the old open channel which formerly supplied Madras with water from the Red Hills tanks, a distance of 4,000 feet. Here the supply is divided into three mains, a 42-inch cast iron main, which supplies Purasawakam, Georgetown, Tondiarpet and Triplicane. The second main of 30 inches supplies Nungumbakam and Mylapore. A third main, 18 inches in diameter, supplies Perambur.

On Friday, 8th March, the Committee met at "the shaft" and examined the pressure gauges on the mains. They found the pressure at 8 a.m. was 35 feet. They then proceeded to the pumping station and examined the automatic recorder. The pressure at the pumping station was found to be 43 feet at 8–20 a.m. The difference of 8 feet was due to the regulation of the sluice valves at the shaft. The diagrams of the recording apparatus showed that the engine stopped working between 10–30 p.m. and 3 a.m. At 10–30 p.m. there is usually $20\frac{1}{2}$ feet of water in the elevated tank. From 10–30 p.m. to 3 a.m. the water in this tank falls to 10 feet.

The engines are then started and the pressure at 5–30 a.m. is 8 feet above the bottom of the tank. At 8 a.m. there is still 8 feet of water in the tank corresponding to a pressure of 43 feet at the pumping station and 35 at "the shaft". The maximum pressure when the tank is full, i.e., when it holds $27\frac{1}{2}$ feet of water is $62\frac{1}{2}$ feet. These pressures are measured from the basement level of the tank building. The discharge of the pumps at 8 a.m. is at the rate of 1,325,000 gallons per hour. At 10 a.m. the discharge falls to 800,000 gallons per hour owing to the reduction of draw off by the town.

The three mains mentioned above are gradually reduced in size by the taking off of branches to supply the various streets of the City. A scheme has been drawn up and sanctioned for enlarging, adding to, and re-arranging the distribution pipes, the principle aimed at is that no distribution pipe should be less than 4 inches in diameter but owing to various causes this has had to be departed from and a number of the old 2 and 3-inch pipes after being cleaned of deposit and repainted have been put into use again. As the old supply of water to the City was from an open channel and this water was not filtered most of the old pipes were seriously reduced in calibre owing to deposit. No attempt at scouring such pipes could be successful under the former conditions as the pressure available was insufficient and there were few scour valves provided.

The pipes are cast iron pipes. Some of the old pipes have burst and have had to be replaced and the joints of these old pipes have given a considerable amount of trouble.

(2) SLUICE VALVES, SCOUR VALVES, FIRE HYDRANTS AND SPECIALS.

Sluice valves are provided on branches from the mains as usual for the purpose of regulating the draw off. The new distribution scheme includes provision for sluice valves on mains, these valves being of less diameter than the mains themselves. This has been done because the cost of the smaller sized valve is less; the depth at which the mains have to be laid is considerably reduced and this saves in the cost of the laying. Bye-passes are unnecessary with the smaller valves. Hydrants are provided in the new distribution scheme not more than 300 feet apart subject to the condition that they should be in the neighbourhood of important buildings, they are also provided at street inter-sections. The type of hydrant proposed to be used is the sluice valve hydrant with post extending 3 feet above the ground level. This type of hydrant was adopted, it is said, as the formerly used ball hydrants at road level were sanitarily objectionable because they allow the road washings and other impurities to enter the main. As far as the Committee are aware none of these new hydrants have been erected.

Scours.—These are termed wash-outs in the new distribution scheme and they are stated to have been provided "at every depression on trunk and leading mains to allow the pipes to be emptied and cleaned out." On the distribution mains it is stated in the report on the new distribution scheme that "wash-outs are not required" as "the hydrants will serve as wash-outs."

These hydrants are for fire purposes, road watering and in the smaller distribution mains they are intended to serve as scour pipes. The size of all hydrants are the same in order to fit the fire hose. The diameter available for scouring purposes is 2½ inches.

(3) HOUSE CONNEXIONS.

(In the City there are at present 29,000 house service connexions. Of this number only 900 are metered and of the 900, 102 are Government buildings. The total amount collected during 1916–17 for water supplied for non-domestic purposes, which include the excess water consumed over the free allowance, was Rs. 1,52,717. The rate charged for the excess water was 12 annas per 1,000 gallons and the free allowance was calculated at the rate of 160 gallons per month for every rupee of the monthly rental subject to a minimum of 3,000 gallons a month.

The Committee note that the old rate for excess consumption of water was also 12 annas per 1,000 gallons when the supply was a gravitation one from the Red Hills and unfiltered. Considering that an enormous expenditure has been incurred in carrying out the new water-works and a large annual expenditure is necessary in pumping the water to the City after filtration, the policy of continuing to charge the low-rate of 12 annas per 1,000 gallons for this service seems to require early consideration. An increase in the charge would not only tend to reduce waste but would tend to obviate the necessity for new works such as additional filter beds, etc.; at least the date when such works would be required would be deferred. The Committee therefore recommend the early adoption of a revised rate and they also recommend the introduction of differential rates, for instance, a large consumer of water for essential industrial purposes, we think, might receive more favourable terms than the case of the consumer of water for gardens.

The house connexions as a general rule are made of galvanized iron pipe. The old pipes are not specially protected but the rules for new

pipes require them to be wrapped with tape dipped in composition. The authorized sizes of these house connexions are from ½ inch — 2 inches, the smaller size being intended for a second-class service with one tap and no meter.)

(4) METERS.

(Meters are intended to be fixed on all first-class services, the meter being hired from the Corporation. For a ¾-inch connexion the rate charged is Rs. 1–4–0 per mensem. The President of the Corporation may fix meters on house connexions irrespective of the class of service. The question of the fixing of meters on house connexions has been gone into under other paragraphs of this report. The Committee have been much impressed with the small number of meters fixed in the City compared with the number of house connexions and they think that the distinction between first and second class services should not limit the number of meters which should be decided on the more practical basis of whether a house connexion first or second class uses or may use more water than the free allowance.)

(5) INSPECTION BY COMMITTEE.

On 8th March the Committee carried out their first inspection of the distribution system when they started from Kilpauk and inspected the first part of main No. 1. The first thing noted by the Committee was that certain houses in the Purasawakam High Road had no meters fixed to their house connexions. These houses have taps in the gardens. In one instance a plot of guinea grass was being irrigated and the tap was fully opened. In another case water was being used for irrigating flower beds. The Committee consider that all houses of any size especially those with gardens should be metered. They consider that either all taps in gardens should be prohibited or that such taps should be separately metered and double the excess rate should be charged, no free allowance being given for a garden supply. The Committee would remark that it seems absurd to limit irrigation at the Red Hills and at the same time filter the water and pump it at considerable expense into the city and permit its use for irrigation of gardens at a low-rate. On the other hand as the recommendations of the Committee would probably mean the introduction of wells and re-opening of old wells it will be necessary to use precautions to prevent the breeding of mosquitoes in these wells. The use of all wells should be regulated in the following manner. They should be effectively covered and fitted with pumps. The Committee cannot too strongly impress on those concerned the necessity of avoiding the possibility of further breeding of mosquitoes within the City area and consequently the use of wells must be under the strictest supervision not only by the Corporation but by the people themselves and such regulations as may be issued must be supervised and effectively controlled by the Health Department.

The Health Officer should be required, each year, in his annual report to certify that the regulations for the use of wells have been strictly followed.

It was stated that the staff for looking after the distribution in the city consisted of—

3 Foremen on	Rs. 80—150
10 Overseers on	Rs. 40—50

There were two foremen present at the Committee's inspection and also overseers. These men informed us that they had no rules to guide them in maintaining the distribution system in an efficient condition. They were, however, provided with a water-work's handbook which on inspection was found to contain rules for the provision of house service connexions, their repair and for the reading of meters. The staff informed us that they had no written or printed directions for opening scour valves or as they were termed in the City wash-outs.

In fact one overseer stated that he only opened the "wash-outs" when the people complained of the smell of the drinking-water. On the plan supplied to the Committee a certain number of wash-outs are shown. The number in the opinion of the Committee is quite inadequate even if the fire hydrants are assumed to be of any use in mains of over 4 inches in diameter for the purpose of scouring the pipes.

In Purasawakam High Road there is a 14-inch "wash-out" on the 42-inch main, this after nearly half an hour's delay in obtaining keys was opened and the water was found to be clean. The Committee will refer later to the question of sizes and number of "wash-outs".

The Committee were informed that opposite the Ganesha Kovil tank there was a 9-inch scour or wash-out on the 36-inch main. This discharged into the tank below water level. This valve could not be opened on account of the road metal being heaped over it. The Committee express surprise at the continuation of this arrangement as the chance of the dirty tank water getting back into the mains when they are empty must be admitted and is more than a possibility. The Committee were unable to carry out any further inspection owing to a misunderstanding on the part of the staff who were not prepared for an inspection on this line and according to their own statements had been up late the night before opening the scours on the Nungambakkam main.

It appears to the Committee that there is a want of system in the arrangements for providing keys for opening valves and other specials of the water-works. The keys are apparently kept in a divisional store at some distance from the place where they may be required. At night these stores are supposed to be looked after by a watchman but the keys of the premises are not in his possession. Consequently if a valve had to be shut during the night owing to a burst in the main it would be necessary first to find the overseer of the section, who would then have to find the Divisional Storekeeper for the key. In the event of one of the employees being absent serious consequences might arise from delay in cutting off the supply.

The Committee would suggest that in convenient places in each of the ten overseers' divisions of the city there should be built by the road side a small but ornamental store shed of dimensions 6′ × 6′ in which all the different sizes of keys required in that section of the town would be placed in racks. The key of this store would be a master key which would open similar divisional stores in the city and these master keys should be supplied to head turncocks overseers, foremen, assistant engineers and water-works staff generally.

On the 9th March the Committee inspected the Mylapore section of the distribution. At a hydrant in Luz Church Road near the St. Thomé Cathedral the pressure was found to be only 12 feet at 7–30 a.m. It is said to be usually 17 feet. The main on the road is an old one and is laid deeper than usual, the fire hydrant valve head was 1 foot 2 inches below the road level. There is a meter on the police lines on this road and we specially noticed that the private houses were not fitted with meters. In the Bazaar road a hydrant measured 14 feet pressure at 7–50 a.m. Further on towards Barbers Bridge the Committee inspected what was marked on the map as a silt pit—this seems an extraordinary arrangement. On the 10-inch main there has been built a masonry chamber 5 feet square and 8 feet deep. The 10-inch main in crossing this chamber bends down by means of two right-angled bends, passes horizontally across the chamber and rises to its former level by other two right-angled bends. On the horizontal section of the 10-inch main a 4-inch branch is taken off as a scour pipe and this discharges at the side of the road. The outlet had to be dug up showing it had not been used for some time said to have been three weeks ago. On opening the scour valve the discharge water was found to be clear after a short time. The valve had probably been opened not long before. No arrangement is made here for the discharge of scour water into a drain. The scour water simply overflows the road to the discomfort of foot passengers. Further on at the junction of Edward Elliott Road it was found impossible to open the scour valve as the spindle head was broken. The outlet pipe was choked with mud and debris. The overseer stated that the valve had been opened three weeks ago. The Committee are unable to accept this statement. Pressure at the hydrant at Barbers Bridge was 27 feet at 8–15 a.m. A 4-inch valve in Ice House Road was opened copious black silt came out. This is too small a scour for the 12-inch main on which it is fixed. The fire hydrant in Ramaswami Maistry Street was next opened. The water ran brown but the hydrant had to be shut before the brown colour ceased to show as the street was being flooded and grain was being exposed lower down the lane and was in danger of being swamped. The position of this valve discharging into the centre of one of the principal lanes shows want of system in placing the hydrants. The fire hydrant on the main road adjoining was found clear, the water here is used for road watering. Of late there is little evidence of road watering in the City. The dust nuisance has been very great. The stoppage of road watering is perhaps due to an endeavour to save water. In addition to the dust nuisance there is another disadvantage in stopping road watering; when roads are watered hydrants are frequently used for the purpose and to some extent serve as scours for the mains.

On this date the Committee finally inspected a 9-inch scour outlet on the 27-inch main at corner of Wallajah Road and Triplicane High Road. The water was found clear. The scour is stated to have been opened three days previously and there was evidence of this. The size of this scour is too small it ought to be 15 inches in diameter.

The Committee would remark that as in a previous inspection they found that scours on important roads and the convenient localities had been attended to, but it is essential that all scours should be regularly attended to and that there should be records of the dates of opening these scours and the results.

As this is one of the most important if not the most important point in connexion with the distribution of water in pipes throughout a town and as much to the Committee's surprise they find no rules on the subject exist in Madras they propose to go into the subject in considerable detail in formulating their conclusions.

The Committee continued their inspection on 13th March. The pressure at junction of Hospital Road and Mount Road at 7–20 a.m. was 27 feet. Here there is a 22-inch main with a 7-inch scour discharging into an open masonry drain, this scour should be 12 inches in diameter.

At junction of Broadway and Esplanade there is a 22-inch main with 5-inch scour which it was stated had been opened three months ago. Probably the reason the scour is not opened more frequently is due to the fact that the valve is in a pit between the tramway rails. No scour valves should be in such position as it interferes with tramway traffic when opened.

There is a students' hostel opposite the Christian College in Thambu Chetti Street from which a drain was running to waste large quantities of clear water, there was no meter on the connexion. This is only one of very many instances noticed by the Committee. In their walk along the streets the Committee were impressed by the enormous quantity of clear water which was running to waste from house drains into the street drains. We were informed no meters existed in all such cases. It seems to be forgotten that this water has been filtered and pumped into the City at great cost. The fixing of meters in such houses would result in the people shutting the taps.

Several hydrants and a few scours were examined during the inspection in this part of the town and we would draw attention to the following :—

The scour on the 18-inch main at the corner of Thambu Chetti Street and Alwa Chetti Street discharged into a manhole below ground, the intention being to surplus the water through the opening on the surface of the road and allow it to find its way to the nearest drain. A scour pipe must be led from the main to the nearest drain and should discharge above the level of water in that drain. In this particular case the manhole could not be opened but the Committee inspected a similar arrangement in Monegar Choultry Road.

The waste water from this chamber runs over an important thoroughfare before it reaches a drain thus damaging the road. This chamber has been recently constructed. The Committee are surprised to find this arrangement.

At Kachala Bewara Temple tank there was a 7-inch scour on a 7-inch main which is a branch of the 18-inch main in Thambu Chetti Street. The outlet of this scour discharged into the tank which contained slimy green coloured water. It was stated that the temple people objected to the scour being opened, and consequently it had never been opened as far as the overseer remembered. The Committee had the scour opened and for fully five minutes black and brown silt belched forth. This is the most effective scour the Committee have as yet found.

Opposite No. 55 Ayyappa Chetti Street the Committee had a 2½-inch fire hydrant on a 4-inch main opened. This fire hydrant unlike many others had not been opened prior to the Committee's visit. For 25 minutes water heavily charged with brown silt flowed from this fire hydrant which is on a side street. There are no hydrants in Sengalaneer Pillaiyar Pagoda Street, a continuation of the last named street nor are there any in Savarimuttu Street.

The Committee found that fire hydrants in main streets are invariably clean as the water is used for watering the roads, unfortunatly they are of little use as scours on mains larger than 4-inch diameter.

During the Committee's inspection of Georgetown they noticed these important points :—

(1) The absence of wash-outs or scours in this old section of the water-works.

(2) The absence of meters for important houses.

(3) Easily avoidable waste of water.

With reference to (1) the Committee would remark that scours should have been fitted to the old water-works mains two or three years ago when a supply of new pipes and valves was received. The Committee understand that numbers of these are still in stock. The Assistant Engineer said there were 200 hydrants which could be placed on the smaller mains. The number of scour valves is not known.

With reference to (2) and (3) it is astonishing to find so many important houses not metered.

IV. QUANTITY OF WATER.

(1) QUANTITY AVAILABLE AT RED HILLS TANK.

The quantity of water available at Red Hills tank is that supplied from its own catchment of 23 square miles and the quantity of water which is brought by the Red Hills supply channel from the Tamarapakam anicut on the Korttalaiyar river. The area draining into the river above the anicut is 837 square miles and the area draining into the supply channel from the anicut is 106 square miles. The total area on which the Red Hills tank depends for a supply is 977 square miles. The annual rainfall over this area is about 40 inches. The capacity of the Red Hills tank above the level of the offtake tower outlet is 1,712 millions of cubic feet. The Red Hills tank was not, however, solely constructed for the water-supply of the City, but irrigates 5,000 acres. The storage at present is approximately 2,000 million cubic feet. A temporary earthen bund, two feet high, has been erected on the masonry surplus weir, in order to test the increased storage capacity of the tank which bund increases the capacity

by about 300 million cubic feet. In years of normal rainfall the Red Hills tank has sufficient storage capacity to supply the city with the quantity of water allowed for in the new water-works scheme and also to supply the irrigation under the tank. The Committee do not think that their report is one which should deal with the question of the storage capacity of the tank in a detailed manner, but experience of the last two or three years has demonstrated that sufficient water is available. They would, however, point out that years of normal rainfall should not be taken as the basis of calculation, but the capacity of the tank should be judged from the results of three or four years of deficient rainfall. In these years there would be difficulty in giving the city a supply to which it may have been accustomed, it is, therefore, all the more necessary that the supply per head per day should not exceed the quantity for which the new works have been designed. When the population increases to 660,000 it will be imposible to give this number 29 gallons per head per day although it may be possible today to give 523,000 this quantity. The proposed raising of the full tank level of the tank by 18 inches should be examined in detail and completed, if feasible, before the population reaches the maximum for which the scheme was intended.

In connexion with the possible failure of the tank in years of deficient rainfall the Committee give as an appendix (O.N.T.) a letter and statement received from Mr. J. M. Lacey, Superintending Engineer, V Circle.

(2) QUANTITY FOR WHICH NEW SUPPLY SCHEME WAS DESIGNED.

This quantity has been estimated on a basis of 25 gallons per head per day for 660,000 people. This quantity was fixed on by the Government Committee in 1890 and compares favourably with other cities, such as Calcutta 24·1, London 27, Paris 17, Agra 11, Allahabad 11, Benares 17 and the mufassal towns in Madras Presidency 15. Prior to the introduction of the new water-supply scheme the old open channel supplied the City with 16 gallons per head per day.

(3) QUANTITY SUPPLIED TO THE CITY SINCE THE OPENING OF THE NEW WATER-WORKS.

In appendix ON_2 is shown the quantity of water supplied per week for the year 1917 as recorded by the Venturi meter at the Kilpauk pumping station. The Committee notice that the weekly supply has varied between 75 million gallons for the week 2nd—9th July, to 104 million gallons for the week 16th—23rd July or from 20½ to 28½ gallons per head per day. The low consumption of 20½ gallons per head per day for the week 2nd—9th July 1917 was presumably due to the occurrence of rainfall during this week rendering the irrigation of gardens unnecessary. A fortnight afterwards the consumption rose to 28½ gallons per head per day pointing to a much higher draw-off for irrigation of gardens.

The pressures maintained at the heads of trunk mains according to the statement supplied to us are as follows :—

6 a.m. to 9 a.m.	45	feet.
9 a.m. to 10 a.m.	35	„
10 a.m. to 6 p.m.	25	„
6 p.m. to 6 a.m.	10	„

The Committee would point out that the maintenance of the above pressures is the primary cause of the excess draw-off by the town. If the pressures were increased the draw-off would be much greater, for instance, an experiment made at the Kilpauk pumping station in maintaining higher pressures varying from 95 to 78 feet throughout the 24 hours gave a consumption in the city of 23½ million gallons equivalent to 45 gallons per head per day. This experiment, it is thought, should have led the Corporation to adopt the policy of fixing the quantity of water in gallons per minute for the periods referred to in the above table instead of fixing the pressures during these periods. The Committee would therefore point out that the quantity of water pumped to the city should not exceed except by a narrow margin 25 gallons per head per day for the population for the time being and in order to carry out this, the quantity between 6-9, 9—10, 10—6 and 6 p.m. and 6 a.m. should be determined. When this is done it will be of interest to note the pressures obtaining at the pumping station. The total quantity of water pumped daily will be equal to the sum of the quantities supplied to the city as per the time-table above.

As an example of what the Committee are suggesting, the table below shows a typical example of the distribution of supply throughout the day.

The designer of the original scheme, the Committee note, did not contemplate a rise in the consumption of water per head from 16 to 25 gallons, but presumed that the increase would be gradual and consequently he only provided 14 filters out of the ultimate total of 21.

6 a.m. to 9 a.m. at	1,100,000	gallons per hour	3,300,000
9 a.m. to 10 a.m. at	900,000	„ „	900,000
10 a.m. to 6 p.m. at	800,000	„ „	6,400,000
6 p.m. to 6 a.m. at	200,000	„ „	2,400,000
		Total ...	13,000,000

523,000 people × 25 gallons per head = 13,075,000 gallons per day.

The Committee have based their table on the Venturi meter diagram for the week 2nd—9th April 1917. Supposing this quantity is supplied to the City, the Committee note that it would have been sufficient for the weeks 15th—22nd January 1917 and 24th September—1st October and it would have been more than the quantity actually supplied to the City for the weeks 4th—11th June, 11th—18th June, 18th—25th June, 25th June—2nd July, 2nd—9th July, 9th—16th July, 15th—22nd October and 5th—12th November, all in the year 1917.

The excess consumption during other weeks of the year 1917 is due to the fact that the pressure at the pumping station was higher than it should have been thus encouraging waste (see appendix ON_2).

Although the Committee have worked out the quantity at the rate of 25 gallons per head for the population of 523,000 and this means a daily consumption of 13 million gallons, the Committee are aware that the total output of fourteen filter beds is 14,000,000 gallons and that at least three of these beds would be out of use under cleaning, so that the net quantity of filtered water available for the City would only be 11,000,000 gallons daily. This being so the Committee consider that the water supplied to the City should have been from the beginning, only that quantity which the filter beds could supply, viz., 11 million gallons daily and this quantity should have been distributed throughout the 24 hours in the manner indicated above and not by the arbitrary method of fixing pressures at the pumping station without check on the quantity consumed and regard to the quantity of filtered water available. If this principle had been adopted when the water-works were first opened there would have been no necessity to add unfiltered water to the filtered water. As, however, this principle of adding unfiltered to filtered water to increase the supply has been adopted, the Committee recognise that it is too late to revert to a supply of 11 million gallons per day—they are therefore prepared to accept the inevitable and to recommend the early construction of two more filter beds so as to obtain a daily supply of 13 million gallons of filtered water. The Committee are confident that if the supply to the distribution mains is regulated by the sluice valves on them and if meters are fixed on all important house connexions and in addition the use and misuse of water for gardening purposes is controlled a supply of 13,000,000 gallons daily to the City will suffice for its present needs and for a number of years to come.

The Committee note that in Government Order * seven additional filter beds and a clear water reservoir were sanctioned, but these have not been constructed through want of funds. We would point out that the construction of these filter beds and an additional clear water reservoir would bring the total to 21 filters and 4 clear water reservoirs. These are intended to supply a population of 660,000 at 25 gallons per head per day (vide report on original scheme). There is, in our opinion, no necessity to spend 5½ lakhs of rupees on the above works at a time when the population is only 523,000 and there is little likelihood of it reaching 660,000 for 20 years. Experience has shown that the present works are strained beyond their designed capacity in the endeavour to supply 28½ gallons per head per day when the works were only designed to supply 25. If the seven additional filters and additional clear water reservoir are constructed now and the present policy of supplying more than the designed quantity is persisted in, in a few years time the 21 filter beds will also be found insufficient. The time has come in our opinion for putting a stop to the practice of supplying more than the quantity designed for, we accordingly recommend only two more filters now and the construction of other two in the course of the next ten years.

* G.O. No 1442 M., dated 31st July 1914. Seven more filter beds and a clear water tank.

The statement made that some people in Madras say "Every person in Madras should be provided with as much water as he wishes to take" is perhaps hardly worth consideration by the Committee but as such statements are undoubtedly made the Committee would emphasise their opinion that a supply of 25 gallons per head per day is ample for all reasonable demands and it is not the duty of any Corporation to comply with unreasonable requirements.

From the last administration report of the President it is observed that for every gallon per head over 25 gallons per head, which is the rate for which the water-supply has been designed, the additional cost to the Corporation is Rs. 40,000 per annum. If a supply of 28½ gallons per head per day were pumped into the town throughout the year this would cost the Corporation Rs. 1,40,000 per annum excess. It will therefore be realised how important it is to limit the quantity pumped to the town to the quantity for which the scheme was actually designed.

V. QUALITY OF WATER SUPPLIED.

(1) AT RED HILLS TANK.

Appendices (1), (4), (5), (6), (7), (10) and (13) give the results of the bacteriological analyses of samples of water. It will be noticed, as is to be expected from such a source as the Red Hills tank, that the quality of the water varies. After periods of drought and settlement the quality of the water improves. After rain storms, as is natural, the quality deteriorates. Considering the nature of the catchment area a large part of which is cultivated land, with hamlets attached, it is a good sample of water of its kind and sometimes may be said to be of high bacterial purity. The high albuminoid nitrogen content in the water as shown in appendices (2), (3), (8), (9) and (14) is most probably due to animal pollution. This is not surprising considering the large number of cattle not only within the catchment area but which actually stray on the lake margin. Over 1,000 cattle found straying on the lake margin are annually impounded. This matter will be found referred to in connexion with the Committee's inspection of the catchment area and recommendations will be made at the end of the report to deal with the problem.

The fairly good results obtained from the analyses of water obtained from near the outlet tower is due to the settlement of the water in such a large basin and the action of the sun's rays. Dilution also of contaminated water acts as a natural purification (Houston) in such a large body of water. These natural forces are so active in the case of the Red Hills tank as to produce favourable results but despite this we recognise that the risk of contamination is so evidently present that efficient filtration of the water is essential for the protection of the health of the people of the City. Although filtration is provided it is necessary to point out that the efficient protection of at least a portion of the catchment area around the tank margin is highly desirable and to this end we have made proposals. The simplest improvement that strikes us is efficient check of the work done by the watching establishment.

(2) ROUGHING FILTERS.

The Committee have referred to the roughing filters in some detail in a previous paragraph. Since their inspection the materials inside have been removed and the two compartments are now used as sedimentation and sunning basins prior to the water entering the conduit. The appendices which give the results of the bacteriological analyses show the improvement which has resulted from this operation in the quality of the water. We would remark that both compartments should be periodically cleaned at least once in six months and the inside cement washed or washed with freshly-slaked lime.

(3) CONDUIT.

In the same appendices the results of the analyses of a large number of samples from the conduit are shown. The water in passing through the conduit shows a variable deterioration. In no case does it improve between the roughing filter and Kilpauk and deterioration in the water passing through the conduit can only be ascribed to the following causes:—(1) Deposit in the conduit and syphons and (2) leakage into the conduit from swamps. The Committee examined the first part of the conduit and have already remarked on this point. They were unable to inspect the whole of the inside of the conduit but they saw enough from their inspection of the first part to have grounds for believing that the conduit should be cleaned from end to end and alterations or additions to the syphons as recommended by them should be carried out. When the cleaning operations are being conducted careful inspection should be made of the inside of the conduit and especially of the parts which pass through swampy ground, to see whether there is any signs of leakage of sub-soil water. The Committee do not suggest that there is such leakage but there is always the chance of the possibility of settlement which would lead to such leakage. We have recommended special precautions in the portions of the conduit which pass through swampy ground.

(4) FILTERED WATER.

Prior to the appointment of the Committee to report on the defects of the Madras Water-works large numbers of samples had been examined at the King Institute of Preventive Medicine, Guindy, and the general result of such examination may be summed up in a statement that the filtered water was worse in quality than the unfiltered water. The Committee do not propose to go back and examine the results prior to their appointment as they consider it will be more satisfactory if they deal with the results of analyses of samples of water taken after their appointment because in the latter case they are in a position to judge their results from their observations during inspections of the filter beds, etc. The first analyses of samples (Appendix 1) was taken on 25th September and 11th October 1917. These results as will be seen by perusal of appendix were very unsatisfactory. The filtered water was definitely worse than the Red Hills water. The Committee however observed that deterioration between the Red Hills Tank and the inlet of the filter beds was very marked and they also observed that this deterioration was marked between the Red Hills tank and the outlet of the roughing filter. We accordingly concentrated our attention on the roughing filter and the conduit

and the results of our observations have been recorded in the paragraphs dealing with these sections of the water-works. We found ourselves in a position to recommend the removal of the stone, etc., from the roughing filter and the cleaning out of that filter and as we proceeded step by step to trace out the sources of deterioration of the water we had a series of the samples of the water analysed and the results will be found in appendices 4, 5, 6, 6-A, 7, 10 and 13. We were unable at the time at our disposal to have the conduit cleaned out throughout its entire length and consequently the quality of the Red Hills water when it arrives at the end of the conduit at Kilpauk is not satisfactory, although an improvement has resulted from the elimination of the source of deterioration found by us in the roughing filters and at the entrance to the conduit. The Committee then inspected in detail the filter beds at Kilpauk and their observations have already been mentioned. The Committee noted that deterioration in the quality of the water occurred in the inlet conduit to the filter beds and that there was insufficient protection to the filter beds at their inlets to prevent entrance of frogs, fish, etc. That the inlet arrangement was defective, and that the 3-foot margin of filter bed without underdrains was apparently a defect. That the sand used was too coarse and not up to specification and that the method of starting a filter was defective. The Committee's attention was finally concentrated on bed No. 4 as that bed was being relaid with a surface layer of washed sand. At the Committee's request instead of running the water through the bed at a slow rate, the water was allowed to remain quiescent in the filter bed for 24 hours. At the end of this time the Committee had the water in the bed lowered to the surface of the sand in order to enable them to judge the formation of the filtering skin. They found that a settlement of 24 hours was insufficient and at their request this bed was refilled with water which was allowed to stand in the bed for three days when the water was run slowly off for another inspection by the Committee.

The Committee found at this inspection that a satisfactory filtering skin had been formed during the three days' settlement (see Appendix P_3). They then accordingly directed filter bed No. 4 to be refilled and brought into use. In Appendix 11, the results of the first samples from bed No. 4 will be seen. The results show that the raw water contained 1,830 colonies per c.c. and lactose fermenters present in 5 c.cs. The filtered water gave 790 colonies per c.c. and lactose fermenters present in 20 c.cs. As the bed had only been a few days in use the Committee considered the results satisfactory. Appendix 11-A shows the chemical analyses of the water, while there was an excess of ammoniacal nitrogen in the filtrate the reduction in the albuminoid nitrogen and in the oxygen absorbed was satisfactory.

In Appendix 10, on 29th March or twelve days later the bacteriological analyses from the same bed showed the highly satisfactory result of a reduction in the total colonies in the raw water of 460 per c.c. to 140 c.c. in the filtered water and a reduction in the lactose fermenters which were present in 5 c.cs. of the raw water to none present in 60 c.cs. of the filtered water. In all cases no vibrios were present.

On the 8th April the result was even more satisfactory. The raw water contained 1,350 colonies per c.c. and filtration reduced this to 160 colonies per c.c. The lactose fermenters test was very marked—present in raw water in 1 c.c. and none were found in 60 c.c. of the filtered water—in other words this filter bed No. 4 produced filtered water over at least a sixty-fold improvement on the basis of this lactose fermenter test.

The chemical analyses (Appendix 12-A) gave somewhat similar results as on previous occasions.

In Appendix 13, the result of examination of samples taken between 16th and 18th April from same bed are given. In this case the reduction in colonies is from 510 to 135 per c.c. Lactose fermenters were present in 5 c.c. raw water and in 60 c.c. of the filtered water. This result is not quite so good as the previous result, and the Committee, therefore, proceeded to Kilpauk and examined the register of filtering head maintained at the works. They found that the filtering head had gradually increased up to 16th April when it reached 1 foot 10½ inches. The following day 17th April the head fell by 1½ inches showing that a break had occurred in the filtering skin. This break must have been due to the presence of frogs, fish, crabs, or to some other interference with the filtering skin. Until the frogs, fish, crabs, etc., are effectively excluded by the provision of screens at the inlets to each filter bed such breaks in the filtering skin are to be expected. Other causes can only be detected by an official who can daily watch the working of the filter beds and discover the reasons for variation in the filtering head. The filtering head is a very accurate gauge of the efficiency of a sand filter when properly maintained. The filtering head is the term used to express the difference in level between the surface of the unfiltered water in a filter bed and the surface of the filtered water in the outlet regulating chamber. If a filter bed were completely clogged, i.e., if the thickness of the filtering skin was so dense as to prevent the passage of any water through it towards the regulating chamber then the filtering head would be the difference in level between the surface of unfiltered water and the floor of the filter bed. This difference might be 7 feet and it is easily conceivable that if the filtering skin was perforated there would be a rush of unfiltered water through the perforation to the filtered water chamber carrying with it all the contaminations in the unfiltered water. As this possibility has to be guarded against we take the precaution of limiting the maximum difference of level or, in other words, the filtering head to 24 inches, because it is considered that a greater head than this is too dangerous for safe working.

The filter head should gradually and steadily rise from 0 to 24 inches. Any sudden decrease in the filtering head, instead of a gradual rise, is always associated with a corresponding deterioration in the quality of the filtrate indicating a break in the filtering skin. When an accurate record is kept of the daily filtering head of a filter it is quite possible to find out at once defective working of the filter bed independent of a bacteriological examination of the filtrate. For instance, in bed No. 4 which was being experimented on by the Committee a sudden decrease occurred in the filtering head from 1 foot 10 inches to 1 foot 8½ inches or by 1½ inches. If nothing had been wrong with the filter instead of a decrease of 1½ inches there should have been a rise of at least half an inch to 1 foot 10½ inches. The Committee were not informed at the time the decrease occurred and if they had been they would have advised the putting of this filter bed out of action and the lowering of the water so that they could inspect the filtering skin and the probable reason for the decrease observed. On the whole, the Committee are satisfied from the results obtained from the analyses of water at Kilpauk and especially from the Committee's experiment with bed No. 4 that satisfactory results from the filtration of water through sand filters when efficiently controlled are obtainable.

In Appendix No. 13 a note is made that a strong smell of sulphuretted hydrogen was noticed in the outlet regulating chambers of six of the filter beds including No. 4. The Committee have already dealt with the probable reasons for this.

(5) QUALITY OF WATER AT PUBLIC FOUNTAINS.

In the various appendices the results of analyses of samples of water from taps on the distribution system show that the quality of water at these taps is generally unsatisfactory and in some cases is even worse than the water at the pumping station. The Committee have no doubt at all that the poor quality of water in the distribution system is largely due to the want of scouring of the distribution pipes from the existing scour valves and the want of a sufficient number of scour valves throughout the

system. They cannot too strongly emphasize the necessity of scouring the distribution pipes. Looking at the question of the relative importance of the different parts of a water supply system, they would put quantity and quality in the first place and in order to ensure the latter, scouring of the distribution pipes as a work of the highest importance.

VI. STAFF.

(1) RED HILLS.

The staff here consists of one overseer, an assistant overseer, two serangs and fifteen lascars. The overseer is paid Rs. 40 to Rs. 50 per mensem, assistant overseer Rs. 25; both have free quarters. Of the 15 lascars 10 are supposed to be employed in patrolling the margin of the lake. The rules lay down that the overseer should patrol at least twice a week at night. In addition to this duty he has to keep the valves, screens, weir meter at the head works, in working order to regulate the discharge over the weir in accordance with instructions from the overseer at the filter beds. Rule 3 states that the overseer shall clean the roughing filters once in six months and oftener, if required. This rule has not been observed.

(2) CONDUIT AND KILPAUK.

The staff at the Kilpauk filter beds consists of an overseer on Rs. 80 to Rs. 100, an assistant overseer on Rs. 50, three turncocks and eight lascars. There are also four gardeners. The rules require that the overseer shall be in responsible charge of the filter beds and shall carry out all the operations required in working them.

In addition to these duties the filter bed overseer, or in his absence the assistant overseer, is supposed to inspect the conduit on the second Wednesday of every month. It is stated in the rules that "his inspection shall be carefully done. He will open every alternate manhole and look through the conduit to the manholes on either side, using lights if required. He will note carefully condition of conduit, as regards its structure, vegetable and other growths on the walls, etc., if any. These notes along with any matters calling for attention should be embodied in a report and submitted to the office not later than the Friday succeeding the inspection."

In addition to the filter bed and conduit work the overseer has to regulate the pressure at the heads of the distribution mains at Kilpauk. He is also required to proceed to these mains at any time when a fire is reported in the city.

The labour required in cleaning the filters is employed daily when required.

(3) DISTRIBUTION.

The staff in the distribution system consists of 3 foremen, 12 overseers, 10 fitters, 20 assistant fitters, 20 turncocks and 100 lascars. The foremen are paid Rs. 80 to Rs. 120, and the overseers Rs. 40 to Rs. 50 per mensem. This staff is engaged on the maintenance of all water supply works and fittings including meters and house services. They are required to put a stop to waste and misuse of water and to report on such cases. To set right all leaky taps, pipes and fittings and to keep all specials in good order such as valves, meters, hydrants, etc.

They are required to distribute water equitably to all consumers and to report on all applications for house services. They are provided with a copy of the "Water-works handbook." The Committee have perused this handbook and find that it deals with house services, application for, fitting of the same and also instructions for the reading of meters. The copy of the duties of the distribution staff does not, the Committee note contain any instruction or rule for the very important duty of scouring of the distribution mains. The Committee also noticed that the distribution staff, foremen and overseers, are not supplied with handy maps of the area in their charge. This is essential and during their inspection the Committee found difficulty in locating mains, sluice valves and scour valves, also hydrants, and in fact they had to trust to the memory of the staff in locating the details of the distribution system. Such handy maps should be supplied and on them should be clearly marked the sizes of all mains and the positions of specials. We would further recommend as a necessity that the positions of these specials should be clearly marked on the walls of the adjoining buildings and these marks should include sizes. Each of these specials should also be numbered both on the building and on the handy map plan, and the staff in reporting that such and such special requires repairs or other attention should give the number of the special in his report. The present system of describing the position of a special as in a certain street and near a certain lane is not only cumbersome but inexact.

When a valve is out of order and requires repair the staff apparently report the occurrence either in a special letter or as an odd remark in a diary dealing with other subjects. This the Committee found impossible to check and documents were not forthcoming. We consider that the overseer should submit a weekly distribution return containing the results of his inspection during the week, of valves, scour pipes, hydrants public fountains and house connexions.

In addition to the staff abovementioned there are three overseers and six lascars employed on waste detection.

The Committee understand that the water-works from the Red Hills to Kilpauk including the filter beds are in charge of the special engineer of the Corporation who is also engaged in working out a drainage scheme for the city. From Kilpauk the distribution works are in charge of the Engineer of the Corporation who has three assistant engineers under him. These assistant engineers are to some extent responsible for the distribution, but have many other duties to attend to. In addition to the establishment there is a special assistant engineer working under the special engineer and employed on the laying of new distribution mains. He is also in general charge of the water-works from Red Hills to Kilpauk.

(4) PROPOSALS FOR REORGANIZATION.

A perusal of the statement above will show that the staff of engineers is apparently engaged in multifarious duties and no single official can be held to be directly responsible for all the water-works. The result of this is, in the opinion of the Committee, that duties far too important are left in the hands of subordinates. For instance in the case of the 14 filter beds at Kilpauk the duty of working, cleaning and restarting the filter beds and patrolling the conduit is left in the hands of an overseer. It is true that the overseer is given a set of rules and although in the opinion of the Committee this overseer is fairly intelligent and efficient as an overseer, they can only assume that he is left to carry out duties which are beyond his powers.

The operation of starting a filter bed is in the Committee's opinion one which requires to be personally supervised by an engineer if the works are of such magnitude as the Madras works are to justify his employment. This operation is too often regarded as a simple matter when it has become a rule of thumb, whereas it is essential that an experienced engineer should be in daily attendance to personally supervise the operations. This is no new proposal. Any water-works of the magnitude of the Madras water-works has an experienced engineer in charge and also as a rule resident at or near the head works. Such an engineer would be one who had several years' experience of the working of water-works and his duties would be confined to the supervision of the water-works alone. In our opinion such an engineer should be engaged for the Madras water-

works as soon as he can be obtained. His pay should be such as to attract the proper stamp of engineer and in addition to his pay he should be provided with a residence within the area of the head works at Kilpauk so that he could daily supervise the working of the filters and other works there such as the pumping station. Under this engineer at the head works there should be an overseer ; this overseer's duties should not include the patrolling of a conduit, $7\frac{1}{2}$ miles long, but his duties should be confined to the Kilpauk area. The labour employed for cleaning the filter beds should be on the permanent staff and not casual labour. The reason for this is obvious.

As far as the Red Hills establishment is concerned we do not suggest any change but we consider as an additional argument for the appointment of an engineer in sole charge of the water-works that both the conduit, roughing filter, and Red Hills lake area require more constant supervision than is apparently possible under present conditions. To facilitate the more thorough inspection of these works we have proposed in another place an inspection path along the conduit and around the lake within a 1,000 feet of the water margin.

From Red Hills to Villivakkam, the conduit line can be inspected by the Red Hills staff and from Kilpauk to Villivakkam one of the city overseers can be deputed to carry out this inspection. The duty of patrolling the margin of the lake is a most important one. The Committee from observation of the amount of trespass on the foreshore of the lake, i.e., across the lake from the bund, think that the patrolling of this part of the catchment area of the tank is not as effectively done as it should be nor do they think that it can be effectively done until a proper inspection path is made around the lake so that the overseer can use a bicycle thereon. We attach much importance to this and also to the check by superior officers of the work of the overseer. We do not think that a pay of Rs. 40—50 for this overseer is sufficient especially when it is remembered that he is responsible for the reporting of offences under section 319 of the Act and has to conduct these prosecutions when ordered to do so by the President.

The Corporation should employ a bacteriological assistant with a suitably fitted up laboratory at Kilpauk so that daily investigations can be carried out on the quality of the water.

On the distribution system a large number of scour valves will be required and the existing valves will have to be more frequently opened —this will require a larger staff.

With the exception of foremen who seemed to know their duties the Committee think that such men should be of superior stamp and better paid. They also consider that the overseer establishment requires improvement. They are not in a position to lay down the numbers of the staff required for the distribution as this will greatly depend on how the new works progress. The staff employed on waste detection is quite inadequate not only is it too small but it requires to be reorganized and put on a proper footing in keeping with its importance. We note that out of 29,000 house connexions only 900 are metered and yet the income from these amounts to the large sum of Rs. 1,52,717 per annum. The whole of this house service and waste detection establishment should be reorganized and brought under a superintendent of house services ; this man should be paid a salary of Rs. 300--500 per mensem and he should be held responsible for the fixing of meters on house services and the keeping of the same in order. He should be provided with a suitable staff for the purpose which will naturally have to be added to as the number of meters increases. The Committee observed quite sufficient during the inspection of the distribution system to be confident that there are several thousand connexions which ought to be metered at the earliest date possible. They recognize the difficulty of obtaining meters at the present time but every endeavour should be made by the Corporation to carry out a vigorous meter policy and the cost involved will be amply recouped from the additional revenue obtained from charges for excess water consumed at house services.

We would also point out that the early metering of house services and the supervision of them by a competent and adequate staff has an additional advantage besides the obtaining of more revenue. The result of carrying out this policy will mean a large reduction in amount of water consumed per head per day in the city because waste will be largely reduced. The result of reducing the water consumed per head per day to a legitimate demand will mean a large saving in the cost of pumping at Kilpauk (estimated by the President at Rs. 40,000 per annum for every gallon per head per day saved) and there will be no necessity for the Corporation to construct additional filters, clear water reservoirs and other works in advance of the legitimate time. The Committee feel compelled to say that this policy advocated by them should have been adopted from the beginning and if it had been adopted for say only one quarter of the house services, the city would probably not be using now more water per head than the works were designed for and contemplating the provision of no less than seven additional filters.

VII. CONCLUSIONS DRAWN BY THE COMMITTEE FROM A STUDY OF THE MADRAS WATER-WORKS.

In putting down our conclusions from a study of the water-works we desire to preface them with a few preliminary remarks. In the first place we have been considerably handicapped by the fact that we have had to carry on our official duties at the same time that we were dealing with this important question of examining the Madras Water-works and studying the defects of the system. The reference made to us by Government embraced the whole of the works involving inspections, the taking of samples, analyses of the same and a study of the results. This work had to be carried on by us in our spare time and consequently the enquiry covered a considerable period. At the same time it was not one which could be done hurriedly as time was necessary to obtain the analyses of samples of water taken under different conditions. Such analyses had frequently to be followed by an inspection of the works so that correct conclusions might be drawn from the results. In the following conclusions we will condense our remarks as much as possible and further information on the points brought to notice and other reasons will be found in corresponding paragraphs in the body of the report.

(1) RED HILLS.

We found the Red Hills tank to be a satisfactory source of water-supply to the City of Madras. Proposals are in contemplation for increasing the storage capacity of the tank. If this is found possible after detailed enquiry of the excess quantity of water, if any, from the catchment area, we support this policy, but at the same time wish to say that the extension of a tank should not proceed by many years the necessity for such extension. We have generally found in dealing with the waterworks that the supply of water to the city is more than it should be and more than the quantity for which the water-supply and the drainage works have been designed. We deprecate the continuance of this policy and consequently we deprecate the extension of the Red Hills tank if the idea is to continue to supply more water to the present population than they are entitled to receive.

We have found that the quality of the Red Hills tank-water is on the whole good, thanks to the large area of the tank and the sunning and sedimentation the water receives in it. We however consider that additional precautions are necessary to prevent contamination of the tank water from the area immediately surrounding the margin of the lake and the banks of the supply channel from Cholavaram tank.

Our recommendations are—

(a) that an area of land around the margin of the tank 1,000 feet wide should be acquired and that an inspection path should be formed through this area ;

(b) that the banks of the supply channel from Cholavaram tank should be fenced and also the area between the Tiruvellore road, Red Hills village and the tank margin ;

(c) that the patrolling staff of ten lascars and one overseer should be reorganized, supplied with proper uniform, mustered regularly and their work checked more frequently by superior officers ;

(d) that the village of Kannadyapalliyam be removed further to the east of the tank bund and as an alternative temporary measure this village be fenced on three sides to prevent access by the villagers and their cattle to the tank water ;

(e) *Outlet tower.*—In withdrawing water from the outlet tower to the roughing filter the inlet pipes should be protected by screens and the upper valve below the water level should always be used, any deficiency of supply being supplemented by a partial opening of the middle valve. The bottom valve should only be used when, owing to low level of water in the tank, this is found absolutely necessary.

(f) *Valve House.*—Owing to the inefficiency due to their small size of the scour pipes on the 24-inch mains from the lake to the valve house, it is necessary to provide 14-inch scour pipes and as the length of these mains from the valve house to the roughing filter is not scoured at all at present the valve house should be shifted as near as possible to the roughing filters and the new scour pipes provided at the new site.

(2) ROUGHING FILTERS.

We found that the broken stone in these filters had not been cleaned out for three years and it was impregnated with offensive deposit of silt, etc., which caused a serious deterioration in the quality of the water in passing through the filters. We therefore recommend that broken stones should not be used in these filters but that they should be used simply as tanks acting as small sedimentation and sunning basins. The stacking of materials in any way against the walls surrounding the roughing filter and weir basins should not be allowed so as to prevent the entrance of frogs, etc., into the water. The drawing of water from, or other interference with the water in, these basins must be prohibited. Certain teakwood shutters to close the openings of the side conduits and the entrance to the main conduit should be provided and the roughing filter basins and the weir and overflow basins should be emptied every six months carefully cleared of any deposit and cement washed or washed with a coat of whitewash made from freshly slaked lime.

The compound around the roughing filter basins should be cleared of surplus materials, all pits should be filled in, roads and necessary paths formed, a compound wall constructed around the area, a gate or gates provided and the compound maintained in a tidy condition.

(3) CONDUIT.

An inspection path should be formed on the line of the conduit from the Red Hills to Kilpauk except for the lake portion which can be inspected from the inspection boat. When the conduit passes through swampy ground, water should not be allowed to stand nearer the walls of the conduit than 10 to 15 feet and to carry out this the bank along the line of the conduit should be suitably extended. Whenever possible such swamps should be filled up or drained to prevent stagnation of water near the conduit line. The three syphons on the conduit should either be duplicated and provided with means for emptying them or the conduit should be reconstructed at these places at its usual gradient and the cross drainages which originally required the construction of syphons on the conduit should themselves be syphoned under the conduit. These works are necessary in order to minimise or prevent the deposit of silt in the present syphons and for which no means for its removal exist at present.

All loose stone manhole coverings on the conduit line should be cemented down and the bank over them made up. The iron manhole covers which are at present fastened from inside the conduit should be altered so as to fasten from the outside to facilitate legitimate inspection by the water works staff. The inlet ventilators which consist of grated hinged covers, easily opened, should either be altered by building a suitable masonry block over them or what would be more satisfactory they should be converted into air inlet pipes similar to the Cregan air outlet pipes at present used. If this alteration requires the lengthening of the present outlet ventilators this should be carried out.

The two villages on the conduit line, Sulurpet and Puttavaram should be provided with wells supplied from the conduit, and the service connexion north-west of the filter beds at Kilpauk should be extended as far as manhole No. 54. The Committee recommend that this area and collection of houses near manhole No. 54 should be brought within the administration of the Corporation as it is too close to the filter beds to be allowed to extend as a village-site uncontrolled by the sanitary authorities.

The whole line of the conduit must be efficiently patrolled and we recommend the checking of this patrolling should form one of the duties of the superior staff who should submit a weekly return to the Corporation. The conduit, in our opinion, should be cleaned out from end to end and when analyses show deterioration in the water passing through the conduit, it should be inferred that deterioration is due to collection of silt or other foreign matter, or possible leakage from swamps, or interference with the water in the conduit by villagers which insufficient patrolling has overlooked, or possibly the entrance of insects or other vermin through the ventilating openings. In the latter case the openings must be protected by screens.

The Committee are not satisfied with the arrangements for screening the water as it enters and leaves the conduit especially at Kilpauk as the risk of frogs, crabs, fish, etc., entering the filters is considerable. The Committee would recommend the provision of double screens at the beginning and end of the conduit so that at no time would there be less than one screen interposed. A guard wall should surround the outlet of the conduit at Kilpauk similar to the wall around the filter beds to keep out frogs, crabs, etc.

(4) FILTER BEDS.

Inlet conduit.

We found only two manholes on the inlet conduit one at each of the right angle turns—we were unable to inspect the inside of the inlet conduit except at the two corner manholes—and the overflow manhole at the end, where the presence of silt was detected in all of them. We consider there should be a sufficient number of manholes in this conduit for inspection purposes and cleaning out of the same. The covering consists of a 4-inch cement concrete slab, where this passes under the road, there is a possibility of leakage of surface water and this should be examined after manholes are provided. We would prefer a manhole on this conduit at the inlet to each filter. The inlet screen might, with advantage, be placed in this manhole which should have a protective wall similar to that around the filter beds.

Air inlet and air outlet ventilators should be provided as no ventilation exists at present. The conduit should be periodically cleaned out, the period being determined from inspection by the superior staff.

Inlets into filters.

It was observed that the guard wall at the inlet of each filter had been cut down resulting in the scouring of the sand of the filter bed.

The inlet pipe should enter the inlet chamber through a quarter bend with its mouth turned downwards so as to prevent scouring of the surface of the sand by the water when entering the bed as the velocity of approach, especially at the starting of a filter, is considerable. The inlet chamber should be provided with a screen as an additional precaution against entrance of frogs, crabs, fish, etc.

The filter beds.

The Committee found by digging up a filter bed that the materials were filled in in a somewhat unusual manner. Instead of the underdrains and the broken stones being extended to the walls of the filter they were stopped three feet short of them and the space here was occupied by the superimposed sand. From reports perused by the Committee they observed that this construction was a departure from the original design, and was made with the object of avoiding creep of unfiltered water down the side walls of a filter, which also they observed had been battered for the same reason. The Committee have no objection to the battering but they consider it proved from the results of their investigation that the 3-feet margin of sand on the floor of the filter is a defect and partly responsible for the formation of sulphuretted hydrogen, because this margin of sand constitutes a "dead end" in which there is partial stagnation of water. The Committee are satisfied that no further provision than the battering of the walls was advisable, nor are they convinced that even this was necessary. Experiments at the King Institute have shown that the theory of creep down the side walls of a filter is found in practice not to exist in a properly worked filter. We found that the provision of this 3-feet margin forming a "dead end" in the filter beds caused the formation of black silt to a depth of nearly four inches: this black silt was very offensive and smelling strongly of sulphuretted hydrogen. We have gone into this question in more detail in our report but would refer here to the occasional formation of black silt in other parts of the bed; this deposit was only occasionally found in other parts and is due in our opinion partly to stagnation caused by insufficiency of depth of broken stone underlying the sand. In the original design the depth of this broken stone was 14 inches but, during execution, this was reduced to 4 inches.

Filtering sand.

We have referred in detail to this in the report. We find the sand is coarser than specified and was not washed as originally intended. The sand used contains a portion of iron in the form of oxide which is acted on by the decomposing albuminoid nitrogen in the raw water resulting in the formation of black sulphide of iron from which the sulphuretted hydrogen is produced at places where the free flow of water is retarded. (Vide appendix S_3.) It would have been preferable to obtain a whiter sand or one containing less iron. From whatever source the sand is obtained it should be washed free from all impurities before being placed in the filter beds. The thickness of the filtering sand is only 2 feet 4 inches and as the Committee consider that the filtering sand should not be reduced below 2 feet to secure good results; the 4-inch margin for scraping purposes means that the sand will have to be replaced more frequently than is usually the case. The depth of water over the sand is 3 feet 9 inches. This depth might be reduced to 3 feet and the 9 inches thus saved might be utilized in adding 3 inches to the filtering sand layer making it 2 feet 7 inches and 6 inches to the broken stone layer making it 10 inches instead of 4 inches as at present. In the latter case this depth of 6 inches should be utilized to provide a broken stone layer of gauge ¾ inch to 1½ inches on the top of the brick underdrains.

The Committee, after careful consideration of the peculiar nature of the Madras water and its effects on the iron contents in the filtering sand, are inclined to think that ventilator pipes should be provided for ventilating the underdrains. Before, however, adding these ventilator pipes to all the filters they would require further proof of their necessity. They accordingly recommend that one of the beds, when their other recommendations are being carried out, should have six pipe ventilators fixed to it—there should be three ventilator pipes on each long side of the bed.

In carrying out the alterations to the filter beds they would recommend that the work should be done in the following order :—(1) conversion of the 3-feet margin by extending underdrains and broken stone to side walls after carefully removing the 4 inches thick black silt layer, (2) increase to the depth of the filtering sand by 3 inches, (3) increase in the thickness of broken stone under-layers by 6 inches, (4) screening and washing of the sand used in the filter beds; the original standard grade of sand to be used, viz., the filtering sand to pass through a screen of 30 meshes to the lineal inch and be retained on a screen of 50 meshes to the lineal inch.

Formation of filtering skin.

From the experiments carried out on bed No. 4, the Committee consider that the following should be the rule for cleaning and starting a filter in the Madras water-works :—When a filter is put out of action, which will be when the filter head has reached 24 inches, the inlet valve shall be closed and the water in the filter bed allowed to fall to that level which is limited by "the travel" of the filtered water outlet. The scour valve shall then be opened so as to lower the water level further at the same rate as the filter bed had been working, i.e., at 4 inches vertical per hour. The level of water shall be lowered until it is 2 feet below the surface of the sand. The surface of the filtering skin on the sand shall then be allowed to dry in the sun until the filtering skin is completely dry and is curled up in the usual manner. The filtering skin will then be raked into heaps, using wooden rakes provided with hoop iron protectors. Lines of planks will be laid lengthwise on the bed and the heaps of filtering skin will be removed in baskets, the coolies walking on the planks. These baskets of filtering skin will be deposited in a pit provided for the purpose and of such depth as will prevent the blowing about of dust from the pit. A depth of 1 inch of sand will then be removed from the surface of the bed under cleaning. The operation will be carried out in a similar manner to that adopted for the removal of the filtering skin but the sand will be deposited in a separate enclosure where it will be kept for re-washing and use again. If it be decided it would be cheaper to supply fresh sand in place of utilizing the old sand after washing, and this is preferable if possible; the old sand should be removed from the filter bed area and used for filling up low-lying places in the neighbourhood. This sand on no account should be kept lying about in heaps as after drying in an Indian sun objectionable dust from these heaps is liable to be blown into the filter beds. As soon as the 1 inch of sand has been removed from the bed the planks will be removed, taking care that no depressions are left on the surface of the sand; wooden rakes should be used to fill these. The raking should start from one end and finish at the other. Experience of the working is necessary to determine how long the bed should remain exposed to the sun and air before further action and whether it is also necessary to completely empty the bed of water to the floor level. The Committee observe that it should be possible for the staff to prevent crows entering the filtering bed at any time, if necessary, a fowling piece should be used. We, however, think that the additional screens which we have recommended will keep out of the filter beds the frogs, fish, crabs, etc., which the crows enter the dried bed to catch. In starting a filter the following shall be carried out :—

The valve on the pipe from the filtered water conduit shall be opened so as to fill the bed with filtered water from below. When the water has risen to the level of the top of the guard wall of the inlet chamber the

inlet valve from the filtered water conduit shall be shut and the inlet valve on the pipe from the unfiltered water conduit shall be opened and the bed filled with the raw water. If necessary a line of piping should be laid from the steel tank to supply the filtered water if the level of the same in the filtered water conduit is insufficient. The raw water should be allowed to stand quiescent on the bed for three days. At the end of this time the scour valve shall be opened so as to run to waste the water in the filter bed at the rate of 1 inch per hour for the first day when the scour valve will be closed and the valve on the outlet regulating chamber pipe shall be opened so as to draw off the water in the filter bed for the second day at the rate of 2 inches per hour, the third day at 3 inches and fourth day at the maximum rate of 4 inches per hour. Simultaneously with the opening of this valve the valve on the pipe from the inlet to the filter bed shall be fully opened so as to keep up the level of water in the filter bed. The filter bed will now be in full working order. The weirs in the patent regulator in the outlet chamber shall be adjusted to work the filter at this rate of 4 inches per hour.

Filtering Head.

The measuring of the filtering head should be more accurately determined than is the case at present. The arrangement of the floats requires alteration. Larger floats would produce more accurate results. In no case should the filtering head be allowed to exceed 24 inches. When it reaches this amount the filter bed should be stopped.

(5) FILTER WATER CONDUIT.

There are no manholes on this conduit for inspection purposes. Ventilators should be provided and the conduit should be periodically cleaned.

(6) CLEAR WATER RESERVOIRS.

There are three of these. Each of these reservoirs should be cleaned out every six months and the inside walls and pillars cement or lime washed, i.e., every two months one reservoir would be under cleaning. The inlet ventilators in their present position, simply flat gratings on the ground, are open to objection as storm water and impurities may enter the reservoir through them. They shoud be closed and the requisite air inlet provided at the inlet-houses the windows of which should be in the form of screens and not left open as at present. The outlet ventilators only project 2 or 3 feet above the ground level. These ventilators which are of the Creegan type should be lengthened to 15 feet to induce an outward current.

The surface of the ground instead of being flat should be sloped and it would be well to provide subsoil drains on the reservoir roof to lead away subsoil water which penetrates from the surface. These subsoil drains could discharge into the scour conduit. Generally all manhole and other openings for access to the clear water reservoirs should be kept shut when not actually in use. The gauge chambers which are used for pumping out the last 2 feet of water in the two clear water reservoirs into the scour conduit should be covered and not left open as at present. These reservoirs cannot be scoured directly into the scour conduit owing to the high level of the scour conduit, consequently no proper scour connexions are provided and pumping by temporary pumping plant is necessary.

(7) PUMPING STATION.

The general appearance of the pumping station is good but the Committee do not approve of the provision of a suction culvert underneath the floor and two openings therefrom opening directly into the engine room. It is impossible to maintain good quality of the water with such an arrangement. Further the foot valves of the pumps are at too high a level. The result of this is that the suction culvert and the filtered water conduit leading to it and the clear water reservoirs cannot be emptied by the main pumps for periodical cleaning; this is an important defect which the Committee consider should be remedied as early as possible. The Committee in the report have recommended the provision of pump wells outside the engine-house and so arranged that each pump well can be disconnected and cleaned. The suction pipe of a pump should be extended into one of these pump wells.

(8) STEEL TANK.

The Committee have said all they have to say about this in the report. Shortly what is required is the provision of scour outlets and periodical cleaning.

(9) QUANTITY OF WATER.

The quantity of water intended to be supplied to the City at the rate of 25 gallons per head per day of the population and to deal with which the water-works and drainage schemes have been designed is in the opinion of the Committee ample and the present policy of supplying an unlimited quantity should be given up. The Committee have dealt with this question in considerable detail in the body of this report and they will only reiterate here that the fixing of arbitrary pressures between certain hours at the Kilpauk pumping station is wrong in principle. Instead of doing so they have recommended that between the same hours the quantity of water necessary to supply the varying draw-off of the City should be pumped and they have shown how this can be done in giving a supply of 13,000,000 gallons a day to the City. In the event of such a supply being found insufficient on any particular day so as to maintain sufficient pressure at the ends of the distribution system the Committee would point out that this disadvantage can be overcome in the usual manner, namely, by the regulating of the sluice valves on the branch distribution mains so as to provide as nearly as possible a satisfactory and equitable amount of water in the various sections of the City. They have seen sufficient during their inspection of the distribution system to remark that there is at present no organized regulation of the distribution draw-off such as they have indicated above.

The Committee recognize the advantages of adding Deacon's waste detecting meters to the distribution mains of the City, but they do not think that the introduction of these detecting meters should precede the reduction of waste at house services which can be easily detected by eye. They have therefore recommended in their report the early introduction of house service meters. Out of 29,000 house service connexions only 900 are metered and of this 900 no less than 102 are fixed on Government buildings. We have, in our report for reasons given, recommended the introduction of more house service meters as early as possible and we contemplate that one-quarter of the house services will be metered in the next few years. We also propose in our report a special staff for the proper organization of house services and meters and we foresee that the carrying out of this policy will result in a large increase of revenue, from consumption of excess water used, over the present revenue of Rs. 1,52,717 per annum. We further recommend that the charge for excess water used which is at present 12 annas per 1,000 gallons, the same rate as in the days of the old gravitation channel and although the present supply has to be filtered and pumped to the City at considerable cost, should be raised to Re. 1 per 1,000 gallons except in the case of large consumers for industrial purposes.

Two new filter beds.

As the present filter beds are only capable of supplying eleven million gallons daily and as thirteen million gallons are required we recommend the construction of two additional filter beds to the north of existing beds Nos. 13 and 14.

(10) DISTRIBUTION.

We are of opinion that the distribution establishment requires to be re-organized and improved—see report.

In the first place all the specials on the distribution lines require to have distinctive numbers placed in a convenient position and the staff require to be supplied with maps showing the position of each distribution line and also all the valves, specials, etc., marked on the maps. New rules require to be drawn up in considerable detail for the instruction and guidance of the distribution staff. In these rules the importance of scouring the distribution pipes should be emphasised. The Committee remarked on the absence of any rules for scouring the distribution pipes. The returns to be submitted by the staff should be printed and should contain information of the dates when the scour valves were opened and the condition of the water flowing therefrom. The distribution system should be periodically inspected by a superior officer and the work of the distribution staff thereby efficiently checked.

Keys for opening valves and other water-works tools should be more readily accessible.

The number of scour valves at present in the system is out of all proportion to the requirements of an efficient system. The Committee are satisfied that the 2½-inch hydrants are useless for scouring purposes except on 4-inch pipes. In all larger sized pipes numerous scour valves should be fixed; the size of which should be fixed by the rule—diameter of scour branch equals half diameter of pipe to be scoured plus 1 inch. The scour valves should in no case be less than this and in specially favourable circumstances they should be more.

The Committee have referred to certain scour valve outlets which discharge into insanitary tanks below water level, into manholes and other places where the outlets are blocked with soil, etc. All scour pipes should have free outlets above risk of contamination.

(11) ESTABLISHMENT.

The Committee have been impressed during their inspection of the water-works with the fact that the maintenance of the water-works is divided up amongst a number of different officials more or less independent of each other. The works in our opinion suffer from this divided control. We are aware that, from 1st April 1918, it is the intention to have one assistant engineer in charge of the distribution under the Engineer of the Corporation. Other parts of the works are not, we understand, to be under the same agency. We have no hesitation in saying we consider these divided arrangements will be unsatisfactory. We are confident of the urgent necessity of the Corporation employing a water-works engineer to be in charge of the whole system. This engineer should give his whole-time to the duty of supervising the working of the water-works and maintaining them in the requisite state of efficiency. He should be supplied with a residence within the headworks area so that he can daily supervise the working of the filter beds and the pumping station. He should be a man of experience in water-works maintenance and his salary should be in keeping with the importance of the duties and sufficient to attract the right class of men. Rupees 800—50—1,250 might attract suitable candidates. Under this engineer there would be one assistant engineer, and the subordinate staff would be re-organized as recommended by us in the report.

(12) GENERAL REMARKS.

The Committee would comment on an important defect in the maintenance of the water-works. Owing probably to the fact that the superior staff available had numerous other duties to perform they were unable to carry out sufficient inspections of the system and check the duties performed by the subordinate staff. Unless this duty is performed the works must suffer in efficiency. The Committee have carefully considered whether they should recommend that an annual inspection of the works should be made by the Sanitary Commissioner and the Sanitary Engineer to Government. After due consideration they have come to the conclusion that except on special occasions this inspection is unnecessary because the Corporation maintain a superior staff which can carry out the duties required if their time were not taken up with other duties. The Committee. however, would suggest that the superior staff of the Corporation should freely consult the Sanitary Commissioner and Sanitary Engineer to Government and take advantage of the experiance these officers have acquired by inspection and supervision of numerous mufassal water-works. The engineer proposed by us to be employed by the Corporation for charge of the water-works should carry out regular and methodical inspections of the different parts of the system and should record his findings in a weekly statement. We consider that the Corporation should form a small water-works subcommittee, who should also make inspections at least once a month of the water-works and to whom the weekly statements of the engineer would be submitted as well as the results of the analyses of the water. The engineer would prepare annually a report on the working of the waterworks and submit it to the convener of the water-works sub-committee. After due consideration by the sub-committee this report would be submitted by them to the Corporation. These annual reports would form valuable records of the working of the water-works and containing as they should all necessary information they would obviate intermediate references and enquiries to a large extent. We have noted the absence of a completion report on the water-works as constructed and the absence of an annual report on their maintenance.

COST.

The Committee do not state the amount of money which will be required to carry out their recommendations as they have not the time to go into the matter in detail nor do they consider it part of their duties but would point out that they have only recommended two additional filters instead of the seven, the construction of which was approved by the Corporation. The other recommendations are in connexion with the improvement of details the cost of which would be relatively small, although the importance of carrying out the recommendations is great. There is, however, one important point which will ultimately cost a considerable sum and that is the washing, screening and relaying of the filter bed materials. Our recommendation is that this work should be proceeded with as early as possible and as funds permit. In the meantime the removal of the 3 feet margin which forms a "dead end" should be undertaken without delay.

W. A. JUSTICE, M.B., C.M., D.P.H., Major, I.M.S.,
Sanitary Commissioner for the Govt. of Madras.

W. HUTTON, A.M.I.C.E.,
Supg. Engineer, P.W.D.,
late Sanitary Engineer to the Govt. of Madras.

MADRAS,
29th April 1918.

APPENDICES.

(1)—A PRECIS of the results of bacteriological and chemical analysis of 41 samples of water taken between 25th September and 11th October 1917, which were examined at the King Institute laboratory with a view to study the bacteriological and chemical history of the Madras water from the Red Hills Lake, to the filters and from filters to the city.

Serial number.	Sources of samples.		I Set. First Series of Experiments.				II Set. Second Series of Experiments.				Chemical II Set.				
			Date of collection.	Total colonies per c.c. on agar at 37°C.	Lactose fermenters present in how many c.c.?	Result of vibrios test.	Date of collection	Total colonies per c.c. on agar at 37°C.	Lactose fermenters present in c.c.?	Result of vibrios test.	Ammoniacal nitrogen parts per 100,000.	Albuminoid nitrogen parts per 100,000.	Oxygen absorbed (Tidy's process).	Date of starting of filter-bed.	Filter head as recorded on 10th October 1917.
		Second Series.	1917.		c. c.		1917.		c. c.					1917.	
1	Raw ...	Red Hills Tank (4′ below surface) near Intake Tower.	25th Sep.	850	5	No vibrios.	9th Oct.	967	30	*Present.*	0·002	0·031	0·137	...	...
2	Do. ...	Roughing Filter Outlet.	Do.	800	5	Do.	Do.	3,950	10	No vibrios.	0·003	0·029	0·137	...	...
3	Do. ...	Manhole No. 35 on the covered conduit.	Do.	1,400	1	Do.	...	...	...	...	...	...	...	...	...
4	Do. ...	Inlet of filter beds ...	Do.	1,150	1	Do.	9th Oct.	4,200	3	No vibrios.	Trace.	0·034	0·137	...	...
5	Filtered	From Outlet Regulator of Bed No. 2.	2nd Oct	1,480	3	*Present.*	10th Oct	1,760	10	Do.	0·006	0·018	0·088	10th Oct	0 4½″
6	Do.	From Outlet Regulator of Bed No. 3	Do.	1,160	10	*Do.*	Do.	1,440	15	Do.	0·012	0·018	0·098	11th Sep.	1 5½″
7	Do.	From Outlet Regulator of Bed No. 4.	Do.	1,200	10	No vibrios.	Do.	1,315	1	Do.	0·007	0·017	0·059	9th. Oct.	0 4½″
8	Do.	From Outlet Regulator of Bed No. 5.	...	...	...	...	Do.	1,920	1	Do.	0·003	0·020	0·098	5th Oct.	0 3″
9	Do.	From Outlet Regulator of Bed No. 6.	2nd Oct.	1,353	3	No vibrios.	Do.	1,520	5	Do.	0·006	0·015	0·107	8th Oct.	0 6″
10	Do.	From Outlet Regulator of Bed No. 7.	Do.	1,400	3	Do.	Do.	1,990	5	Do.	0·006	0·015	0·098	23rd Sep	0 3½″
11	Do.	From Outlet Regulator of Bed No. 8.	...	...	...	...	Do.	1,550	9	Do	0·012	0·016	0·098	5th Oct.	0 9½″
12	Do.	From Outlet Regulator of Bed No. 10.	2nd Oct.	2,290	5	No vibrios.	Do.	980	5	*Present.*	0·006	0·015	0·098	28th Sep.	0 9″
13	Do.	From Outlet Regulator of Bed No. 11.	Do.	1,050	20	*Present.*	Do.	620	10	No vibrios.	0·010	0·016	0·098	10th Sep.	0 3½″
14	Do.	From Outlet Regulator of Bed No. 12	Do.	1,297	60	*Do.*	...	...	...	...	...	...	...	...	...
15	Do.	From Outlet Regulator of Bed No. 13	...	...	...	...	10th Oct	Countless.	0·01	No vibrios.	0 020	0·031	0·127	9th Oct.	0 1½″
16	Do.	From Outlet Regulator of Bed No. 14.	2nd Oct.	1,233	5	No vibrios.	Do.	680	6	Do	0·008	0·017	0·078	30th Sep.	1 6″
17	Mixed.	Pump Suction Culvert Engine House.	26th Sep.	1,900	1	Do.		...	...	...	...	...	...	...	...
18	Do.	Purasawalkam High Road and Kelly's Road Junction, I Series, and II Series, Orme's Road and Purasawalkam High Road.	Do.	2,200	5	Do.	10th Oct	3,740	0·1	No vibrios.	0·016	0·008	0·107	...	...
19	Do.	Georgetown	Do.	2,190	3	Do.	Do.	2,810	1	Do.	0·003	0 018	0 107	...	...
20	Do.	Tondiarpet	Do.	3,400	1	Do.	11th Oct.	1,860	5	Do.	0·002	0·020	0·088	...	...
21	Do.	Pump Suction Culvert Engine House	28th Sep	1,650	1	Do.	...	...	...	...		...	...	...	...
22	Do.	Triplicane (Ice House Road and Triplicane High Road Junction).	Do.	1,610	5	Do.	10th Oct.	1,980	5	No vibrios	0·003	0·021	0·107	...	...
23	Do.	Triplicane (Walajah Road and Triplicane High Road Junction).	Do.	2,650	0·1	Do.	...	...	...	...	...	...	...	...	...
24	Do.	Mylapore (No. 19, Brodies Road).	Do.	2,400	1	Do.	11th Oct.	Countless.	0·01	No vibrios.	0·006	0·023	0·098	...	...
25	Do.	Purasawalkam	Do.	1,350	1	Do.	...	...	...	...	...	...	..	...	...

(2)—TABULAR Statement of results of chemical analysis of samples taken at the instance of the Sanitary Commissioner.

Date of collection.	Sources.	Colour and transparency.	Smell.	Total solids parts per 100,000.	Temporary hardness.	Permanent hardness.	Total hardness.	Chlorine.	Ammoniacal nitrogen.	Albuminoid nitrogen.	Oxygen absorption.	Nitric nitrogen.	Nitrites.	Sulphates.	Phosphates.	Iron, poisonous metals.
9th Oct. 1917.	Red Hills lake water.	Yellowish and hazy.	None.	29·000	7·000	2·000	9·000	4 970	0·002	0·031	0·137	Nil.	Nil.	Present.	Nil.	Nil.
Do.	Red Hills water after passing through roughing filter.	Do.	Do.	28·600	7·000	2·000	9·000	4·970	0·003	0·029	0 137					
Do.	End of conduit before water enters the filter beds.	Do.	Do.	30·000	7·000	2 000	9·000	4 970	Trace	0·034	0·137					
10th Oct. 1917.	Filtered water from Bed No. 2.	Colorless and clear.	Do.	31·000	7·000	2·000	9·000	4·970	0·006	0·018	0 088					
Do.	Do. No. 3.	Do.	Do.	27·000	7·000	2 000	9·000	4·970	0 012	0·018	0 098					
Do.	Do. No. 4.	Do.	Do.	34·000	9·000	4·000	13·000	4·970	0·007	0·017	0 059					
Do.	Do. No. 5.	Yellowish but clear.	Do.	28·600	7·000	2·000	9·000	4 970	0·003	0 020	0·098					
Do.	Do. No. 6.	Do.	Do.	29 000	7·000	2 000	9·000	4·970	0·006	0·015	0·107	0·100				
Do.	Do. No. 7.	Do.	Do.	28·000	7·000	2·000	9 000	4·970	0·006	0 015	0 098	Nil.				
Do.	Do. No. 8.	Do.	Do.	27·600	7·000	2·000	9·000	4·970	0·012	0·016	0·098					
Do.	Do. No. 10.	Do.	Do.	29·000	7·000	2·000	9·000	4·970	0·006	0·015	0 098					
Do.	Do. No. 11	Do.	Do.	29·000	7·000	2 000	9 000	4·970	0 010	0·016	0 098					
Do.	Do. No. 13.	Do.	Do.	30·000	12·500	2·500	15 000	4·970	0 020	0·031	0·127					
Do.	Do. No. 14.	Yellowish and hazy.	Do.	28·400	7·000	2·000	9·000	4·970	0 008	0·017	0·078					
Do.	Public fountain, Orme's Road.	Yellowish but clear.	Do.	28·400	7·000	2 000	9·000	4·970	0·016	0·008	0·107					
Do.	Public Tap in Georgetown.	Do.	Do.	29·000	7·000	2·000	9·000	4 970	0·003	0·018	0·107					
Do.	Public Tap in Triplicane.	Do.	Do.	28·600	6·500	2·500	9·000	4 970	0·003	0·021	0·107					
11th Oct. 1917.	Tap in Mylapore.	Yellowish and hazy.	Do.	29·000	7·000	2 000	9·000	4·970	0·006	0·023	0·098					
Do.	Public Tap in Tondiarpet.	Yellowish but clear.	Do.	27·600	7·000	2·000	9·000	4·970	0·002	0·020	0·088					

(3) RESULTS of chemical examination of 41 samples of water collected between 7th and 9th November 1917 from the different places.

Date of collection.	Sources.	Colour and transpatency.	Smell.	Total Solids.	Temporary Hardness.	Permanent Hardness.	Total Hardness.	Chlorine.	Ammoniacal Nitrogen.	Albuminoid Nitrogen.	Oxygen Absorption.	Nitric Nitrogen.	Nitrites.	Sulphates.	Phosphates.	Iron, Poisonous metals.	Sediment parts per 100,000.
7th November 1917.	Red Hills lake (Top valve).	Yellowish and hazy.	None.	27·000	7·500	3·500	11·000	4·615	0·003	0 028	0 113	Nil.	Nil.	Present.	Nil.	Nil.	0·400
	Red Hills lake (Middle valve)			27·000	7·500	3·500	11·000	4·615	0·003	0·029	0·113						0·400
	Red Hills lake (Bottom valve)			26·000	7·500	3·500	11·000	4·615	0·003	0·029	0·113						
	Red Hills lake (Lowermost valve).			28·000	7·500	3·500	11·000	4·615	0·005	0·032	0·113						
	Red Hills before passing through the main portion of the roughing filter.			26·400	7·000	4·000	11·000	4·615	0·003	0·029	0 113						
	Red Hills after roughing filter.			26·000	7·000	4·000	11·000	4·615	0·003	0·028	0·113						
	Red Hills from Manhole No. 35.			27·000	7·000	4·000	11·000	4·615	0·003	0·031	0·113						
	Sample from end of conduit before water enters into filter beds (general).			28·000	7·000	4·000	11·000	1·615	0·003	0·029	0·113						
	Inlet of bed No. 1.			27·000	8·000	4·000	12·000	4·615	0·002	0·030	0·123						
	Do. No. 2.			27·000	8·000	4·000	12·000	4·615	0·004	0·028	0·123						
	De. No. 3·			28·000	7·000	4·000	11·000	4·615	0·004	0·027	0·123						
	Do. No. 4.			29·000	7·000	4·000	11·000	4·615	0·003	0·034	0 123						
	Do. No. 5			27·000	7·000	4·000	11 000	4·615	0·002	0·028	0·123						
	Do. No. 6.			26·600	7·000	4·000	11·000	4·615	0·002	0·029	0·113						
	Do. No. 7·			26·000	7·000	4·000	11·000	4 615	0·002	0·028	0·113						
	Do. No. 9.			26·400	7·000	4·000	11 000	4·615	0·002	0·031	0·113						
	Do. No. 11.			27 000	7·000	4·000	11·000	4·615	0·002	0·026	0·113						
	Do. No. 12			27·600	7·000	4·000	11·000	4·615	0·003	0·027	0·113						
	Do. No. 13			27·000	7·000	4·000	11·000	4·615	0·003	0·029	0·113						
	Do. No. 14.			27·600	7·000	4·000	11·000	4·615	0·003	0 029	0·113						
8th November 1917.	Outlet of filter bed No. 1.	Slightly yellowish but clear.		27·400	7·000	4·000	11·000	4·615	0·003	0·018	0·072						
	Do. No. 2.			27·400	7·000	4·000	11·000	4·615	0·003	0·019	0·088	Trace					
	Do. No. 3.			27·400	7·000	4·000	11·000	4·615	0·006	0·016	0·088	Nil.					
	Do. No. 4.			27·400	7·000	4·000	11·200	4·970	0·007	0·018	0·088	Trace.					
	Do. No. 5			28·000	7·000	4·000	11·000	4·615	4·005	0·015	0·088	Nil.					
	Do. No. 6.			26·600	7·000	4·000	11·000	4·615	0·006	0 016	0·078						
	Do. No. 7.			27·400	7·000	4·000	11·000	4·615	0·003	0 015	0·088						
	Do No. 9.			27·600	7·0J0	4·000	11·000	4·615	0·002	0·017	0·088						
	Do. No. 11.			27·600	7·000	4·000	11·000	4·615	0·007	0·016	0·088						
	Do. No. 12·			27·000	7·000	4·000	11·000	4·615	0 002	0·013	0·088						
	Do. No. 13.			27·400	7·000	4·000	11·000	4·615	0·003	0·015	0·088						
	Do. No. 14			27·400	7·000	4·000	11·000	4·615	0·002	0·016	0 088						
	Do. Eastern Reservoir.	Yellowish but clear.		27·000	7·000	4·000	11·000	4·615	0·002	0·017	0·072						
	Do. Central Reservoir.			27·600	7·000	4·000	11·000	4·615	0·004	0·015	0·072						
	Do. Western Reservoir	Yellowish and hazy.		26·600	7·000	4·000	11·000	4·615	0·002	0·029	0·113						
	Do. elevated Tank or Reservoir.	Slightly yellowish but clear.		27·400	7·000	4·000	11·000	4·615	0·006	0·022	0·088						
	First tap after pumps.			28·000	7·000	4·000	11·000	4·615	0·002	0·015	0 088						
	A public tap in Georgetown.			27·000	7·000	4·000	11·000	4·615	0·003	0·016	0·093						
	Do in Triplicane High Road.			27·600	7·000	4·000	11·000	4·615	0·003	0·017	0·088						
9th Nov 1917	Do. Tondiyarpet.			27·000	7·000	4·000	11·000	4·615	0·003	0·015	0·088						
	Do. Mylapore	Yellowish and hazy.		26·600	7·000	4·000	11·000	4·615	0·002	0·018	0·088						

(4) RESULTS of bacteriological examination of 42 samples of water collected between 7th and 9th November 1917 from different places in the Madras City Water-supply system.

Serial number.	Date of collection of samples.	Source of samples as per label.	Total colonies per c.c. of sample on agar at 37° c.	Lactose Fermenters, present in how many c.c. ?.	Result of Vibrios Test. (Present or Absent.)
				c.c.	
1	7 Nov. 1917.	Raw water from Red Hills Lake, top valve, 1 foot 2·08 inches below surface.	765	60 and upwards.	*Vibrios present in* 100 *c.c.*
2	Do.	Raw water from Red Hills Lake, middle valve, 5 feet 5 inches below surface.	620	Do.	*Do.*
3	Do.	Raw water from Red Hills Lake, bottom valve, 11 feet 4 inches below surface.	790	Do.	*Do*
4	Do.	Raw water from Red Hills Lake, lower-most valve, 15 feet 10½ inches below surface.	940	60	*Do.*
4-A	Do.	Raw water from Red Hills Lake, from surface of lake.	860	30	*Do.*
5	Do.	Raw water taken before passing into the main portion of roughing filter.	1,740	0·1	No vibrios in 100 c.c.*
6	Do.	Raw water, taken after passing through roughing filter.	1,410	1	Do.
7	Do.	Raw water from Manhole No. 35	3,760	†0·1	Do.
8	Do.	Do. from end of conduit before entering filter beds (General Inlet).	8,300	1	Do.
9	Do.	Raw water from Inlet of Bed No. I.	3,740	0·01	Do.
10	Do.	Do. do. II.	6,520	0·1	*Vibrios present in* 100 *c.c.*
11	Do.	Do. do. III.	5,890	0·1	No vibrios in 100 c.c.*
12	Do.	Do. do. IV.	3,480	1	Do.
13	Do.	Do. do. V.	4,190	1	Do.
14	Do.	Do. do. VI.	5,180	0·1	Do.
15	Do.	Do. do. VII.	6,430	0·1	Do.
16	Do.	Do. do. IX.	4,870	1	Do.
17	Do.	Do. do. XI.	5,410	1	*Vibrios present in* 100 *c.c.*
18	Do.	Do. do. XII.	3,920	1	*Do.*
19	Do.	Do. do. XIII.	2,440	1	No vibrios in 100 c.c.
20	Do.	Do. do. XIV.	5,600	1	Do.
21	8 Nov. 1917.	Filtered water from Outlet Regulator of Bed No. I.	1,120	5	Do.
22	Do.	Do. do. II.	1,630	1	Do.
23	Do.	Do. do. III.	540	6	Do
24	Do.	Do. do. IV.	3,150	1	Do.
25	Do.	Do. do. V.	1,600	4	Do.
26	Do.	Do. do. VI.	445	5	Do.
27	Do.	Do. do. VII.	1,400	5	*Vibrios present in* 100 *c.c.**
28	Do.	Do. do. IX.	1,340	5	No vibrios in 100 c.c.
29	Do.	Do. do. XI.	2,950	1	*Vibrios present in* 100 *c.c.**
30	Do.	Do. do. XII.	2,200	5	No vibrios in 100 c.c.
31	Do.	Do. do. XIII.	1,155	5	Do.
32	Do.	Do. do. XIV.	1,580	5	Do.
33	Do.	(?) Water from Eastern Reservoir ..	1,530	1	Do.
34	Do.	(?) do. Central do. ...	1,810	0·1	Do.
35	Do.	(?) do. Western do. ...	1,880	0·01	Do.
36	Do.	(?) Elevated Tank or do. ...	1,490	1	Do.
37	Do.	(?) do. First tap after pumps. ...	1,015	2	Do.
38	Do.	(?) do. Public tap in Georgetown.	1,620	1	Do.
39	Do.	Do. Triplicane ...	1,040	5	Do.
40	9 Nov. 1917.	Do. Tondiarpet ...	1,230	5	Do.
41	Do.	Do. Mylapore ...	2,050	1	Do.

* Half roughing filter under cleaning.

† A probable experimental error.

(5)—RESULTS of bacteriological examination of eight samples of water, collected on 4th December 1917 from Red Hills and roughing filters, under instructions of the Committee.

Serial number.	Sources of samples as per label.	Total colonies per c.c. on agar at 37° c.	Lactose fermenters present in how many c.c.	Result of vibrios test.
			c.c.	
1	Red Hills, middle valve, 5′ 5″ below surface ...	380	60	No vibrios in 100.
2	A tap on south main leading to roughing filter, *with* materials.	610	30	Do.
3	A tap on north main leading to roughing filter, *without* materials.	460	30	Do.
4	Inlet to west roughing filter *with* materials	1,440	15	Do.
5	Inlet to east roughing filter *without* materials	830	30	Do.
6	Outlet of roughing filter *with* materials	1,280	5	Do.
7	Outlet of roughing filter *without* materials	600	60	Do.
8	From manhole No. I	1,600	1	Do.

(6)—SAMPLES collected on 7th January 1911—See p. 70.

(6-*a*).—RESULTS of bacteriological examination of forty-one (41) samples of water taken on 22nd, 23rd and 24th January 1918 from sources shown below.

Serial number.	Dates of collection.	Source of sample as per label.	Total colonies on agar at 37° c.	Lactose fermenters present in ? c.c	Result of vibrios test.
				c.c.	
1	22nd January 1918.	From Red Hills Lake, 23 feet from tower.	310	5	Vibrios present in 100 c.c.
2		Do. 18 feet do.	305	5	Do.
3		From inlet of east roughing filter ..	285	5	Do.
4		From outlet of do. ...	280	5	Do.
5		Leakage water at the inlet of west roughing filter.	1,410	5	No vibrios in 100 c.c.
6		Entrance to conduit	410	5	Vibrios present in 100 c.c.
7		Manhole No. I on conduit	370	5	Do.
8		Do. No. II do.	290	5	Do.
9		Do. No. XXXV on conduit	360	5	Do.
10		End of conduit (at the Kilpauk filter beds).	540	5	Do.
11	Morning of 23rd January 1918	End of conduit (at Kilpauk) (same as above but taken on the following day).	430	10	Do.
12		Raw water from inlet of bed No. I. ...	380	10	Do.
13		Do. do. No. II ...	880	1	Do.
14		Do. do. No. III ...	560	5	Do.
15		Do. do. No. V ...	460	5	Do.
16		Do do. No. VII ...	1,040	1	Do.
17		Do. do. No. VIII ...	810	1	Do.
18		Do. do. No. IX ...	460	5	Do.
19		Do. do. No. X ...	480	5	Do.
20		Do. do. No. XI ...	490	5	Do.
21		Do. do. No. XII ...	440	5	Do.
22		Do. do. No. XIV ...	790	1	Do.
23	Afternoon of 23rd January 1918.	Filtered water from outlet of bed No. I	210	None in 60	No vibrios in 100 c.c.
24		Do. do. No. II.	225	Do. 60	Vibrios present in 100 c.c.
25		Do. do. No. III.	740	5	No vibrios in 100 c.c.
26		Do. do. No. V.	205	None in 60	Vibrios present in 100 c.c.
27		Do. do. No. VII	285	Present in 60	No vibrios in 100 c.c.
28		Do. do. No. VIII.	340	20	Do.
29		Do. do. No. IX.	215	None in 60	Do.
30		Do. do. No. X.	630	5	Do.
31		Do. do. No. XI.	415	15	Do.
32		Do. do. No. XII.	240	None in 60	Vibrios present in 100 c.c.
33		Do. do. No. XIV.	310	Present in 60	Do.
34	24th January 1918.	From eastern clear water reservoir ...	960	1	No vibrios in 100 c.c.
35		From central do. ...	730	10	Do.
36		From western do. ...	880	1	Vibrios present in 100 c.c.
37		From manhole	640	5	Do.
38		From Suction well in pumping station ..	820	1	Do.
39		Test tap on main outlet pipe in pumping station.	560	5	Do.
40		Tap in Lunatic Asylum	605	5	Do.
41		Tap near Kilpauk toll-gate	775	5	Do.

(7).—RESULTS of bacteriological examination of thirty-nine (39) samples of water taken on 18th to 20th February 1918 from the Madras filters.

Serial number.	Source of sample as per label.	Total colonies on agar at 37° c.	Lactose fermenters in how many c c.?	Result of vibrios test.	Remarks, January analysis.
			c.c.		c.c.
1	Red Hills, 23 feet from tower, 18th February 1918.	145	10	No vibrios in 100 c.c.	310 5
2	Red Hills, 18 feet from tower ..	220	10	Do.	305 5
3	Inlet of east roughing filter ...	360	10	No vibrios	285 5
4	Outlet of do.	380	9	Do.	280 5
5	Entrance to conduit	650	5	Do.	410 5
6	Manhole No. I	540	5	Do.	370 5
7	Do. No. II	580	5	Do.	290 5
8	Do. No. XXXV	670	5	Do.	360 5
9	End of conduit at Kilpauk, evening of 18th February 1918.	395	0·1	Do.	540 5
10	End of conduit at Kilpauk, on the morning of 19th February 1918.	680	1	Do.	430 10
11	Inlet cistern of Bed No. 3	550	1	Do.	560 5
12	Do. No. 5	690	5	Do.	460 5
13	Do. No. 7	790	1	Do.	1,040 1
14	Do. No. 9	480	5	Do.	460 5
15	Do. No. 11	930	0·01	Do.	490 5
16	Do. No. 13	810	1	Do.	Not working.
17	Do. No. 14	730	1	Do.	790 1
18	Do. No. 10	710	1	Do.	480 5
19	Do. No. 8	760	1	Do.	810 1
20	Do. No. 6	640	1	Do.	Not working.
21	Filtered water from outlet of bed No. 3.	275	20	Do.	740 5
22	Do. do. No. 5.	340	5	Do.	205–60
23	Do. do. No. 6.	280	20	Do.	......
24	Do. do. No. 7.	165	None in 60	Do.	285 + 60
25	Do. do. No. 8.	310	10	Do.	340 20
26	Do. do. No. 9.	220	60	Do.	215–60
27	Do. do. No. 10.	430	20	Do.	630 5
28	Do. do. No. 11.	490	1	Do.	415 15
29	Do. do. No. 13.	510	1	Do.	Not working.
30	Do. do. No. 14.	230	20	Do.	310 + 60
31	Filtered water conduit	525	5	Do.	Not taken.
32	Eastern clear water reservoir, 20th February 1918.	610	5	Do.	960 1
33	Central clear water Reservoir ...	680	5	Do.	730 10
34	Western do. ...	860	1	Do.	880 1
35	Manhole opposite pumping station near experimental oil filter now abandoned.	520	5	Do.	640 5
36	Suction well inside pumping station.	810	1	Do.	820 1
37	Test tap on main outlet pipe inside pumping station.	620	1	Do.	560 5
38	Tap in Lunatic Asylum	440	5	Do.	605 5
39	Tap near toll-gate	425	5	Do.	775 5

(8 & 9)—RESULTS of chemical examination of six (6) samples of water taken on 29th and 30th March 1918 from the Madras City Water-supply.

		Tap at the end of Malayaperumal Street next to east gate of Kothaval Bazaar.	Tap in Sullivan Street in front of Helen Villa near St. Thomé Cathedral.
Physical appearances.	Colour and transparency.	Yellowish and hazy.	Yellowish but clear.
	Smell ...	None.	None.
QUANTITATIVE.			
Total solids	Parts per 100,000	28·000	27·600
Temporary hardness	Do.	7·000	7·000
Permanent hardness	Do.	4·000	4·000
Total hardness	Do.	11·000	11·000
Chlorine	Do.	4·970	4·970
Ammoniacal Nitrogen	Do.	0·002	0·004
Albuminoid Nitrogen	Do.	0·020	0·018
Oxygen absorbed (*Tidy's Process*)	Do.	0·091	0·073
Nitric Nitrogen	Do.	Nil.	Nil.
QUALITATIVE.			
Nitrites	...	Nil.	Nil.
Sulphates		Present.	Present.
Phosphates	...	Nil.	Nil.
Iron, poisonous metals	...	Nil. Nil.	Nil. Nil.

		Unfiltered water.	Kilpauk filter-bed filter water conduit.
Physical appearances.	Colour and transparency.	Yellowish and hazy.	Yellowish but clear.
	Smell	None.	None.
QUANTITATIVE.			
Total solids	Parts per 100,000	28·000	27·000
Temporary hardness	Do.	7·000	7·000
Permanent hardness	Do.	4·000	4·000
Total hardness	Do.	11·000	11·000
Chlorine	Do.	4·970	4·970
Ammoniacal Nitrogen	Do.	0·003	0·004
Albuminoid Nitrogen	Do.	0·029	0·016
Oxygen absorbed (*Tidy's Process*)	Do.	0·105	0·076
Nitric Nitrogen	Do.	Nil.	Nil.
QUALITATIVE.			
Nitrites	...	Nil.	Nil.
Sulphates	...	Present.	Present.
Phosphates		Nil.	Nil.
Iron, poisonous metals	...	Nil. Nil.	Nil. Nil.

		Tap near Kilpauk Toll-gate.	Tap in Tondiarpet next to house No. 2/192.
Physical appearances.	Colour and transparency.	Yellowish but clear.	Yellowish and hazy.
	Smell	None.	None.
QUANTITATIVE.			
Total solids	Parts per 100,000	27·400	27·000
Temporary hardness	Do.	7·000	7·000
Permanent hardness	Do.	4·000	3·500
Total hardness	Do.	11·000	10·500
Chlorine	Do.	4·970	4·970
Ammoniacal Nitrogen	Do.	0·003	0·004
Albuminoid Nitrogen	Do.	0·020	0·017
Oxygen absorbed (*Tidy's Process*)	Do.	0·090	0·073
Nitric Nitrogen	Do.	Nil.	Nil.
QUALITATIVE.			
Nitrites	...	Nil.	Nil.
Sulphates	...	Present.	Present.
Phosphates	...	Nil.	Nil.
Iron, poisonous metals	...	Nil. Nil.	Nil. Nil.

(10)—RESULTS of bacteriological examination of forty-six (46) samples of water taken on 28th and 30th March 1918 from the Madras City Water-supply system.

Serial number.	Date of collection.	Sources of samples as per label.	Total colonies per c.c. on agar at 37° c.	Lactose fermenters present in how many c.c.?	Result of vibrios test.
				c.c.	
1	28th March 1918.	Red Hills Lake, 23 feet from tower ...	150	15	No vibrios in 100 c.c.
2		Do. 18 feet do. ...	165	15	Do.
3		Inlet of west roughing filter	240	10	Do.
4		Outlet of do. do.	165	10	Do.
5		Entrance to conduit	180	7	Do.
6		Manhole No. I	210	7	Do.
7		Do. II	280	10	Do.
8		Do. 20	320	10	Do.
9		Do. 23	430	7	Do.
10		Do. 28	460	5	Do.
11		Do. 31	385	10	Do.
12		Do. 35	350	10	Do.
13		Do. 46	610	5	Do.
14		Do. 49	570	5	Do.
15		End of conduit at Kilpauk	520	5	Do.
16	Morning, 29th March 1918.	End of conduit at Kilpauk	480	10	Do.
17		Unfiltered water from inlet of Bed No. 3 ...	810	7	Do.
18		Do. do. 5 ...	580	10	Do.
19		Do. do. 7 ...	940	0·1	Do.
20		Do. do. 13 ...	270	5	Do.
21		Do. do. 12 ...	840	1	Do.
22		Do. do. 10 ..	650	1	Do.
23		Do. do. 8 ...	720	1	Do.
24		Do. do. 4 ...	460	5	Do.
25		Do. do. 2 ...	980	0·1	Do.
26	Afternoon, 29th March 1918.	Filtered water from outlet of Bed No. 2 ...	310	30	Do.
27		Do. do. 3 ..	285	60	Do
28		Do. do. 4 ...	140	None in 60	Do.
29		Do. do. 5 ...	205	60	Do.
30		Do. do. 7 ...	470	5	Do.
31		Do. do. 8 ...	360	20	Do.
32		Do. do. 10 ...	330	15	Do.
33		Do. do. 12 ...	175	None in 60	Do.
34		Do. do. 13 ...	240	60	Do.
35		Filtered water from filtered water conduit.	520	10	Do.
36	30th March 1918.	Eastern clear water reservoir	810	10	Do.
37		Central do. ...	590	7	Do.
38		Western do.	1,350	5	Do.
39		Manhole (opposite pumping station near Experimental oil filter now abandoned.)	760	10	Do.
40		Suction well inside pumping station ...	575	10	Do.
41		Test tap on main outlet pipe inside pumping station.	610	7	Do.
42		Tap in Lunatic Asylum	940	5	Do.
43		Tap near Tollgate (Kilpauk)	690	7	Do.
44		Public tap in Tondiarpet Public Fountain in Tiruvottiyur High Road next to door No. 2/192.	480	10	Do.
45		Public tap in Georgetown Malayaperumal Street corner, adjoining East entrance to Kothuval bazaar.	790	10	Do.
46		Public tap in San Thomé, Sullivan's Street near San Thomé Cathedral in front of Helen Villa.	1,050	7	Do.

(11)—RESULTS of bacteriological examination of two samples of water taken on 17th March 1918 from Bed No. 4.

Serial number.	Particulars of source.	Tota colonies per c.c. on agar.	Lactose fermenters in how many c.c.?	Result of vibrios test.
1	Raw water from Inlet of Bed No. 4	1,830	5 c.c.	No vibrios in 100 c.c.
2	Filtered water from Outlet of Bed No. 4	790	20 „	Do.

(11-a)—CHEMICAL analysis of water collected on 17th March 1918.

		Raw water from Inlet of Bed No. 4.	Filtered water from Outlet of Bed No. 4.
Physical appearances.	Colour and transparency.	Yellowish and hazy.	Yellowish but clear.
	Smell	None.	None.
QUANTITATIVE.			
Total solids	Parts per 100,000	28·400	27·000
Temporary hardness	Do.	9·000	9·000
Permanent hardness	Do.	4·000	3·000
Total hardness	Do.	13·000	12·000
Chlorine	Do.	4·970	4·970
Ammoniacal Nitrogen	Do.	0·002	0·004
Albuminoid Nitrogen	Do.	0·029	0·014
Oxygen absorbed *(Tidy's Process)*	Do.	0·121	0·074
Nitric Nitrogen	Do.	Nil.	Nil.
QUALITATIVE.			
Nitrites	..	Nil.	Nil.
Sulphates	..	Present	Present.
Phosphates	..	Nil.	Nil.
Iron, poisonous metals	...	Nil. Nil.	Nil. Nil.

(12)—RESULTS of bacteriological examination of two samples of water collected on 8th April 1918 from Kilpauk filters.

Serial number.	Description of sample.	Total colonies per c.c. of sample on agar at 37° c.	Lactose fermenters present in how many c.c.	Result of vibrios test.
1	Unfiltered water from Inlet of Bed No. 4	1,350	1 c.c.	No vibrios in 100 c.c.
2	Filtered water from Outlet Regulator Chamber of Bed No. 4.	160	None in 60 „	Do.

(12-a)—CHEMICAL analysis of water collected on 8th April 1918.

		Unfiltered water from Inlet of Bed No. 4.	Filtered water from Outlet Register Chamber of Bed No. 4.
Physical appearances.	Colour and transparency.	Yellowish and opaque.	Yellowish but clear.
	Smell	None.	None.
QUANTITATIVE.			
Total solids	Parts per 100,000	29·000	28·000
Temporary hardness	Do.	8·000	8·000
Permanent hardness	Do.	4·000	4·000
Total hardness	Do.	12·000	12·000
Chlorine	Do.	5·325	5·325
Ammoniacal Nitrogen	Do.	0·003	0·004
Albuminoid Nitrogen	Do.	0·031	0·013
Oxygen absorbed *(Tidy's Process)*	Do.	0·127	0·091
Nitric Nitrogen	Do.	Nil.	Nil.
QUALITATIVE.			
Nitrates	...	Nil.	Nil.
Sulphates	...	Present.	Present.
Phosphates	...	Nil.	Nil.
Iron, poisonous metals	...	Nil. Nil.	Nil. Nil.

(S₁)—SAMPLE of sand in use from Bed No. 6, 25 tolas of sample taken for analysis.

Number of meshes in the inch.	Rejected in tolas.	Passed through in tolas.	Percentage passing sieve.
6 × 6	...	25·00	100·00
10 × 10	0·75	24·25	97·00
16 × 16	1·25	23·00	92·00
20 × 20	6·125	16·875	67·50
30 × 30	7·375	9·50	38·00
40 × 40	2·50	7·00	28·00
50 × 50	3·75	3·25	13·00
60 × 60	2·00	1·25	5·00
80 × 80	...	...	...
100 × 100	...	...	...

(S₂)—SAMPLE of sand after washing and proposed to be filled in beds, 25 tolas of sample taken for analysis.

Number of sieve meshes in the inch.	Rejected in tolas.	Passed through in tolas.	Percentage passing sieve.
6 × 6	0·125	24·875	99·50
10 × 10	0·625	24·250	97·00
16 × 16	1·00	23·25	93·00
20 × 20	6·25	17·00	68·00
30 × 30	8·75	8·25	33·00
40 × 40	2·375	5·875	23·50
50 × 50	4·00	1·875	7·50
60 × 60	1·375	·50	2·00
80 × 80	...	...	...
100 × 100	...	...	...

(S₃)

Letter—from Dr. J. L. SIMONSEN, Additional Professor of Chemistry, Presidency College, Madras.

To—Major W. A. JUSTICE, M.B., C.M., D.P.H., I.M.S., Sanitary Commissioner for Madras.

Dated—the 12th February 1918.

I have had the sand from the filter beds examined chemically and the results are as follows :—

(i) Nitrogen is absent from all the specimens. Kjeldahl determination.

(ii) the black specimens contain a relatively considerable quantity of sulphide.

(iii) there is only the merest trace of sulphate present in the sand from the centre of the beds and no sulphide.

(iv) the black specimens contain sulphate especially after exposure to sunlight and air.

2. From these experiments it would appear that lack of aeration is the cause of the black colour and it would disappear if there were no "dead ends".

3. This view contains some support from the fact that there is more iron in the black sand than in the sand from the centre of the bed. This may be due to the following series of changes :—Sulphur (from albumen)—iron sulphide—iron sulphate (due to air oxidation) and this passes away dissolved in the water.

4. It might prove possible to determine if this is correct by determining the iron content of the water before and after treatment through the beds.

5. If there is any other information you would like me to try and obtain you might let me know.

(S₄)

Letter—from Dr. J. L. SIMONSEN, Additional Professor of Chemistry, Presidency College, Madras.

To—Major W. A. JUSTICE, M.B., C.M., D.P.H., I.M.S., Sanitary Commissioner for Madras.

Dated—the 7th March 1918.

Your demi-official of the 6th instant forwarding two specimens of Madras water.

2. Both specimens are quite free from hydrogen sulphide and contain the same percentage of sulphate.

3. The iron content of them both is extremely low. By approximate colour test, the filtered water contains a slightly greater quantity. Owing however to the minute quantity of iron present not very much reliance can be placed on this determination.

4. In paragraph 4 of my letter of February 12th, I suggested that iron sulphate might be formed and that this would be dissolved in the water. This would probably be the case (i.e., solution) if the oxidation of the sulphide stopped at the ferrous stage with formation of ferrous sulphate which is readily soluble in water. If, on the other hand, ferric sulphate were formed this would remain, probably, on the filter bed in the form of the insoluble basic salt.

5. It is possible that an analysis of the sulphur content of the filter bed sand before and after use might throw light on this point. In view of the absence of hydrogen sulphide from the unfiltered water, it looks as if the sulphur was of organic origin. Of course the contamination of the unfiltered water with sulphur compounds may only be occasional and the specimen I received may have been taken during a "free" period.

(S₅)—TWO samples of sand from Madras filter beds analysed at the King Institute of Preventive Medicine, 16–2–1918.

——		Top layer of filter bed.	Bottom layer (black sand).
Moisture	per cent.	6·091	21·659
Insoluble matter in hydrochloric acid	„	93·300	78·620
Fe_2O_3 (oxide of iron)	„	0·510	0·430
Lime (CaO)	„	0·022	0·030
Magnesia (MgO)	„	0·034	0·033
Sulphuric anhydride (SO_3)	„	0·012	0·013
Total SO_3 after oxidising with nitric acid.	„	...	0·036 per cent.

(1) The slight reddish brown tint in the sand is due to the presence of the oxide of iron.

(2) This oxide of iron exists in an easily soluble form and can be got rid of by washing the sand with acid.

(3) The presence of the sulphide of iron is responsible for black colour of No. 2. This black colour fades away, if the sand is exposed to air for some time, but is liable to return if the sand is not washed.

(P₁)

Letter—from T. BAINBRIGGE-FLETCHER, Esq., F.L.S., F.E.S., F.Z.S., Imperial Entomologist, Pusa, Bihar.

To—the Director, the King Institute of Preventive Medicine, Guindy, Madras.

Dated—the 11th February 1918.

No.—1148.

With reference to your letter No. 3668-1B., dated 30th ultimo, I have the honour to inform you that the larvæ sent by you are those of a hydrophilid beetle which frequents rivers and ponds (see Professor I. C. Miall, The Natural History of Aquatic Insects, pp. 61–93, edition 1903).

In the absence of the adults reared from the larvae, it is not possible for me to give their specific determination. If more larvae be available, I should like to have them packed in a tin case with holes containing moist aquatic weeds. Or you might be able to breed some out and send us the adults for determination.

Letter—from THE IMPERIAL ENTOMOLOGIST, Pusa, Bihar.

To—the Director, the King Institute of Preventive Medicine, Guindy, Madras.

Daetd—the 8th May 1918.

No.—101.

With reference to your letters Nos. 3668–6/13 and 3668 of 1917, I have the honour to inform you that the larvæ are those of Caddis-flies-Trichoptera. The adults belong to the group

Trichoptera, Family Hydropsychidae. If you will arrange to send me adult specimens in papers, I shall have them properly set and identified for you.

(P_2)—RESULTS of naked eye and microscopic examinations of the samples of sand taken from Bed No. 4 and of Adyar water and experimental filter surface sand.

Sample of surface sand from near inlet of Bed No. 4—contains diatoms, desmids, infusors, rotifers and vegetable filaments and debris in large numbers, in addition to numerous reddish larvæ of aquatic flies (possibly chironomudae.)

Sample of surface sand from near middle of one side of filter No. 4—contains diatoms in large numbers, desmids, infusors and rotifers comparatively fewer in number, vegetable flaments and debris, in addition to the reddish larvæ abovenamed.

Sample of surface sand from near outlet of filter No. 4—contains diatoms and infusors, vegetable filaments and debris, desmids and rotifers very few in number, *no larvæ seen.*

Adyar water.—Infusors present in very large numbers, diatoms comparatively very few.

Film removed from open filter.—Contains diatoms and infusors in considerable numbers. Algæ and egg cases and moults of aquatic insects.

(C_1)—CHEMICAL analysis of water collected on 19th February 1918.

Physical appearances.		End of conduit filtered at Kilpauk, raw water.	Filtered water.
	Colour and transparency.	Yellowish and hazy.	Colourless and clear.
	Smell	None.	None.
QUANTITATIVE.			
Total solids	Parts per 100,000	26·200	25·120
Temporary hardness	Do.	7·500	7·500
Permanent hardness	Do.	3·500	3·500
Total hardness	Do.	11·000	11·000
Chlorine	Do.	4·970	4·970
Ammoniacal nitrogen ...	Do.	0·004	0·004
Albuminoid nitrogen	Do.	0·026	0·016
Oxygen absorbed (*Tidy's Process*)	Do.	0·118	0·082
Nitric nitrogen	Do	Nil.	Nil.
QUALITATIVE.			
Nitrites	...	Nil.	Nil.
Sulphates	...	Present.	Present.
Phosphates	...	Nil.	Nil.
Iron, poisonous metals	...	Nil. níl.	Nil, nil.

SAMPLES of water.

—		End of conduit at Kilpauk, raw water.	Filtered water.
*Total solids	Parts per 100,000	26·200	25·120
Temporary hardness	Do.	7·500	7·500
Permanent hardness	Do.	3·500	3·500
Total hardness	Do.	11·000	11·000
Containing—			
*Insoluble in hydrochloric acid	Parts per 100,000	1·400	1·280
Ferric oxide and alumina	Do.	Nil.	Nil.
Lime (CaO)	Do.	2·400	2·400
Magnesia (MgO)	Do.	1·584	1·584
Potassium oxide (K_2O)	Do.	Trace.	Trace.
Sodium oxide (Na_2O)	Do.	5·618	5·850
Sulphuric anhydride (SO_3)	Do.	2·058	2·058
Nitric anhydride (N_2O_5)	Do.	Nil.	Nil.
Chlorine (Cl)	Do.	4·970	4·970

(13)—RESULTS of bacteriological examination of fifty-four samples of water from the Madras city Water-supply system collected between 16th and 18th April 1918.

Serial number.	Source of sample as per label.	Date of collection.	Total colonies per c.c. on agar at 37° c.	Lactose fermenters present or absent in how many c.c.?	Result of vibrios test.
				c.c.	
1	Red Hills Lake, 23 feet from Tower	16th April 1918.	195	15	No vibrios in any of the fifty-four samples of water.
2	Do. 18 feet do.		210	10	
3	Inlet of East Roughing Filter		240	10	
4	Do. West do.		225	10	
5	Outlet of East do.		230	5	
6	Do. West do.		260	10	
7	Entrance to conduit		265	7	
8	Manhole No. I		220	5	
9	Do. No. II		215	5	
10	Do. No. XX		210	5	
11	Do. No. XXIII		290	5	
12	Do. No. XXVIII		270	5	
13	Do. No. XXXI		245	5	
14	Do. No. XXXV		220	7	
15	Do. No. XLVI		175	10	
16	Do. No. XLIX		210	7	
17	End of conduit at Kilpauk		385	5	
18	Do. do. (next day)	17th April 1918.	395	5	
19	Raw water from inlet of bed No. 3		420	5	
20	Do. do. No. 5		510	5	
21	Do. do. No. 7 ...		360	5	
22	Do. do. No. 9		430	5	
23	Do. do. No. 11		560	5	
24	Do. do. No. 14		415	5	
25	Do. do. No. 12		460	1	
26	Do. do. No. 10		475	1	
27	Do. do. No. 8		390	5	
28	Do. do. No. 6		440	5	
29	Do. do. No. 4		510	5	
30	Do. do. No. 2		380	1	
31	Filtered water from outlet of bed No. 2		205	30	
32	Do. do. No. 3 ...		115	None in 60	
33	Do. do. No. 4		135	60	
34	Do. do. No. 5 ...		200	20	
35	Do. do. No. 6		190	20	
36	Do. do. No. 7		130	None in 60	
37	Do. do. No. 8		205	15	
38	Do. do. No. 9		120	None in 60	
39	Do. do. No. 10		140	60	
40	Do. do. No. 11		165	60	
41	Do. do. No. 12		145	None in 60	
42	Do. do. No. 14		150	None in 60	
43	Do. from Filtered water conduit ...		160	20	
44	Eastern clear water reservoir	18th April 1918.	285	5	
45	Central do.		195	20	
46	Western do.		210	10	
47	Manhole on conduit leading to pumping station ...		240	10	
48	Suction well inside pumping station		570	5	
49	Test tap on main in pumping station		420	10	
50	Tap in Lunatic Asylum		375	10	
51	Tap near toll-gate (Kilpauk)		390	5	
52	Public tap in Tondiarpet adjoining No. 2/192 in Tiruvottiyur High Road.		280	10	
53	Public tap at the end of Malayaperumal Street east gate, Kothwal Bazaar, Georgetown.		320	10	
54	Tap in Sullivan Street near San Thomé Cathedral opposite "Helen Villa."		630	1	

Remarks.—A strong smell of sulphuretted hydrogen was noticed in the outlet regulator chambers of bed Nos. 2, 3, 4, 8, 10, 12 and also in the filtered water conduit.

(14)—CHEMICAL analysis of water sample collected on 17th and 18th April 1918.

Physical appearances.		End of conduit at Kilpauk unfiltered water.	Filtered water conduit filtered water.
	Colour and Transparency.	Yellowish and hazy.	Yellowish but clear.
	Smell	None.	Slight smell of sulphuretted hydrogen.
QUANTITATIVE.			
Total solids	Parts per 100,000.	29·000	28·400
Temporary hardness	Do.	7·000	7·000
Permanent hardness	Do.	4·000	4·000
Total hardness	Do.	11·000	11·000
Chlorine	Do.	5·325	5·325
Ammoniacal Nitrogen	Do.	0·003	0·004
Albuminoid Nitrogen	Do.	0·034	0·013
Oxygen absorbed (*Tidy's Process*)	Do.	0·133	0·100
Nitric Nitrogen	Do.	Nil.	Nil.
QUALITATIVE.			
Nitrites	..	Nil.	Nil.
Sulphates	...	Present.	Present.
Phosphates	...	Nil.	Nil.
Iron, poisonous metals	...	Nil.	Nil.

Physical appearances.		Tap in Tondaiyarpet.	Tap in Malayaperumal Street, Georgetown.
	Colour and Transparency.	Yellowish and hazy.	Yellowish but clear.
	Smell	None.	None.
QUANTITATIVE.			
Total solids	Parts per 100,000.	28·000	28·000
Temporary hardness	Do.	7·000	7·000
Permanent hardness	Do.	4·000	4·000
Total hardness	Do.	11·000	11·000
Chlorine	Do.	5·325	5·325
Ammoniacal Nitrogen	Do.	0·003	0·002
Albuminoid Nitrogen	Do.	0·013	0·015
Oxygen absorbed (*Tidy's Process*)	Do.	0·087	0·104
Nitric Nitrogen	Do.	Nil.	Nil.
QUALITATIVE.			
Nitrites	...	Nil	Nil.
Sulphates	...	Present.	Present.
Phosphates	..	Nil.	Nil.
Iron, poisonous metals	...	Nil.	Nil.

Physical appearances.		Tap in Sullivan Street, San Thomé.	Tap near Kilpauk Toll-gate.
	Colour and transparency.	Yellowish but clear.	Yellowish but clear.
	Smell	None.	None.
QUANTITATIVE.			
Total solids	Parts per 100,000.	28·000	28·000
Temporary hardness	Do.	7·000	7·000
Permanent hardness	Do.	4·000	4·000
Total hardness	Do.	11·000	11·000
Chlorine	Do.	5·325	5·325
Ammoniacal Nitrogen	Do.	Trace	0·003
Albuminoid Nitrogen	Do.	0·015	0·015
Oxygen absorbed (*Tidy's Process*)	Do.	0·087	0·087
Nitric Nitrogen	Do.	Nil.	Nil.
QUALITATIVE.			
Nitrites	...	Nil.	Nil.
Sulphates	...	Present.	Present.
Phosphates	...	Nil.	Nil.
Iron, poisonous metals		Nil.	Nil.

(15)—PROCEEDINGS of the Committee ordered in G.O. No. 1576 M., dated 15th September 1917, on the Madras water-works and the supply to the Madras City generally.

1. The Committee appointed by Government in G.O. No. 1576 M., dated 15th September 1917, met on 22nd *idem* and considered the terms of the reference to them, viz., " to inspect and report on the water-works and the supply to the City of Madras generally " and to " examine carefully the defects of the present system and suggest remedies where necessary ".

2. The Committee consider that before proceeding to inspect the water-works, they should be put in possession of the following information :—

(1) A report of the water-works as originally designed.
(2) A report on the water-works as executed, with special reference to any important alterations made during execution.
(3) A report on the working of the water-works since the date of opening ; with statements showing the number of filter-beds in use, date when each was brought into use, the duration of work of each filter, results of analyses of water from each filter during its working period, the amount of water passed through each filter and rate of filtration adopted.
(4) A copy of the rules in force for working the filters.
(5) Report on the analyses of water made from time to time at the King Institute of Preventive Medicine, by whom the samples were taken, by what method they were taken and at what places.
(6) The average quantity of water supplied to the town from time to time and the quantity of unfiltered water added and by what means this was effected.
(7) Rate per head per day of supply of water as compared with the rate contemplated in the original scheme. Explanation of excess variation, if any.
(8) Rules for the guidance of the staff at the pumping station with reference to the quantity of water pumped daily.
(9) Copy of rules for the guidance of the staff in supervising the distribution system.
(10) Statement of the staff employed on the water-works with their duties.

3. The Committee are arranging with the President of the Corporation to afford facilities for the taking of samples of water from various places for examination at the King Institute of Preventive Medicine.

4. The Committee are of opinion that it will be necessary to engage additional staff at the King Institute of Preventive Medicine to conduct the bacteriological examination of the many samples of water which will have to be analysed. The Sanitary Commissioner will submit a proposition statement and the approval of Government for this is requested.

I. The Committee met at the King Institute, Guindy, on the 2nd November 1917, and considered the preliminary investigation of analyses undertaken under their direction.

Present.

(1) Major W. A. Justice, I.M.S., Sanitary Commissioner, Madras.
(2) W. Hutton, Esq., A.M.I.C.E., Sanitary Engineer to Government, Madras.
(Surgeon-General W. B. Bannerman, C.S.I., I.M.S., being ill, was unable to attend.)

II. They are of opinion that further samples should be taken for the purpose of comparison and that additional samples should also be collected at the five points indicated below and analysed :—

(*a*) at entrance to roughing filter,
(*b*) at manhole No. 35 in the conduit,
(*c*) at inlet of each filter bed,
(*d*) one from each clear service reservoir, and
(*e*) at the depth of each outlet valve [a note should be made which valve (or number of valves) is at the time supplying the conduit, and the condition of all valves at the time the sample was taken, whether open, half open or shut and which valve is supplying water to the town].

III. In view of the statement by the President, Corporation of Madras, in his annual report that the daily consumption of water per head of population in the City was now 29 gallons per day, the Superintending Engineer, V Circle, be addressed and his opinion obtained whether he considers that the increased supply can be obtained from the present Red Hills catchment area without running the risk of a deficiency occurring.

I. The Committee met on 20th November 1917 at the King Institute of Preventive Medicine, Guindy, and considered the results of the analyses of the additional samples ordered in paragraph II of Minutes of last meeting.

Present.

(1) Major W. A. Justice, I.M.S., Sanitary Commissioner, Madras.
(2) W. Hutton, Esq., A.M.I.C.E., Sanitary Engineer to Government, Madras.
(The Hon'ble Surgeon-General W. B. Bannerman, C.S.I., I.M.S., was unavoidably absent.)

It appears that there is gross deterioration between the lower inlet in the lake and the automatic valve chamber at the entrance to the roughing filter.

II. The Committee resolve to examine as early as possible the lake, the outlet tower, inlet chamber to roughing filter, the roughing filter, entrance to conduit and one or two manholes on the conduit line with a view to examination of possible deposit which the analyses by continuous increase in total colonies leads us to suspect occurs. The question of possible leakage is also to be enquired into and this can be proved by taking samples from every manhole *en route* to locate it. This is as far as the Committee consider it advisable to go for the present until our inspection.

III. The Committee resolve that intimation be sent to Mr. Madeley to fix a day for the inspection.

IV. The Committee express the desire that Mr. Madeley should accompany the members to explain any matter which may require clearing up.

V. *Chemical analyses, raw water.*—From analyses reports so far obtained the Committee are of opinion that the high albuminoid nitrogen and the oxygen absorption ratio 1—4 is small and is suggestive of animal contamination.

Nothing else calls for comment. Chemically all the several headings of the analyses are normal.

Filtered water.—In the water from the filter-beds, however, an increase of free ammonia is observed and a trace of nitrates in two samples II and IV beds would indicate that the nitrifying organisms are given time to act to convert the ammonia into nitrates showing that there is stagnation in the filters and that some of the filter passages may be choked in these beds.

I. The Committee met on 1st December 1917 at the King Institute, Guindy.

Present.

(1) Major W. A. Justice, I.M.S., Sanitary Commissioner, Madras.
(2) W. Hutton, Esq., A.M.I.C.E., Sanitary Engineer to Government.
(The Hon'ble Surgeon-General W. B. Bannerman, C.S.I., I.M.S., was unavoidably absent.)

II. The Sanitary Commissioner and the Sanitary Engineer duly carried out the inspections on 30th November 1917 referred to in paragraph II of the Minutes of the third meeting of the Committee. The members of the Committee inspected the outlet tower and its valve arrangements, the condition of the tank water, condition of the bund and the general surroundings.

2. The Special Engineer to the Corporation was kind enough to accompany the Committee members and rendered them every assistance during their inspection.

3. The Red Hills Tank, which is the source of supply to the City, appeared to be well filled and there was no evidence of contamination of the water so far as could be seen from the outlet tower. The Committee propose to examine the question of the sufficiency of supply and the condition of the catchment area on receipt of information called for from the Superintending Engineer, V Circle, and after an inspection of the catchment area.

4. *Outlet tower.*—This outlet tower is fitted with six draw-off valves operated by gearing from the tower. These draw-off valves are located at different levels with the object of drawing off water from the tank as near the surface as possible. Three of the draw-off valves are connected with one 24-inch cast iron main which passes under the bund of the tank to a valve chamber, thence to a roughing filter at entrance to the conduit. As a standby against accident to this arrangement, which might involve the cutting off of water-supply to the City, a duplicate set of valves, mains, etc., is provided. The whole arrangement is such that water can be drawn from three different levels which for simplicity, the Committee will refer to hereafter as the upper, the middle, and the lower valves. On the day of inspection the Committee found that the lower valve was fully opened and the middle valve to the extent of 6 inches whereas in ordinary circumstances the (upper) valve should have been fully opened (24 inches) and the middle valve 6 inches or more if necessary to provide the desired supply. The reason assigned for using the lower valve instead of the upper valve was that a less amount of floating weeds, leaves, etc., was drawn off from the water in the lake. The Committee would observe that it is an accepted fact which has been proved by analyses of samples of water in other water supplies that the upper layers of water within 4–5 feet of the surface are purer than the layers of water at a greater depth and at times when the tank water is turbid, the difference in this respect would be greater. This being so, the Committee consider that the usual practice of drawing water off from the tank 4 or 5 feet below the surface should be followed in future and that a lower valve should not be opened unless the supply from the upper valve is deficient in quantity. The Committee would point out however that the upper valve should not be used when depth of water above it is less than 3 or 4 feet. The entry of leaves, weeds, etc., into the valve in use can be avoided by the provision of screens circular or octagonal and of mesh suitable for the purpose desired.

The Committee observed a number of old casuarina trees below the tank bund near the outlet tower and were informed that when the prevailing wind (south-east) is blowing, a large number of casuarina needles are blown into the water near the outlet tower and find their way through the valves to the roughing filters, tending to choke the screens of these filters. These trees are in charge of the Public Works Department and the Committee do not doubt that that Department, when the nuisance is brought to their notice, would remove these casuarina trees on each side of the outlet tower for a distance of 100 yards. The Committee would also recommend as a precaution that the proper designation of each valve should be clearly pointed on the valve so that mistakes in operating may be avoided as they noticed that the staff appeared to hesitate when called on to state which valve was open or shut.

5. The next place examined was the valve house below the tank bund. This house contains two 24-inch sluice valves, one on each of the 24-inch mains from the outlet tower. Immediately adjoining the sluice valves and between them and the outlet tower are two scour pipes each provided with a sluice valve. These pipes are intended to scour the 24-inch mains from the outlet tower. As the 24-inch mains are immediately below ground level and the outlets of the scour pipes have to be above ground level, the head available for scouring the 24-inch mains is low and as the scour pipes are only 6 inches in diameter, the effect of them on the scouring of the 24-inch mains must only be local. The Committee consider that there must be a deposit of silt in the 24-inch mains which will affect the bacteriological purity of the lake water but they will go into this question further after a study of the result of further samples of water which they have directed to be taken in ten days' time. The last samples of water analysed referred to in paragraph I of the minutes of the third meeting indicated the presence of silt or other source of contamination in these 24-inch mains and to test this the scour valves were opened. The south scour was found to be choked. The north scour disclosed the presence of a considerable amount of black silt. The Committee have asked for two taps to be fixed on the 24-inch mains at this valve chamber to permit of samples of water being taken from the mains.

6. *Roughing filters.*—We were informed by our sample-taker that the filters were being cleaned at the time of his visit. The Committee requested the President not to restore the filters until our inspection. This was most fortunate for we were able to see what exactly was happening in these two filters and the condition of one of them. They had not previously been cleaned and were consequently very dirty as was evident from the deposit removed from one. The retention of these filters is engaging the attention of the Committee and this subject will be referred to later on. Samples are now to be taken from the filter emptied of stones from which this water goes direct to the conduit and compared with samples from roughing filter intact.

7. *Conduit.*—The Committee examined the first three manholes in the conduit. The ventilators in the manholes are defective in that they allow insects to enter the conduit. This can easily be remedied. The amount of silt in No. 1 manhole was as is expected more than the succeeding manholes and was not great—roughly about an inch as gauged by dipping a long pole into the water to the bottom.

8. *State of compound.*—The Committee would remark that the compound at the head-works is not in the state which is desirable for a water-works and especially for so important a water-works as the Madras water-works. They would recommend that the low places should be filled up, necessary roads and paths made, and such sanitary conveniences provided as are required by the staff at the headworks. The compound should also be fenced and provided with necessary gate or gates and the growing of ornamental shrubs encouraged.

I. The Committee met on 6th December 1917 at the King Institute, Guindy, to consider the analyses of samples ordered to be taken to test the experiment of working without material in the roughing filters.

Present.

(1) Major W. A. Justice, I.M.S., Sanitary Commissioner, Madras.
(2) W. Hutton, Esq., A.M.I.C.E., Sanitary Engineer to Government, Madras.
(The Hon'ble Surgeon-General W. B. Bannerman, C.S.I., I.M.S., was unavoidably absent.)

II. The subjoined table of results show how much our surmises were correct. The deterioration is evident between the inlet valve and the valve house in *both* mains pointing to deposit in these mains and the necessity for scouring. They also show that there is deterioration between the valve house and the inlet to the west roughing filter. There is a remarkable deterioration in the water as it passes through the west roughing filter from which the materials have not been removed or cleaned since the works were started. On the other hand, the water which has passed through the east roughing filter from which these filtering materials have been removed has improved, being a two-fold improvement.

III. There is an enormous deterioration between the mixed water from the roughing filter and the manhole No. I and the Committee propose to inspect the outlet and the manhole and sees.

if there is not a deposit of silt between these two places. The analyses further show that by a brief rest in the basin of roughing filter without filtering material, the water is greatly improved.

IV. The analyses are such that the Committee can with confidence recommend the removal of the filtering material from the remaining roughing filter (i.e., the *West*) prior to the taking of further samples to prove the advantage of having the roughing filters simply as sunning, sedimentation and aerating basins only.

RESULTS of bacteriological examination of eight samples of water collected on 4th December 1917 from Red Hills and roughing filters under instructions of the Committee.

Serial No.	Sources of samples as per label.	Total colonies per c.c. on agar at 37° c.	Lactose fermenters present in how many c c.	Result of vibrios test.
			c.c.	
1	Red Hills, middle valve 5′ 5″ below surface ...	380	60	No vibrios in 100 c.c.
2	A tap on south main leading to roughing filter *with* materials.	610	30	Do.
3	A tap on north leading to roughing filter *without* materials.	460	30	Do.
4	Inlet to west roughing filter *with* materials ..	1,440	15	Do.
5	Inlet to east roughing filter *without* materials.	830	30	Do.
6	Outlet of roughing filter *with* materials ...	1,280	5	Do.
7	Outlet of roughing filter *without* materials ...	600	60	Do.
8	From Manhole No. I	1,600	1	Do.

I. The Committee met at Madras on the 8th December 1917.

Present.

(1) Major W. A. Justice, I.M.S., Sanitary Commissioner, Madras.
(2) W. Hutton, Esq., A.M.I.C.E., Sanitary Engineer to Government, Madras.
(The Hon'ble Surgeon-General W. B. Bannerman, C.S.I., I.M.S., was unavoidably absent.)

II. With reference to paragraph III of the minutes of the fifth meeting, the Committee proceeded to again inspect the headworks at the Red Hills on 7th December 1917. The Special Engineer accompanied the Committee. The outlet sluices of both compartments of the roughing filter were closed for a short period sufficient to allow the Committee to have the sump between the sluices and the measuring weir inspected for deposit of silt, etc. Also the two side culverts, the basin below the measuring weir and the succeeding portion of the conduit up to manhole No. I. There was a certain amount of deposit apparently consisting of lime shells and small pieces of gravel in which there were larvæ-like life. From manhole No. I a piece of rope found attached to the foot rests was impregnated with these larvæ. The Committee are of opinion that these presence of these larvæ is an additional reason why the materials should be removed from the roughing filter. The Committee are impressed with the fact that even if the roughing filter is cleaned every six months, there will still be considerable deposit on the stones of the filter and such deposit of silt is sure to contaminate the drinking water and form foci for the breeding of larvæ, etc., mentioned and cause a large multiplication of the bacteria which in the raw water are comparatively small in number. The Committee would mention that these roughing filters are commonly used for the purification of sewage and the like, but when applied to water-supplies such as the Red Hills, they are more likely to deteriorate the quality of the water than to improve it by forming a favourable 'nidus' for the multiplication of bacteria. The Committee consider that the basins as designed are suitable for sunning and sedimentation tanks and the materials in them which consist of broken metal can be usefully employed in improving the paths and roadways in the enclosure at the Headworks. The Committee have accordingly asked Mr. Madeley to have the material removed from the remaining compartment of the roughing filter, to have both compartments thoroughly cleaned of all deposit on the walls and floor and to have the compartments cement-washed and the iron work re-painted.

III. With reference to the deterioration of water between the inlet tower and the valve house, two sample taps have been fixed on the 24-inch main in the valve house. The examination of the analyses of these taps shows that deterioration of the water of the lake occurs here. The lowest or fourth valves (emergency valves) which would only be used if the lake happened to be lower than the lowest inlet valve, were tested and found to be shut showing that any deposit in the 24-inch mains had not entered through these valves. As on a former occasion the lowest inlet valves were found to be in use instead of the upper valves, the deposit in the pipes probably entered through these valves. On opening the scours on the 24-inch mains at the valve chamber, evidence of the deposit in the pipe was again shewn, although the Committee were informed that the scour valves had been opened the day before their visit. This fact shows that the scour valves as fixed are too small to effectively scour the large 24-inch mains and as the analyses show the importance of avoiding the contamination of the Red Hills water with this deposit of silt in the mains, the Committee are of opinion that it must be effectively got rid of and fresh deposit prevented. The following is the recommendation of the Committee how this can be done :—

The valve chamber should be shifted closer to the roughing filter and the two existing 24-inch sluice valves in the chamber fixed at the new site. From each of these 24-inch mains at the valve chamber, two new scour branches, each 14 inches in diameter, provided with valves, should be fixed, so as to discharge into the low level irrigation channel which runs along the toe of the bund.

If this alteration is made, the velocity obtained in the 24-inch mains from the inlet tower to the new site of the valve house when the new 14-inch scour valves are opened, will be sufficiently great to ensure the thorough scouring of the 24-inch mains. This scouring cannot be done efficiently at present as the velocity obtained in a 24-inch main when the small diameter scour pipe is opened, is so slight as to have only a local action on the deposit of silt. The silt in the 24-inch main away from the opening of the scour pipe is not affected by the opening of the scour pipe.

Between the valve house and the inlet chambers of the roughing filters, there will still be a short length of 24-inch main which will not be scoured by the above arrangement as it will be on the other side of the shut sluice valves; this length being short can be cleaned by hand from the manhole near the inlet chamber of roughing filter.

IV. The Committee owing to the inclement weather were unable to inspect the manholes further along the conduit, but this will be done at a subsequent inspection.

When both compartments of roughing filter have been cleaned out as recommended by us, further samples will be taken from the following points :—

(1) Outlet tower—near working valve.
(2) Two sample taps in valve house.
(3) At both inlets into roughing filter.
(4) Between screen and penstock valves at outlets of both roughing filters.
(5) Between penstock valves and measuring weir—two samples, one from opposite each penstock valve.
(6) In basin between measuring weir and inlet to conduit.
(7) Manhole No. 1.
(8) Samples from manholes where formerly taken.

The Committee met at the King Institute of Preventive Medicine, Guindy, on Thursday, the 10th January 1918, to examine results of samples taken on 7th January 1918.

Present.

(1) Major W. A. Justice, I.M.S., Sanitary Commissioner, Madras.
(2) W. Hutton, Esq., A.M.I.C.E., Sanitary Engineer to Government, Madras.

2. The attached tables show the results compared with those of samples taken on 19th December 1917 shown in thick type. The Committee remark on the uniformity of the quality of the water during transit to second manhole. The raw water has deteriorated from its previous high standard of purity due to all probability to the heavy rains in the first two days of the New Year.

3. The Committee propose to inspect the roughing filter basin which is now empty and is reported to have been cleaned, and the first part of the conduit on Saturday afternoon, 12th instant. After inspection water will be let into the basins and orders issued for fresh samples to be taken from Red Hills Tank to Kilpauk.

4. The inspection report on the catchment area by Colonel Thomson will be circulated to the Committee.

SAMPLES collected on 7th January 1918.

[*Thick figures indicate results of 19th December 1917.*]

Serial number.	Source of sample.	Total colonies per c.c. on agar at 37° c.	Lactose tennentes present in how many c.c. ?	Result of vibrios test.
1	Red Hills Lake, 23 feet from tower, lower valve.	860 **285**	5 c.c. and upwards. **15 c.c.**	No vibrios in 100 c.c. **Do.**
2	Red Hills Lake, 18 feet from tower, middle valve.	795 **355**	5 c.c. and upwards. **15 c.c.**	No vibrios in 100 c.c. **Do.**
3	Tap on north main	735 **410**	5 c.c. and upwards. **15 c.c.**	No vibrios in 100 c.c. **Do.**
4	Inlet to the roughing filter	640 **345**	5 c.c. and upwards. **15 c.c.**	No vibrios in 100 c.c **Do.**
5	Outlet of roughing filter, behind sluice door.	675 **435**	5 c.c. and upwards. **10 c.c.**	No vibrios in 100 c.c **Do.**
6	Do. in front of sluice door.	695 **450**	5 c.c. and upwards. **10 c.c.**	No vibrios in 100 c.c. **Do.**
7	Entrance to conduit below weir	660 **405**	5 c.c. and upwards. **10 c.c.**	No vibrios in 100 c.c. **Do.**
8	Manhole No. 1	645 **418**	5 c.c. and upwards. **10 c.c.**	No vibrios in 100 c.c. **Do.**
9	Manhole No. 2	650 **605**	5 c.c. and upwards. **5 c.c.**	No vibrios in 100 c.c. **Do.**

Note.—The second figures represent results obtained on 19th December 1917.

K.I.P.M., GUINDY,
9th January 1918.

F. MAITLAND GIBSON, M.B., B.SC.,
Director.

The Committee met on Saturday, the 12th January 1918.

The Committee proceeded to the Red Hills accompanied by the Special Engineer. At the request of the Committee the water was shut off from the conduit and they proceeded to inspect the inside of the conduit as far as the second manhole. When the water ceased to flow, it was found the weir had been cleaned and cement washed. It was understood that this was usually done to remove the moss growing on it. The conduit was found to be water-tight and in the first length of it, there was a deposit of lime shells—the result of using slaked lime as an experiment—to purify the water. This deposit contained large quantities of the larvæ mentioned in the last minutes of the Committee and samples were taken for examination at the King Institute of Preventive Medicine. These samples had an offensive smell. The two semi-circular arms from the outlet of the roughing filter were inspected and were found to contain a considerable quantity of this moss. It was obvious that the growth of moss was encouraged by light and it would, therefore, be advisable to close the openings in these arms by a thin teakwood shutter. These shutters would also prevent the diffusion of water from the basin below the weir into semi-circular culverts from the scour outlets of the roughing filters.

To prevent moss growing on the walls at the entrance of the conduit, a similar shutter should be placed over the entrance of the conduit to a depth 2 inches or 3 inches into the water—to replace the present wire screen which is liable to be broken.

Brownish moss was found to grow on the sides and floor of the conduit—none on the roof. The moss grew more readily near the ventilating openings through which a certain amount of light entered. Some bricks, stones and other debris were gathered *en route* and taken out of the conduit for closer inspection. They were found to be covered with cocoons and larvæ.

This wire gauze recently fitted to the ventilators on our recommendation is of too wide a mesh. A smaller mesh would be preferable. If this mesh cannot be obtained, a double layer of the present mesh will do.

The stones and silt removed from the roughing filter should not be stored beside the basins. If the stone is washed this should be done at some distance from the roughing filter basins and the effluent should be passed quickly away from the site and we would suggest the present irrigation channel passing alongside the bund of the Red Hills tank. The overseer should give a written statement of what he found when he cleaned out the roughing filter both compartments.

Roughing filter basin.—Owing to heavy rains and owing to one of the 24-inch mains from Red Hills tank leaking, we were unable to inspect the compartment of the roughing filter which had been lately cleared of material and cement washed but we inspected the material removed and also the silt taken from below the Cuddapah slabs. The silt was black and offensive showing the necessity for the removal of these materials and the cleaning of this roughing filter. As the Committee stated in the minutes of a former meeting, these roughing filters had not been cleared out for three years in fact since the opening of the water-works. Both compartments are now clear of this silt and material—it was recommended to allow water to pass through the basins. This is now being done.

The Committee met at Kilpauk filter beds on 14th January 1918 in order to obtain some general idea of the arrangements and the working of the filters.

The Special Engineer was present.

There are fourteen filter beds at Kilpauk each 100 × 200 feet and on the day of the visit ten were working, two which had been under cleaning operations, were completed and ready for starting, and two were under cleaning operations. The filter beds were in charge of an overseer on Rs. 80 per mensem. This overseer stated that he was a passed lower subordinate of the College of Engineering, Madras. He had been in charge of filter beds at Kilpauk since their opening. He stated that he had an Assistant who had passed some of the technical examinations but possessed no other qualifications. The overseer stated that six months after the filter beds were brought into use, they became clogged and the top 9 inches of sand was dug up. The Committee ascertained that from the date of the first clogging of the filters, stated to be six months after the opening of the water-works, the filter beds were dug up to a depth of 9 inches with mamuties so as to allow the water to pass through the sand. This practice continued, we were informed, up to July 1917, despite the fact that new rules on the subject for working the filters had been issued on 26th October 1915. The Special Engineer informed us that this practice had gone on without his knowledge.

In August 1917 the top layer of sand was removed from the beds and washed and replaced in some beds and this operation is still proceeding.

The Committee asked to be shown the present rules for working the filters and were shown a set of type-written instructions (dated 26th October 1915). These instructions were that a filter bed was to be filled with filtered water from below to a height of 6 inches above the sand, then the inlet valve was to be opened and water from the conduit allowed to enter the filter bed until it stood at a depth of about 3 feet 9 inches on the sand. This water was to be allowed to settle for 24 hours. At the end of this time, the scour valve was to be opened so as to lower the water through the filter at a rate of ½ inch per hour—this valve was to be shut at the end of 4 hours and then the filter outlet regulator was to be opened so as to allow a depth of ½ inch over the weirs of the automatic regulator. The depth of ½ inch was to be increased gradually until at the end of the third day, the depth of water running over these weirs was 3 inches, which is the depth required to give the present maximum discharge from the filter beds.

In reply to the Committees' query as to why 24 hours' settlement was fixed, it was stated that this was determined on the results of bacteriological examination. The Committee were informed that no attempt had ever been made to determine the presence and uniform distribution of the filtering skin over the filter bed. The Committee will return to this important matter again.

Quantity of water obtained from each filter.—This is calculated in the usual way from the depth flowing over the two measuring weirs of each regulator. The length of each weir is 18 inches. The depth now allowed to flow over each weir is 3 inches, this amount having been fixed six months ago. Formerly a depth of 4 inches and sometimes 5 inches was allowed.

As the dimensions of each filter bed are 200 feet × 100 feet, these depths mentioned above correspond to a draw off of one million gallons from each bed in 24 hours, corresponding to a rate of 450 gallons per square yard per day or a vertical velocity of 4 inches per hour.

Washing of sand from filter beds.—A new type of sand washing machine made locally was being experimented with with a view to a quicker method of washing than formerly, the old method being a platform which the Committee inspected. A sample of this washed sand was taken by the Committee for examination to be mechanically tested.

The Committee asked the Special Engineer to have one of the sand filters then under cleaning excavated at one corner so that the materials down to the floor level could be examined; this was to be ready for inspection on the following day.

The Committee looked at filter bed No. 13 which was being scraped and noticed that the filtering skin was not uniform but in patches.

In filter bed No. 10 which was being filled with water, the Committee noticed that the inlet chamber weir had been cut at the sides adjoining the filter bed wall. This was stated to have been done with the view to avoid the scouring of the surface of the sand but it was noticed that this was not very effective in this respect as scouring was evident at the places at which the weir had been cut away. In bed No. 4 further evidence of this scouring was observed near the inlet chamber by discolourations on the walls of the filter.

Before leaving the works the Committee asked to have the water in one bed which was in process of sedimentation lowered for our inspection at the same rate permitted by the rules in force and adjourned till the following day.

The Committee decided to carefully consider the means for overcoming this scouring of the upper sand during the operation of filling the filter and the result of their deliberations in this matter will be recorded in a future minute (Meeting on 10th February 1918).

The Committee met on 15th January 1918.

Pit dug in bed No. 4.—The excavation made was inspected on 14th. The sand, broken stone and bricks of the filter were exposed to view and were in a clean condition. The filling in of the beds differ from the usual method in the following particular :—" Instead of the broken stone and brick supports extending to the walls of the filter they stop short 3 feet from them and the sand filling rests on this space of the floor all round the bed." This was done, it is said, with the object of obviating creep of water down the side walls without passing down the filtering skin and the sand.

The Committee found that to a depth of 3 inches to 4 inches the sand lying on the floor had become impregnated with black silt—this silt smelt strongly of sulphuretted Hydrogen and apparently extended uniformly around the filter bed to a breadth of 3 feet, i.e., the width of the floor not provided with bricks and broken stone. No such silt was found in the sand overlying the broken stone and bricks nor in the latter at this pit. The Committee took a sample of the black silt and also of the sand overlying the broken stones for examination.

The Committee met on the morning of 16th January 1918 at Kilpauk filter beds.

The Special Engineer was present.

Filter bed No. 13 was inspected. Three pits had been dug to floor level by desire of Committee at the inspection of 14th January 1918, one pit in each corner of one side and one in middle of one side.

Excavation in south-east corner.—This showed the same depth of black silt in the 3 feet sand margin on floor as found in bed No. 4. There were also slightly discoloured patches in the sand above the broken stone. The depth of black silt in the 3 feet margin was the thickness of a brick.

The same conditions were observed in the pit at the middle of side of filter bed but thin patches were also observed directly over the broken stone—none in superimposed sand.

The excavation in south-west corner was then examined. The black silt was much more evident here, the depth in the 3 feet margin area being 4 inches. Discoloured patches were also observed in the sand over broken stone.

The Committee had a pit dug in the centre of the filter bed area. Here the black silt although present to a depth of 2¼ inches was not so concentrated as in the marginal pits.

The Committee then inspected the filter outlet chambers and observed the method of reading the working head on a filter. One filter which showed a filtering head of 2 feet 6 inches was stated to be about to be put out of action.

On a former visit the Committee were informed by the Overseer that 2 feet was the working head but it was explained at a subsequent inspection that a greater head than this was allowed.

The Committee observed that a number of filter outlets had had their guide wheels renewed. This was done three weeks previously for repairs and consequently the regulators were not in working order.

The Committee then inspected the centre clear water reservoir. There was 18 inches of water in the reservoir so that only the entrance could be inspected. This seemed to be quite clean and free from deposit. It was however said that this reservoir had been emptied for a similar inspection by Dr. Kesava Pai, three months before. It would have been preferable to have had one of the other two reservoirs instead of this reservoir, emptied for inspection. The Committee were not aware of the circumstances in time to choose.

The Committee then inspected the conduit from clear water reservoir towards engine-house. The Committee noticed an experimental filter designed for removing oil from the condensed steam from the hot well of the main engines. The effluent from this was arranged to flow into the clear water conduit. It was stated this arrangement for utilizing the waste water from the 'hot well' had now been given up. The Committee would remark that, owing to the contamination of this water in the 'hot well' by lubricating oil, it is not desirable to add such water to the filtered water in the clear water conduit at any time.

The suction chamber of the pumping station was then inspected. Arrangements were suggested by the Committee to have a test cock placed on main outlet pipe. The Committee would here remark that the arrangement of the suction pipe and level of the suction chamber floor do not permit of the emptying of the conduit and the clear water reservoir for cleaning purposes and this is an important defect which will be gone into on receipt of a plan showing the levels.

The scour arrangements of the steel tank were then inspected and the Committee consider this point requires more consideration as the arrangement seems defective. A plan of the tank will be obtained. Further a diagrammatic section to a sufficient large scale showing principal head works levels is required from the inlet conduit through the filters and clear water reservoirs to the suction chamber of engine-house and thence to steel tank.

It was arranged to have a large number of samples of water taken by the staff of the King Institute as soon as possible.

The Committee met at the King Institute of Preventive Medicine, Guindy, on 4th February 1918.

The results of the samples taken on 22nd, 23rd and 24th January 1918, ordered at the last meeting held on 16th January 1918 were placed before the Committee.

From the beginning of the year to the dates on which these samples were taken the rainfall at Red Hills tank was considerable.

The effect of this flood water on the quality of the lake water is immediately observed. The previous samples taken after a spell of dry weather showed a water of high quality, but the present samples show a deterioration which was to be expected. The result of clearing out the roughing filters and cleansing them is shown by the improved sample which is not worse in quality from the lake water as in former occasions which showed deterioration. The water now

maintains its quality through the roughing filter basin and in the first part of the conduit and on arrival at Kilpauk, these analyses show further improvement. As a spell of dry weather has followed, the Committee propose to have another series of samples taken before laying any emphasis on the results of their suggestions carried out at the headworks. On this occasion the Committee require a complete chemical analysis of the water.

It is observed that the water again deteriorates in the inlet conduit at the site of the filter beds. The Committee are inclined to think that this may be due to silt accumulating or stagnent water in the bottom of the inlet conduit of the filter beds as they find that the floor of this conduit is one foot below the bottom of the inlet pipes to filter beds. This one foot is likely acting as a catch pit retaining sediment and it may be necessary to have the floor of this conduit made up to bottom level of the inlet pipes to filters.

The water in passing through the filter beds is improved to a considerable extent in some, but not in others, but the Committee are of opinion that general improvement cannot be expected so long as the filter beds are in their present condition and are worked under existing rules.

The water in the central compartment of the clear water reservoir is of better quality than the other two which is explained by the fact that the central compartment was cleaned out three months ago, and on inspection by the Committee, was found to be clean and in good condition.

The supply to the town as gauged from public taps shows no improvement from the raw water but as the raw water is being mixed with the filtered water, this is to be expected.

The Committee met on 10th February 1918.

The Committee proceeded to Kilpauk on 9th February accompanied by the Special Engineer and inspected the filter beds.

Bed No. 4.—The water after 24 hours' settlement had been lowered below the surface of the sand so that the Committee could inspect the presence of a filtering skin. The inspection showed that there was no satisfactory filtering skin. This shews that settlement of 24 hours was insufficient. The Committee therefore requested the bed to be refilled and to stand for three days before the water is lowered again. When the bed is ready for inspection, the Committee will proceed to Kilpauk again.

Filter bed No. 12.—The inlet chamber was being modified according to our suggestion. The wall was being uniformly lowered to a height of 6 inches above the surface of the sand. The Committee having had this question under consideration as referred to in previous minutes decided to recommend the following :—

The inlet chamber walls should be reduced throughout to a height of 6 inches above surface of sand and a ¼ bend pipe should be fixed to inlet pipe so that the direction of onflow will be downwards towards the floor of inlet chamber—the water will then rise throughout the chamber and flow evenly over the top of the wall without any appreciable velocity of approach. In filling a bed the operation should be performed as follows :—Filtered water will be let into the bed from below until the level is the same as the level of top of inlet chamber wall, i.e., 6 inches above surface of sand, then the raw water will be turned on at the inlet and will spread itself evenly over the filtered water already in the bed without disturbing the sand.

Bed No. 2.—Advantage was taken of filter bed No. 2 being out of action to have a pit excavated in the south-east corner of it. The depth of black silt in the 3-feet margin was found to be 2½ inches thick—there was no evidence of black silt in the sand above the broken stone. Samples of black silt and of sand above the broken stone were taken for chemical analysis.

Bed No. 13 also out of action on which new sand was being put—there were many foot marks. A bed should not be considered ready for use until the bed has been raked over with a wooden squeegee or rake. A pit was dug in the north-east corner of this bed which had not been previously renewed since the opening of the water-works. Black silt was found to be 4½ inches in thickness. A sample of this black silt and the overlying sand was taken for analysis.

The Committee are now of opinion that the other beds must be in the same unsatisfactory condition.

The Committee met on 22nd February 1918.

The Report from Dr. Simonsen on the chemical analyses of the yellow sand and black silt obtained from the filter beds was read.

The Committee require a full chemical analyses of the water before and after filtration. Samples will accordingly be taken for this purpose. The Director, King Institute, Guindy, will be requested to supply two Winchester Quart bottles.

The source of sand used in the filling of the sand filters and the information noted in paragraphs 1 and 2 of letter to the President, Corporation of Madras, are required by the Committee. The President of the Corporation to be written to supply this information. Further questions regarding the sand used for the filters appear to the Committee to be necessary for the purposes of their enquiry. They are—

(1) How was the sand prepared before being placed in the filter bed ?

(2) Was it screened and washed and, if so, through what screens and where and how was it washed ? The maximum cubic feet of sand per day washed by each sand washer ;

(3) Source of the broken stones and bricks and, if washed, in what manner was this operation conducted ?

The bed No. 4 was duly inspected on Thursday morning, but owing to heavy rainfall the previous night it was decided to repeat the experiment.

Read letter from the Special Engineer, dated 14th February 1918, forwarding plan required by our letter, dated 8th February 1918, with the levels marked as requested by the Committee.

The Committee remark on inspection of the plan that several levels are indistinctly marked.

With reference to the question of levels at the headworks, the Committee require the following :—

(1) Level of foot valve of each suction pipe ;
(2) level of invert of each suction chamber ;
(3) level of invert of inlet steel pipe at junction with suction culvert of pumping station ; and
(4) plan showing dimensions of foundations of pumping station and suction culvert.

The Committee met at the King Institute of Preventive Medicine, Guindy, on the 25th February 1918.

The Committee considered the analyses of samples taken between 18th and 20th February 1918. There appears to be a definite deterioration in water between manhole No. 35 on the conduit and the headworks. The Committee resolved therefore to inspect on the 26th instant this section of the conduit. The Committee also note that certain sand filters are giving good results while others are giving inferior results—good results point to the fact that sand filters are a suitable means of purifying the water and when the proposals which the Committee intend to make, as the result of inspection of the works, in the method of working of the filter beds, etc., are carried out, they are confident that uniformly good results will be obtained from the sand filters.

The Committee accompanied by the Special Engineer proceeded to inspect the conduit from Kilpauk on 26th February 1918 and reached manhole No. 35 adjoining the Madras and Southern Mahratta Railway line at Villivakkam.

Within three hundred yards of filters on conduit the Committee found that manhole No. 54 was being regularly used to provide water for washing clothes. The ventilator was turned back fully opened. It was impregnated with silt and had obviously been in this position for a considerable time. The water was apparently withdrawn from the conduit through the open ventilator and the granite stone on the top of the manhole had been smoothed by constant use as a dhobies' stone. The ground around the manhole was a perfect quagmire and puddle in which there was evidence of soap having been used to wash the clothes and further evidence of prolonged use of this manhole by the people was the luxuriant crop of grass in the neighbourhood.

The Committee record these facts not only with surprise but with regret that such a state of affairs should have been allowed to continue. After all the precautions for preventing contamination of the Red Hills Tank and the provision of a closed conduit therefrom, it is surprising to find this loophole of possible contamination existing close to the sand filters. An outbreak of cholera in the village might under such conditions involve the City in an epidemic.

Between manholes Nos. 53–54 on the north side of conduit, there is a dirty pond, the surplus storm water of which passes across the conduit over a weir. The roof of the conduit at this place is reinforced cement beams. The brickwork on the south side of conduit is exposed and there is possibility of leakage of the dirty water into the conduit at this place. The Committee consider that a drop syphon such as is used further along the conduit should be constructed here for the drainage water.

Manhole No. 52.—The ventilator was found open and there was evidence of water having been recently drawn out of it. The manhole cover was however screwed down.

Manhole No. 50.—There was evidence of the ventilator here having been opened and used by dhobies in the past.

Manhole No. 49.—Slight evidence of above.

Between manholes Nos. 48 and 49 there is a pipe syphon. At the inlet manhole No. 48, the water in the conduit was dirty. It was said that a scour pipe was connected to this manhole but the Overseer stated it had not been used. On examination by means of a bamboo, it was found that there were at least 3 inches of silt deposited in the bottom of the conduit at the manhole. From this evidence the Committee consider that the pipe syphon probably contains a considerable quantity of silt and the silt must affect the quality of the water passing on to the filters.

Manhole No. 47.—Cover was off the opening.

Manhole No. 46.—As this manhole provides easy means of access, it will be used for obtaining a sample of water.

Between Manholes Nos. 45 *and* 46.—The Cuddapah slab covering of a temporary manhole was found out of place and the manhole open.

The manholes from 46 to 35 were inspected and it was found that the ventilating shaft manholes were quite of a good type but the air inlet manholes leave much to be desired. The air inlet consists of a cast-iron grating provided with a hinge and no means of locking the grating to its seat The extension of the seat downwards forms a cup-shaped depression which retains

debris which gets into the cup through the openings in the ventilator and is liable to be washed down into the conduit during heavy rains.

The ventilators can be very easily opened as they are light and water can be freely extracted from the conduit. The Committee consider that this type of ventilator is unsuitable and it would be better to convest it to the same pattern as the outlet ventilators. As a matter of minor importance, the Committee would suggest that the manholes should be numbered more conspicuously than they are at present.

The Committee noticed during their inspection of the conduit that it passes through a number of swamps the water of which stands in many places against the walls of the conduit. They think it is advisable that a bank should be formed on the sides of the conduit in order to prevent this and they are further of opinion that the bank over the conduit should be made up, levelled and maintained as a suitable inspection path.

It was apparently a fact that the Overseer whose duty it was to patrol and inspect the conduit every month, had carried out his last inspection on 12th December 1917.

This closed conduit was provided at great expense in order that the water from the Red Hills tank should be brought to Kilpauk filter beds uncontaminated *en route* thus overcoming the disadvantages of old open channel ; the want of efficient patrols has vitiated this protective provision and the Committee cannot too strongly emphasise the necessity of this being carried out in future.

The deterioration between manhole No. 35 and Kilpauk in the quality of the water noticed at the last meeting of the Committee is to a large extent explained by the presence of silt in the syphon and the evidence of washing clothes at manhole No. 54 on conduit and the unprotected state of Ventilators at other manholes.

The Committee met on 5th March to consider the inspection carried out on 28th February 1918 of the conduit from the Red Hills to manhole No. 34 in the railway line at Villivakkam.

The Sulurpet village is near manhole No. 16. It was observed that the people of the village were taking water from a filthy pond which receives the drainage of the village. The villagers are said to have a prescriptive right to water from the Red Hills Tank as their village tank was abandoned when the Red Hills Tank was constructed. They formerly obtained water from a small pond near the old open channel but since the construction of the conduit they have felt difficulty in obtaining water. A Committee of the Corporation met on 6th January 1918 and agreed to provide two wells—one for this village and one for another village on the other side of the conduit—these wells were to be provided from the conduits through pipes with suitable precautions for preventing contamination of conduit water by possible back flow into the conduit.

The Committee consider that such a supply should be provided to avoid any possible inclination on the part of the villagers to tap the water in the conduit. Further along the conduit at manhole No. 20 there is another village Puttavaram. The villagers stated that they obtained water from the old channel bed and when the water in this bed dries up they obtain water from a tank some considerable distance away. As No. 20 is a manhole, with a ventilator so easily opened and near the houses, the Committee think it is more than likely the villagers help themselves to the conduit water. The Committee are of opinion that it is preferable to provide a small well near the conduit and connected with similar precautions to those proposed to be adopted for the Sulurpet village well and to avoid any unauthorized interference with the conduit water.

Between manholes Nos. 21 and 22 there is a short length of drop syphon which passes the conduit across a depression at this place. There are no arrangements made for scouring this syphon and as it has not been cleaned since the opening of the works it is almost certain to contain a considerable amount of deposit.

Owing to the manhole covers being bolted down on each end of the drop syphon it was not possible to ascertain the extent of the deposit.

Similarly there is a syphon arrangement between 29–30. The above remarks apply to this arrangement also.

At manhole No. 31 there was evidence of water being taken from the ventilator as shown by the wet surface on top of manhole and the presence of water in the seating of the ventilator while it was observed the seatings of ventilators at other manholes were quite dry.

During the inspection of the conduit the Committee noticed that there was no silt in the bed of the conduit itself, due in their opinion, to the satisfactory velocity with which the water passes down the conduit. At drop syphons in the length of the conduit evidence was obtained of the existence of deposit of silt : this is not surprising as these drop syphons act as catch pits and from their nature they retain sediment which in the straight lengths of conduit is carried on by the current. This deposit must take place in the syphons owing to the reduction in velocity of the water passing through them.

In more fortunate circumstances this deposit of silt could be removed from the syphons through sufficiently large scour branches. But owing to the flatness of the country through which the conduit passes the requisite fall for these scour branches is not available. The only means under the existing conditions of clearing out the deposit from these drop syphons is by stopping the flow of water in the conduit—pumping out the water in the drop syphon and clearing out the deposit by hand labour. As this operation would interfere with the supply to the City, the Committee would advise the provision of drop syphons in duplicate so that one could be cleared of deposit while the other kept up the supply to the city. As the syphons are limited in length the cost of supplying duplicates to the syphons will not be unreasonable.

An alternative to providing duplicate syphons is the provision of syphons for the three cross drainages under which the present drop syphons are built. The advantage of this would be the elimination altogether of drop syphons on the conduit itself and the avoidance of periodical cleaning out of such syphons. That is the cross drainage would pass through a syphon instead of the conduit water.

The Committee would remark that although the water of the conduit is filtered at Kilpauk there is no reason why it should be liable to deterioration during its passage, for the purer the water is delivered at Kilpauk the less strain is thrown on the filters and the less liability of obtaining an unsatisfactory filtrate.

The Committee met on 6th March 1918 at Kilpauk filter beds. The Special Engineer was present. The water was lowered in bed No. 4, for inspection. The Committee considered there was evidence of a satisfactory filtering skin having been formed. Samples were taken from this skin from near the outlet—near the middle of one side and near the outlet. Then samples were taken to Guindy for microscopic examination. Samples of unfiltered water from the conduit at Kilpauk and a sample of filtered water from a filter bed were taken to Dr. Simonson for chemical analyses.

The Committee met on the 7th March 1918 at King Institute of Preventive Medicine, Guindy, and considered the Director's report on the microscopic examination of the samples of the filtering skin. Specimens were put under the microscope for the Committee's inspection. These disclose the presence of abundant diatomacious deposit which is necessary for the formation of the filtering skin of an efficient sand filter.

The Committee met on 10th March 1918. Letter, dated 7th March 1918 from Dr. Simonson was read.

The Committee met on Friday the 8th at Kilpauk shaft and were shown the pressure on gauges applied to the mains there. They found the pressure at 8 o'clock was 35 feet. They then proceeded to the pumping station and examined the automatic recorders—they found the pressure was 43 feet. The difference between this pressure and the pressure at the shaft is due to the regulation of the valves at the shaft. The diagrams at the pumping station showed that the engines were stopped between 10-30 p.m. and 3 a.m. At 10-30 p.m. there is usually 27½ feet of water in the elevated steel tank.

From 10-30 p.m. to 3 a.m. the water in this tank falls to 10 feet. The engines are then started and pressure at 5-30 a.m. is 8 feet as the mains in the town are being filled. At 8 a.m. there is 8 feet of water in the tank corresponding to a pressure of 43 feet at the pumping station and 35 feet at the shaft. The maximum pressure when the tank is full, i.e., when it holds 27½ feet of water is 62½ feet. The discharge of the pumps at 8 a.m. is at the rate of 1,325,000 gallons per hour. At 10 a.m. the discharge falls to 800,000 gallons per hour owing to the reduction of draw-off by the town. The diagrams for this date will be obtained and further considered by the Committee.

The Committee then proceeded along the 42-inch main in Purasawalkam High Road. They observed houses in this road on which meters are not fixed. These houses have taps in the centre of gardens. In one case a plot of guinea grass was being irrigated and the tap was open. In another case the water was being used for irrigating flower beds. The Committee consider that all houses of any size especially those with gardens should be metered. They consider that either all taps in gardens should be prohibited or that such taps should be separately metered and double the usual rate for excess water should be charged and in the case of a garden supply no free allowance should be permitted. The Committee would remark that it seems absurd to limit irrigation at the Red Hills and at the same time filter the water and pump it at considerable expense and permit its use for irrigation of gardens in the city area at a low rate. On the other hand as the recommendations of the Committee, if accepted, would tend to the use of old and the opening of new wells it will be necessary to use precautions to prevent the breeding of mosquitos in these wells. The use of all wells should be regulated in the following manner. They should be effectively covered and fitted with pumps. The Committee cannot too strongly impress on those concerned the necessity of avoiding the possibility of further breeding of mosquitos within the City area and consequently the use of wells must be under the strictest supervision not only by the Corporation but by the people themselves and such regulations as may be issued must be supervised and effectively controlled by the Health Department. The Health Officer should be called on each year in his annual report to certify that the regulations for the use of wells have been strictly followed.

It was stated that the staff for looking after the distribution in the City consisted of—

		RS.
Three foremen	... ...	80—150
Ten overseers	... ...	40—50

There were two foremen present at the Committee's inspection and also overseers. The men informed us that they had no rules to guide them in maintaining the distribution system in an efficient condition. They were however provided with a water-works handbook which on inspection was found to contain rules for the provision of house service connexions, their repair and for the reading of meters. The staff informed us that they had no written or printed

directions for opening scour valves or as they were termed in the City wash outs. In fact one overseer stated that he only opened the wash outs when the people complained of the smell of the drinking water. On the plan supplied to the Committee a certain number of wash outs are shown. The number in the opinion of the Committee is quite inadequate even if the fire hydrants are assumed to be of any use in mains of over 4 inches in diameter for the purpose of scouring the pipes. In Purasawalkam High Road there is a 14-inch "wash out" in the 42-inch main. This after nearly half an hour delay in obtaining keys was opened and the water was found to be clean. The Committee will refer later to the question of seizes and number of wash outs.

On the 36-inch main the Committee were informed that opposite the Ganesha Kovil tank there was a 9-inch scour or wash out which discharged into the tank below water level. This valve could not be opened on account of the road metal being heaped over it.

The Committee express surprise at the continuation of this arrangement as the chance of the dirty tank water getting back into the mains when they are empty must be admitted and is more than a possibility. The Committee were unable to carry out any further inspection owing to a misunderstanding on the part of the staff who were not prepared for an inspection on this line and according to their own statements had been up late the night before opening the scours on the Nungambakam main.

It appears to the Committee that there is a want of system in the arrangements for providing keys for opening valves and other specials of the water-works. The keys are apparently kept in divisional stores at some distance from the places where they may be required. At night these stores are supposed to be looked after by a watchman but the keys of the premises are not in his possession consequently if a valve had to be shut during the night owing to a burst in the main it would be necessary first to find the overseer of the section who would then have to find the divisional storekeeper for the key. In the event of one of the employees being absent serious consequences might arise from delay in cutting off the supply.

The Committee would suggest that in convenient places in each of the ten overseers divisions of the City there should be built by the road side a sufficient number of small but ornamental store-sheds of dimensions 6′ × 6′ in which all the different sizes of keys required in that section of the town would be placed in racks. The key of this store would be a master key which would open similar divisional stores in the City and these master keys should be supplied to head turn-cocks, overseers, foremen, assistant engineers and water-works staff generally.

The Committee met on 14th March 1918.

On 9th March the Committee proceeded to inspect the Mylapore section of the town beginning at St. Thomé Cathedral. The pressure at a hydrant in Luz Church Road near the Cathedral is only 12 feet at 7–30 a.m. It is said to be usually 17 feet. The main on this road is an old one and is deeper than usual. The free hydrant was 1 foot 2 inches below road level. There is a meter on the Police Lines here, the private houses have no meters.

In Bazaar Road, the hydrant registered 14 feet pressure. Further on towards Barbers Bridge, the Committee inspected what was marked on the map as a silt pit. This seems an extraordinary arrangement. On the 10-inch main there has been built a masonry chamber 5 feet square and 8 feet deep. The main bends down by means of a right-angled branch into this chamber, passes horizontally across it, and rises by another bend to the usual level of the main below ground. On the horizontal section of the main, a 4-inch branch is taken off and this scour discharges at the side of the road. The outlet had to be dug up showing it had not been used for some time, said to have been three weeks ago. On opening the scour valve the discharge water was found to be clear after a short time. No arrangement is made here for the discharge of scour water into a drain, the scour water simply overflows the road. Further on at the junction of Edward Elliot's Road, it was found impossible to open the scour valve as the spindle head was broken. The outlet pipe was choked. The overseer stated that the valve had been opened three weeks ago. The Committee are unable to accept this statement. The pressure at hydrant at Barbers Bridge was 27 feet at 8–15 a.m.

Four-inch valve, Ice House Road, was opened. Copious black silt came out. This is too small a scour for 12-inch main on which it is fixed.

The free hydrant in Ramaswami Maistri Street was next opened. The water ran brown but had to be shut off as the street was being flooded and grain was exposed lower down the lane. The free hydrant on the main road adjoining was found clear, the water here is used for road watering.

The 9-inch scour outlet on the 27-inch main at corner of Wallajah Road and Triplicane High Road was opened. The water was clear. It was opened three days ago.

The Committee met on the 15th March 1918. They inspected on 13th March 1918.

At junction of Hospital Road and Mount Road, pressure at 7–20 a.m. 27 feet. There is a 22-inch main with 7-inch scour discharging with an open masonry drain. This scour is too small for this main. It ought to be 12 inches.

At junction of Broadway and Esplanade, there is a 22-inch main with 5-inch scour said to have been opened three months ago. Probably the reason for not opening this scour oftener was due to the fact that the valve was in a pit between the tramway rails. No scour valves should be in such position as it interferes with tramway traffic when opened.

In Thumbu Chetti Street, there is a students' hostel opposite the Christian College. The drain from this hostel was discharging a large quantity of clear water, there is no meter on this connexion and a large quantity of water is being wasted.

Corner of Thumbu Chetti Street and Aerra Chetti Street, scour on 18-inch main. The Committee found that the scour in this main discharged into a manhole below ground. When the manhole was full the water was intended to surplus through the opening on the surface of the road and flew across the road into the nearest drain. This is an extraordinary arrangement which the Committee must condemn. A scour pipe must be led from the main to the nearest drain and should discharge above the level of water in that drain. In this particular case the manhole could not be opened but the Committee inspected a similar arrangement in Monegar Choultry Road.

Passing along the streets the Committee were impressed by the enormous quantity of clear water which was being discharged by house drains. In all such cases the Committee were assured there were no meters in those houses.

There was one 7-inch scour on the 7-inch main, a branch of 18-inch main, Thumbu Chetti Street at Kachala Eswara Temple tank. The outlet of this scour discharged into the tank which contained slimy water of a green colour. It was stated that the temple people objected to the scour being opened and consequently it had never been opened as far as the overseer remembered. The Committee had the scour opened and for five minutes black and brown silt belched forth. This is the most effective scour the Committee have as yet found.

Opposite No, 55, Aiyappa Chetti Street, the Committee had a 2-inch free hydrant on a 4-inch main opened. This free hydrant unlike many others had not been opened prior to the Committee's visit. For 25 minutes water heavily charged with brown silt flowed from this free hydrant, which is on a side street. The Committee found that water from fire hydrants on main streets was usually clean as the water is used for watering the roads, unfortunately they are of little use as scours on main larger than 4-inch diameter.

(The continuation of the last street) *Sengalaneer Pilliar Pagoda Street*.—There are no hydrants in this street. None also in Savare Muthoo Street. In the Monegar Choultry Road there is a water outlet chamber similar to the one described above. The waste water from this chamber runs over an important thoroughfare before it reaches a drain thus damaging the road. This chamber has recently been constructed. The Committee are surprised to find this arrangement.

During the Committee's inspection of Georgetown, they noticed three important points :—

(1) The absence of water outlets or scours in this old section of the water-works ;

(2) The absence of meters for important houses ; and

(3) Easily avoidable waste of water.

With reference to No. 1, the Committee would remark that scours should have been fitted to the old water-works mains two or three years ago when a supply of new pipes and valves was received. The Committee understand that numbers of these are still in stock, for instance, 200 hydrants, which could be placed on the similar mains. The number of scour valves is not known.

With reference to (2) and (3) it is astonishing to find so many important houses not metered. The fixing of meters in such houses would result in the people shutting the taps.

The amount of clear water running to waste was very noticeable. It seems to be forgotten that this water has been filtered and pumped into the City at great cost.

The Committee met on 24th March 1918 and considered letter from the President, Madras Corporation, No. 505, dated 9th March 1918, forwarding the information called for by the Committee in their letter Nos. 649-S. and 650-S., dated 26th February 1918.

The Committee note that the source of the sand used in filling all the sand filters at Kilpauk was the bed of river Cooum about opposite the seventh mile stone on the Poonamallee Road.

They note that all the sand was screened and only a small portion of the sand was washed at Kilpauk and that the Special Engineer states that no appreciable benefit was obtained from the washing. Apparently no sand washers were used. The Special Engineer states "the only washing most of the sand received was before the filters were first put into use when the water was allowed to run through them until it was perfectly clear." The Committee will refer to this important statement in their report but they would note here that it is not stated that the sand was perfectly clear and only that the water was perfectly clear which came through the filter-beds.

The broken stone, it is stated, was obtained from Pallavaram. It is presumed the statement means that the stones were screened to suitable size and then washed in tubs.

The bricks were obtained from Amji Karai and were placed in the filter-beds unwashed.

With reference to the levels of the pumping station, the Committee note that the level of inlet of steel pipe into the suction chamber is 25·11 and the level of the invert of the suction chamber is 23·17. The level of the foot valve of each suction pipe of the pumps is 26·17. These levels show that the floor of the suction chamber is 1·94 feet below the level of inlet thus forming a catch pit for deposit which of necessity must be regularly cleared. As the level of the foot valve of the pumps is 26·17 and the level of the floor of the clear water reservoir is 27·00 the difference of ·80 of a foot is insufficient to enable the clear water reservoir to be drained dry by the main pumps. The Committee will refer to this in their report as they consider that the presence of a suction chamber underneath the engine room is undesirable and that the suction wells for the pumps are better placed outside the pumping station than inside in order to avoid contamination from the engine room. If this is done the foot valves of the pumps could be placed at such a level as would enable the clear water reservoirs to be drained dry periodically and thus avoid the use of temporary pumping plant. The Committee will refer in their report to the presence of catch pits in the inlet conduit and outlet chamber of clear water reservoir as the presence of these catch pits facilitates the accumulation of deposit.

In letter No. 650-S., dated 26th February 1918, the Committee asked for a statement of daily discharges for the year 1917. As the discharges at the pumping station are recorded only weekly, the Committee have been supplied with a statement of weekly discharges for 1917 as measured by the Venturi meter at the pumping station. The Committee note that the lowest weekly discharge is 74·9 million gallons, and the highest is 104·13 million gallons which shows a variation of nearly 40 per cent in the consumption. To supply the town with 25 gallons a head for a population of 523,000, the quantity of 91·5 million gallons is required weekly. The great variation which is shown in the statement is due to the fixing of certain pressures which the pumping station staff have to maintain. Instead of fixing the pressure at this arbitrary amount the Committee consider that the quantity of water pumped between certain hours should be determined, so that the weekly consumption should not rise above 91·5 million gallons.

If the fixing of this amount which is the amount for which the scheme was designed for 523,000 people at 25 gallons per head per day results in the undue lowering of pressure in certain outlying parts of the suburbs, the Committee would observe that the disadvantages arising therefrom should be overcome not by raising the pressure at Kilpauk but by regulating the pressure in the distribution mains by the sluice valves intended for that purpose.

The supply to the town from 5·30 till 7·30, the draw off reaches the large quantity of over a million gallons per hour, after 7·30 the quantity consumed falls until the consumption is 800,000 gallons per hour and this consumption continues till 6 p.m., after this hour the consumption falls rapidly until 11 p.m. From 11 p.m. to 4 a.m. or 5 hours the consumption is very small.

The supply is required to be high from 5 to 8 or three hours. After this hour the Committee consider the quantity pumped could be reduced up till 3 p.m. when it would be again increased till 6 p.m. after which hour the quantity pumped could remain as at present.

With reference to the statement of staff employed on the water-works and the report of the Special Engineer forwarded with the President's letter quoted above, the Committee will refer to this in their report.

The Committee have received a report on samples of water taken from bed No. 4 which the Committee have had under special observation for formation of filtering skin. The Committee inspected the bed on 13th March and gave directions to be brought into use at once. The samples were taken on the 17th of the same month or four days after the Committee observe that the number of colonies in the unfiltered water has been reduced from 1,830 to 790 by filtration and the lactose fermenters which were present in 5 c.c. of unfiltered are only present in 20 c.c. of the filtered water showing fourfold improvement due to filtration. This is a good result from a filter so soon after being started. Further samples will be taken from time to time which under ordinary conditions should show a progressive improvement in quality.

The Committee have received a letter from the Executive Engineer, Chingleput Division, through the Superintending Engineer, V Circle, on the subject of contamination of the catchment area at the Red Hills Tank. The Committee record this letter in the meantime and will deal with the subject in their report.

The Committee met on 2nd April 1918.

The following were read :—

The minutes of 21st meeting.

Letter from the Corporation Engineer, dated 22nd March 1918, in reply to Committee's letter D. No. 827/S., dated 15th March 1918.

The Committee decided to ask the President to state the rate charges for excess consumption of water prior to the introduction of the Kilpauk Pumping Station and if a change was made the date when the new rate was introduced. The Committee note that there are at present 29,000 house service connexions in the City and only 900 are metered. Of these 102 buildings belong to Government. The Committee are of opinion judging from this statement and from their inspection of the distribution in the City that the number of house service connexions metered is totally inadequate. At least from 5,000 to 6,000 connexions should be metered. If the meters are increased in number as contemplated by the Committee, the quantity of water wasted in the City which the Committee have, during their inspection, noticed in many places will be largely decreased with advantage to the whole community.

The Committee observe that the income derived from water supplied for non-domestic purposes which includes excess consumption at house connexions was for 1916–17 the large sum of Rs. 1,52,717. When the meters are increased by the number suggested by the Committee, the revenue from this source will obviously be very substantial and the Committee point to this source as the means for obtaining the necessary funds required for the enlargement of the water-supply works and for their maintenance in a condition in keeping with their importance.

The Committee subsequently inspected the Tondiarpet section of the town and found conditions somewhat similar to those in other sections.

(ON.)

Letter—from J. M. LACEY, Esq., A.M.I.C.E., Superintending Engineer, V Circle.
To—the Sanitary Commissioner to the Government of Madras (through the Chief Engineer for Irrigation, Madras).
Dated—Madras, 17th January 1918.
No.—45 M.

With reference to your letters Nos. 9537-1/S. of the 6th November 1917, and the 19th November 1917, requesting me to state whether I consider that the supply received into the Red Hills tank is sufficient to maintain a daily consumption of 29 gallons a day per head of population for the City of Madras, I have the honour to inform you that on referring to the Administration Report of the Corporation of Madras for 1916–17, paragraph 72 *et seq.* quoted by you, I find that the consumption of water during 1916–17 was 4,982·34 million gallons which was equivalent to an average consumption of 26·30 gallons per head. This makes the present population 520,000 souls. According to the census of 1901 the population was 509,340 and in 1911 the population was 518,600. Taking a population of 520,000 and a consumption of 29 gallons per head per day the quantity consumed during a month of 30 days would be 72·38 million cubic feet.

2. Dividing the year into a water year from the 1st June to 31st May and taking the period from the 1st June 1890 to 31st May 1916, the two worst years on record are first, 1904–05, and second, 1900–01, that is, 1st June to 31st May.

I enclose a statement showing the receipts and issues into the Red Hills tank for the period commencing 1st June 1904. In the case of the issues to the Madras Corporation, I have taken the issues for 1915–16 which are the maximum on record. It will be seen from the statement that had the issues to the Madras Corporation in 1904–05 been the same as in 1915–16, the tank would have failed.

The year was a very bad one only 61·47 million cubic feet passed over the Tamarapauk anicut in October 1904 and there were no more freshes which topped the anicut till the first period of October 1905 so that there was no possible means of extra source of supply. There was no surplus from the Sholavaram tank or from the Red Hills tank. On the 1st June 1904, the Cholavaram tank was almost full and the Red Hills tank had a supply storage of 1,666·16 million cubic feet against a maximum capacity storage of 2,162 million cubic feet so that conditions on the 1st June 1904 were favourable. A similar statement is enclosed for 1900–01.

3. The average consumption in 1915–16 works out to 76·88 million cubic feet per month against 72·38 million cubic feet, the figures given by you but the figures are near enough to show that any such extraordinary issues are in bad years likely to cause a serious failure of supply of water to the City of Madras, and can only be viewed with alarm. It is better to recognize that in bad years the supply is very limited and the average consumption *must be* reduced. As I have already pointed out to the President of the Corporation of Madras, the obligations of the Corporation are fulfilled when they provide *a pure and wholesome* supply of drinking-water to the population and do not extend to providing them with water to irrigate their gardens also, nor do I understand the ethics of depriving the ryots under the Red Hills and Cholavaram tanks of water for irrigation in order to irrigate gardens in Madras. I have taken up the question in the case of the Chepauk and Marina Gardens, and am investigating the ground water-supply that is available for this purpose. The ground water is near the surface in Madras and it should be possible to irrigate all gardens from wells without utilizing the Corporation filtered supply.

Letter—from Major W. A. JUSTICE, M.B., C.M., D.P.H., I.M.S., Sanitary Commissioner to the Government of Madras.
To—the Superintending Engineer, V Circle.
Dated—Madras, 19th November 1917.
No.—Memo. 9537-1/S.

As desired in your letter No. 1250 M., dated 10th November 1917, I have the honour to forward, for reference and return, a copy of the Administration Report of the Corporation of Madras for 1916–17. For particulars of the water-works of the City, please see paragraph 72 *et seq.* of the report.

Letter—from Major W. A. JUSTICE, M.B., C.M., D.P.H., I.M.S., Sanitary Commissioner to the Government of Madras.
To—the Superintending Engineer, V Circle.
Dated—Madras, 6th November 1917.
No.—Memo. 9347-1/S.

I am directed by the Committee appointed by Government in G.O. No. 1576 M., dated 15th September 1917, in connexion with the Madras water-works to enquire whether in view of the statement made by the President, Corporation of Madras, in his annual report that the daily consumption of water per head of population was now 29 gallons per day, you consider that the increased supply can be obtained from the present Red Hills catchment area without running the risk of a deficiency occurring. An early reply will oblige.

RED HILLS TANK.

—		Receipts.			Cols 3+4+5	Issues.			Cols. 7+8+9.	Col. 6 to Col. 10.		Col. 11 and Col. 12.
Month and period.	Rainfall.	Storage at the beginning.	Run-off from basin.	Supply from Channel.	Total storage at the beginning	Irrigation.	Percolation and surplus.	Evaporation.	Total.	Balance to be drawn from.	Maximum municipal demand of 1915-16.	Balance still available carried to col. 3.
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
May 1st ...	...	442·36		...	442·36	...	— 3·37	37·46	34·09	408·27	39·69	368·58
May 2nd ..	0·14	368·58	...	...	368·58	..	— 0·94	35·67	36·61	331·97	39·05	292·92
1905-06.												
June 1st ...	0·35	292·92	...	...	292·92	...	12·02	26·19	38·21	254·71	46·88	207·83
June 2nd ..	1·82	207·83	15·21	...	223·04	...	...	24·98	24·98	198·06	47·96	150·10
July 1st ..	0·70	150·10	...	...	150·10	...	7·14	20·50	27·64	122·46	41·88	80·58
July 2nd ...	1·81	80·58	10·97	...	91·55	...	...	19·47	19·47	72·08	39·44	32·64
August 1st ...	0·23	32·64	17·97	...	50·61	...	...	21·75	21·75	28·86	34·85	— 5·99
August 2nd ...	1·42	— 5·99	11·24	8·72	10·96	..	...	21·04	21·04	— 10·08	33·31	— 43·39
September 1st ...	1·35	— 43·39	..	62·84	19·45	...	1·88	25·73	25·73	— 6·28	40·28	— 46·56
September 2nd...	0·95	— 46·56	...	19·33	— 27·23	..	4·09	27·75	27·75	— 54·98	40·48	— 95·46
October 1st ...	12·87	— 95·46	408·27	76·10	389·51	...	...	23·85	23·85	362·66	30·07	332·59
October 2nd ...	4·36	332·59	282·86	469·77	1,085·22	2·08	...	37·33	37·33	1,047·89	43·06	1,004·83
STATEMENT 1.—1900–01 AND A PORTION OF 1901–02 (WATER YEAR FROM JUNE TO MAY).												
June 1st ...	...	1,308·06	...	...	1,308·06	18·52	31·63	40·27	90·42	1,217·64	46·88	1,170·76
June 2nd ...	0·39	1,170·76	9·01	...	1,179·77	14·96	..	38·67	53·63	1,126·14	47·96	1,078·18
July 1st ...	0·79	1,078·18	...	...	1,078·18	...	20·46	32·12	52·58	1,025·60	41·88	983·72
July 2nd ...	1·74	983·72	19·47	...	1,003·19	...	...	31·11	31·11	972·08	39·44	932·64
August 1st ...	0·98	932·64	...	...	932·64		8·41	35·07	43·48	889·16	34·85	854·31
August 2nd ...	...	854·31	...	...	854·31	...	14·25	33·73	47·98	806·33	33·31	773·02
September 1st ..	3·51	773·02	52·66	...	825·68	.	..	37·44	37·44	788·24	40·28	747·96
September 2nd ...	0·97	747·96		..	747·96	...	3·27	36·72	39·99	707·97	40·48	667·49
October 1st ...	0·11	667·49	7·72	...	675·21	..	..	29·04	29·04	646·17	30·07	616·10
October 2nd ...	13·33	616·10	174·15	89·37	879·62	...	...	30·52	30·52	849·10	43·06	806·04
November 1st ..	4·04	806·04	38·49	60·46	904·99	...	...	17·13	17·13	887·86	33·26	854·60
November 2nd ...	4·04	854·60	201·78	51·36	1,087·74			18·58	18·58	1,069·16	30·35	1,038·81
December 1st ...	4·86	1,038·81	73·37	55·48	1,167·66	18·31	...	23·99	42·30	1,125·36	33·02	1,092·34
December 2nd ...	1·90	1,092·34	50·71	75·69	1,218·74	13·79	..	24·55	38·34	1,180·40	41·82	1,138·58
January 1st ...	.	1,138·58	...	30·69	1,169·27	21·38	27·39	24·55	73·32	1,095·95	41·08	1,054·87
January 2nd ...	0·30	1,054·87		16·59	1,071·46	21·58	29·47	23·91	74·96	996·50	37·98	958·52
February 1st ...	2·45	958·52	38·12	...	996·64	19·33	.	28·94	48·27	948·37	41·14	907·23
February 2nd ...	1·67	907·23	.	55·86	963·09		11·77	28·73	40·50	922·59	33·58	889·01
March 1st ...	...	889·01	...	30·47	919·48	8·06	30·64	38·96	77·66	841·82	36·96	804·86
March 2nd ...	.	804·86	...	3·55	808·41	1·90	18·85	37·47	58·22	750·19	40·44	709·75
April 1st ...	...	709·75	...	...	709·75	...	6·48	40·68	47·16	666·59	38·31	614·28
April 2nd ...	...	614·28	.	...	614·28	...	— 3·88	39·40	35·52	578·76	37·64	541·12
May 1st ...	0·12	541·12	...	..	541·12	...	1·03	42·42	43·45	497·67	39·69	457·98
May 2nd ...	...	457·98	...	...	457·98	...	6·20	41·44	47·24	410·74	39·05	371·69
1901-02.												
June 1st ..	...	371·69	...	...	371·69	...	13·37	30·18	43·55	328·14	46·88	281·26
June 2nd	0·34	281·26	...	.	281·26	...	19·32	28·62	47·94	233·32	47·96	185·36
July 1st ...	1·19	185·36	...	..	185·36	...	5·07	23·43	28·50	156·86	41·88	114·98
July 2nd ...	4·91	114·98	25·44	...	140·42	...	...	22·38	22·38	118·04	39·44	78·60
August 1st ...	2·88	78·60	21·49	..	100·09	...	...	25·70	25·70	74·39	34·85	39·54
August 2nd ...	4·32	39·54	31·59	...	71·13	..	...	25·07	25·07	46·06	33·31	12·75
Septemper 1st ...	0·07	12·75	0·83	...	13·58	...	...	27·43	27·43	—13·85	40·28	— 54·13
September 2nd...	1·06	— 54·13	0·47	...	— 53·66	...	...	25·84	25·84	—79·50	40·48	— 119·98
October 1st ...	3·84	—119·98	59·16	...	— 60·82	...	...	20·68	20·68	—81·50	30·07	— 111·57
October 2nd ...	5·82	—111·57	15·63	...	— 95·94	...	...	20·54	20·54	—116·48	43·06	— 159·54
November 1st ...	16·28	—159·54	335·72	392·67	568·85	...	...	14·00	14·00	554·85	33·26	521·59
November 2nd...	1·50	521·59	81·13	169·09	771·81	1·18	...	18·77	19·95	751·86	30·35	721·51
STATEMENT 2.—1904–05 AND A PORTION OF 1905–06.												
June 1st ...	0·76	1,666·16	...	...	1,666·16	1·08	7·25	45·83	54·16	1,612·00	46·88	1,565·12
June 2nd	.	1,565·12		...	1,565·12	5·85	8·81	44·46	59·12	1,506·00	47·96	1,458·04
July 1st ...	2·04	1,458·04	5·62	..	1,463·66	7·81	...	37·40	45·21	1,418·45	41·88	1,376·57
July 2nd ...	6·01	1,376·57	55·25	337·71	1,769·53	10·67	..	38·89	49·56	1,719·97	39·44	1,680·53
August 1st ...	2·72	1,680·53	17·43	...	1,697·96	10·52		46·71	57·23	1,640·73	34·85	1,605·88
August 2nd ...	...	1,605·88		...	1,605·88	16·34	14·77	45·74	76·85	1,529·03	33·31	1,495·72
September 1st	2·41	1,495·72	55·55	...	1,551·27	17·99	...	50·96	68·95	1,482·32	40·28	1,442·04
September 2nd..	3·46	1,442·04	58·83	...	1,500·87	21·82	...	50·32	72·14	1,428·73	40·48	1,388·25
October 1st ...	0·50	1,388·25	..		1,388·25	18·94	3·67	40·32	62·93	1,325·32	30·07	1,295·25
October 2nd ...	2·20	1,295·25	23·31	...	1,318·56	12·02	0·06	39·37	51·45	1,267·11	43·06	1,224·05
November 1st	0·56	1,224·05	...	...	1,224·05	12·92	41·90	19·89	74·71	1,149·34	33·26	1,116·08
November 2nd	...	1,116·08	...	..	1,116·08	25·08	2·72	19·27	47·07	1,069·01	30·35	1,038·66
December 1st ...	0·45	1,038·66	.	95·89	1,134·55	35·91	16·89	23·09	75·89	1,058·66	33·02	1,025·64
December 2nd...	1·45	1,025·64	...	56·90	1,082·54	29·85	25·60	22·72	78·17	1,004·37	41·82	963·55
January 1st ...	0·98	963·55		33·22	996·77	3·97	20·06	22·38	46·41	950·36	41·08	909·28
January 2nd ...	...	909·28	...	31·02	940·30	...	36·59	21·72	58·31	881·99	37·98	844·01
February 1st ...	...	844·01	...	14·03	858·04		17·09	26·05	43·14	814·90	41·14	773·76
February 2nd ...	...	773·76	...	6·48	780·24	...	3·46	25·33	28·79	751·45	33·58	717·87
March 1st ...	.	717·87	...	...	717·87	...	— 0·60	33·81	33·21	684·66	36·96	647·70
March 2nd ...	0·46	647·70	5·49	...	653·19	...		32·64	32·64	620·55	40·44	580·11
April 1st ...	0·17	580·11	...	...	580·11	...	1·07	35·65	36·72	543·39	38·31	505·08
April 2nd ...	0·57	505·05	9·34	...	514·39	...	...	34·39	34·39	480·00	37·64	442·36

(ON_2)—WEEKLY water consumption of 48 inches pumping main from 1st January to 31st December 1917.

Period.	48″ Venturi at K.P. Station.	Period.	48″ Venturi at K.P. Station.
	MILLIONS OF GALLONS.		MILLIONS OF GALLONS.
1st to 8th January 1917	91·800	2nd to 9th July 1917...	74·900
8th to 15th "	95·400	9th to 16th "	88·700
15th to 22nd "	91·200	16th to 23rd "	104·130
22nd to 29th "	94·200	23rd to 30th "	97·800
29th to 5th February 1917	93·600	30th to 6th August 1917	109·400
5th to 12th "	93·400	6th to 13th "	102·800
12th to 19th "	96·200	13th to 20th "	98·700
19th to 26th "	96·600	20th to 27th "	96·200
26th to 5th March 1917...	97·202	27th to 3rd September 1917 ...	89·700
5th to 12th "	100·300	3rd to 10th "	95·300
12th to 19th "	101·200	10th to 17th "	93·100
19th to 26th "	100·700	17th to 24th "	95 400
26th to 2nd April 1917	99·300	24th to 1st October 1917	90·900
2nd to 9th "	99·800	1st to 8th "	95 100
9th to 16th "	101·470	8th to 15th "	100·550
16th to 23rd "	102·600	15th to 22nd "	88 650
23rd to 30th "	100·100	22nd to 29th "	92·500
30th to 7th May 1917	102·000	29th to 5th November 1917	97·500
7th to 14th "	101·700	5th to 12th "	89·600
14th to 21st "	102 200	12th to 19th " ...	93·700
21st to 28th "	103·700	19th to 26th "	94 600
28th to 4th June 1917	98·300	26th to 3rd December 1917... ...	99 100
4th to 11th "	78·100	3rd to 10th "	93 300
11th to 18th "	82·000	10th to 17th "	96 900
18th to 25th "	77 700	17th to 24th "	800·200
25th to 2nd July 1917	75·400	24th to 31st "	99·500

(R)

RULES AT PRESENT IN FORCE FOR WORKING THE MADRAS WATER-WORKS FILTERS.

B. REVISED RULES FOR WORKING FILTERS.

[*N.B.*—These rules have been worked to as far as possible, but in the absence of bacteriological control, it has been impossible to comply with them fully—25th September 1917.

Filling filters.

1. Close inlet and outlet valves and open valve for filling filter from below with pure water, so that the water surface rises at a uniform rate of 2 inches vertical per hour till there is a depth of 6 inches of water over the sand.

Then close the filtered water valve and open inlet valve slightly so as to fill the filter slowly till the depth of water over the sand is 18 inches. The filter may then be filled more quickly, but great care must be taken to avoid disturbing the sand surface by admitting the water too fast (above 5 inches vertical per hour).

Filter to rest.

2. When the filter is full, close the inlet valve and allow the water to stand for at least 24 hours or such longer period as tests of the transparency of water may prove to be necessary. Then open the scour valve, so that the water sinks at the rate of ½ inch vertical per hour. Having made this adjustment, open inlet valve wide to keep level in the filter constant. After 4* hours increase the rate of filtration to 1 inch and then gradually to 1½ inches, 2 inches and 3 inches. Run the filter at 3 inches for 3 days and, if after that, there are no lactose fermenters in 100 c.c. allow 4 inches.

Running filtered water to waste.

3. Run water to waste until an efficient filtering skin is formed as proved by bacteriological examination.

Working filter.

4. With an efficient filtering skin has formed, close scour valve, open outlet valve and adjust the automatic outlet, so that the rate of filtration continues the same. Continue at the rate of 3 inches vertical per hour for a total of three days. Then slowly increase the rate to 4 inches vertical per hour, great care being taken that there is no sudden increase in head. When the bacteriological tests have proved that a first-class filtered water is being obtained at the rate of 4 inches vertical per hour, the rate may be increased gradually to 5 inches vertical per hour and maintained at that rate so long as bacteriological tests prove that there is no less in the efficiency of filtration.

Work filter bed until with the head available it is no longer possible to get a greater filtration than 3 inches vertical per hour.

Cleaning filter.

5. Close inlet valve and run water through the outlet valve as low as possible. Then open the scour valve and drain the filter completely.

Close scour valve and clean filter bed by one of the two following methods :—

(*a*) Allow filtering skin to dry by exposure to the sun and remove filtering skin, which will curl up in small patches.

(*b*) Remove filtering skin while moist.

Experience will show which of these methods is most effective and economical. Care should be taken to remove the minimum amount of sand, which should be less than ½ inch. The sand should be smoothed flat, care being taken not to disturb the compact surface.

Precautions when cleaning.

6. Every care should be taken not to foul or disturb the sand surface. For this reason the coolies must wash themselves and their implements, and where necessary planks should be provided for them to walk on. The most effectual and economical way of removing filtering skin must be determined by experiment. Mamooties and wooden rakes should be tried.

Disturbing surface film.

7. When a filter clogs rapidly instead of cleaning it, the surface film may be disturbed in the following manner :—

Close Outlet.—Leave filter standing for 6 hours to allow water to fill spaces in sand, stones and drains. Draw off water to a few inches below sand surface.

Rake over with an iron plate sufficiently serrated to break up the film.

Re-start filter as described below.

The effect of the filtrate analyses of thus disturbing the surface film must be carefully noted before it is finally adopted as a standard method of treating a filter which clogs rapidly.

"The disturbing of the surface film was abandoned after trials had proved it to be unsatisfactory."

Disposal of removed filtering skin.

8. The filtering skin removed in the manner above described will be conveyed to a water-tight platform, and the organic matter washed out of it as soon as possible. The washed sand will then be stacked for use when it is required to refill one of the filters.

NOTE.—The cost of this washing must be determined and if it is found to exceed the cost of fresh sand then the removed filtering skin should be used for filling hollows or other purposes for which it may be suitable, and fresh sand used for replenishing the filter.

"It was found very costly to wash the filtering skin which is accordingly disposed of otherwise."

Re-starting filters.

9. After cleaning, the sand should, if possible, be exposed to the action of the atmosphere. The filters should be re-started after cleaning in exactly the way already described for starting filters.

Minimum thickness of filtering sand.

10. The cleaning above described may be continued until the fine sand is reduced to a thickness of 15 inches unless analyses have proved the filter to have lost its efficiency before.

Renewing filtering materials.

11. When the fine filtering sand has been reduced to 15 inches in thickness, or analyses show that the sand should be removed, then the filter should be emptied and the sand as far as it is discoloured should be removed and washed. The filter should then be refilled with clean sand to the same depth as for new filters.

Rate of filtration.

12. The rate of filtration should not exceed 5 inches vertical per hour, and must be controlled in accordance with the results of bacteriological examination.

Examination of water.

13. The water from each filter should be examined daily to see that it is clear and free from taste and should be compared with the raw water.

Arrangements should be made for regular bacteriological examination. It is desirable that the filtrate from each filter should be examined daily. Should there be any sudden increase in the number of bacteria, the bed should be put out of action and an examination should be made to discover and remove the cause.

Reports.

14. Reports on the working of the filters showing the quantity of water filtered, number of cleanings, and anything calling for special remark, should be sent in bi-monthly, and a general summary of the years working should be submitted in the first week in April for inclusion in the annual Administration Report of the Madras Corporation.

26th October 1915.

(A)

From—Major W. A. JUSTICE, M.B., C.M., D.P.H., I.M.S., Sanitary Commmissioner for the Government of Madras.
To—the President, Corporation of Madras.
Dated—Madras, the 26th February 1918.
No.—D. 649/S.

The Madras Water-works Committee at their meeting on 22nd February 1918 resolved to ask you to furnish them with the following information :—

(1) The source of the sand used in filling the sand filters ;

(2) Were they all filled with the same sand and from the same source ? If not, a detailed note should be sent ;

(3) How was the sand prepared before being placed in the filter bed ?

Was it all (*a*) screened, (*b*) washed—if so, where and how and (*c*) the maximum cubic feet of sand per day washed by each sand washer ;

(4) The source of the broken stones and bricks—if washed, in what manner was this operation conducted ?

2. With reference to the levels at the headworks, the Committee require the following information :—

(1) Level of the foot valve of each suction pipe ;
(2) Level of invert of each suction chamber ;
(3) Level of invert of inlet steel pipe at junction with suction culvert of pumping station ; and
(4) A plan showing dimensions of foundations of pumping station and suction culvert.

(B)

From—J. C. MOLONY, Esq., I.C.S., President, Corporation of Madras.
To—the Sanitary Commissioner for the Government of Madras.
Dated—Madras, the 9th March 1918.
No.—R.O. G.D.C. 505-Sup.

With reference to your letters D. Nos. 649/S and 650/S, dated 26th February 1918, I have the honour to forward herewith a copy of a letter S.E. No. 473, dated 4th March 1918, with enclosures in original, furnishing the information required by the Madras Water-works Committee. I request that the two venturi meter diagrams, showing the average consumption of water for the weeks ending 14th May and 9th April 1917, may be returned when no longer required. The Special Engineer will meet the Committee on their next inspection of the water-works with the plan of the distribution system, showing the sizes of the distribution mains.

ENCLOSURE.

From—the Special Engineer, Corporation of Madras.
To—the President, Corporation of Madras.
Dated—Madras, the 4th March 1918.
No.—S.E. No. 473.

Water-works—Information required by the Sanitary Commissioner to Government.

With reference to the copies of letters from the Sanitary Commissioner, D. Nos. 649-S and 650-S, both dated 26th February 1918, I have to report as follows :—

2. *Letter D. No.* 649-S.—

(1) Bed of river Cooum about opposite 7th mile stone on Poonamallee road.

(2) Yes.

(3) (*a*) Yes. (*b*) A small portion of the sand was washed at Kilpauk but no appreciable benefit was obtained. The oynl washing most of the sand received was before the filters were first put into use, when the water was allowed to run through them until it was perfectly clear.

(4) Broken stone from Pallavaram. Bricks from Amjikarai. Stones were washed by screens in tubs. Bricks were not washed.

3. (1) 26·20.
(2) 23·20.
(3) 25·11.
(4) Mr. Hutton when asked on telephone what information he required, said that he wanted a plan giving information with reference to the suction culvert, which had not been given in the section already supplied from my office. A plan giving this information is attached.

4. *Letter D. No.* 650-S.—

(1) Daily discharges have not been recorded. A statement of weekly discharges for 1917 as measured by the venturi meter at the Kilpauk Pumping station is enclosed herewith.

(2) Venturi meter diagram for the day on which the greatest supply was given to the town will be found facing page 41 of my report, dated 9th October 1917, which I prepared for the Committee. For the average consumption, two diagrams for the weeks ending 14th May and 9th April 1917 are sent herewith. It is requested that they may be returned when finished with.

(3) A statement of the staff employed on the water-works and their duties will be found in Appendix E, pages 56 to 66 of my report, dated 9th October 1917, which has been supplied to the Committee. This statement does not give the superior staff.

At present the main water-works from the Red Hills to the pure water tanks are under the Special Assistant Engineer's general supervision. The pumping station elevated tank and the pumping main are under the Superintendent, Kilpauk Water-works, who has been transferred to the Works department. The distribution system is under the Range Engineers, but the Assistant Special Engineer, Water-works Section, advises on many points that arise and has sole control of the waste detection staff.

At an early date, the whole water-works will be placed under a Water-works Assistant Engineer—a post which has been sanctioned by the Corporation for the next year.

As regards the pay of the staff :—

Superintendent, Water-works, Rs. 150 per mensem, plus bonuses for economical pumping and free quarters.
Overseer, Red Hills, Rs. 40—50, plus free quarters.
Assistant Overseer, Red Hills, Rs. 25, plus free quarters.
Overseer, Kilpauk, Rs. 80—100, plus free quarters.
Assistant Overseer, Kilpauk, Rs. 50, plus free quarters.
Pump Drivers, Rs. 30—75.
Out-door Foreman on the distribution system, Rs. 80—120, plus Rs. 30, motor bi-cycle allowance.
Overseers, Rs. 40—50, plus Rs. 5, bicycle allowance.

I have arranged with Mr. Hutton to take the plan when I meet the Committee on their next inspection.

MADRAS WATER SUPPLY

RED HILLS TANK: PLAN SHEWING CATCHMENT AREA: CONDUIT AND KILPAUK PUMPING STATION.

SCALE 1" = 2 MILES

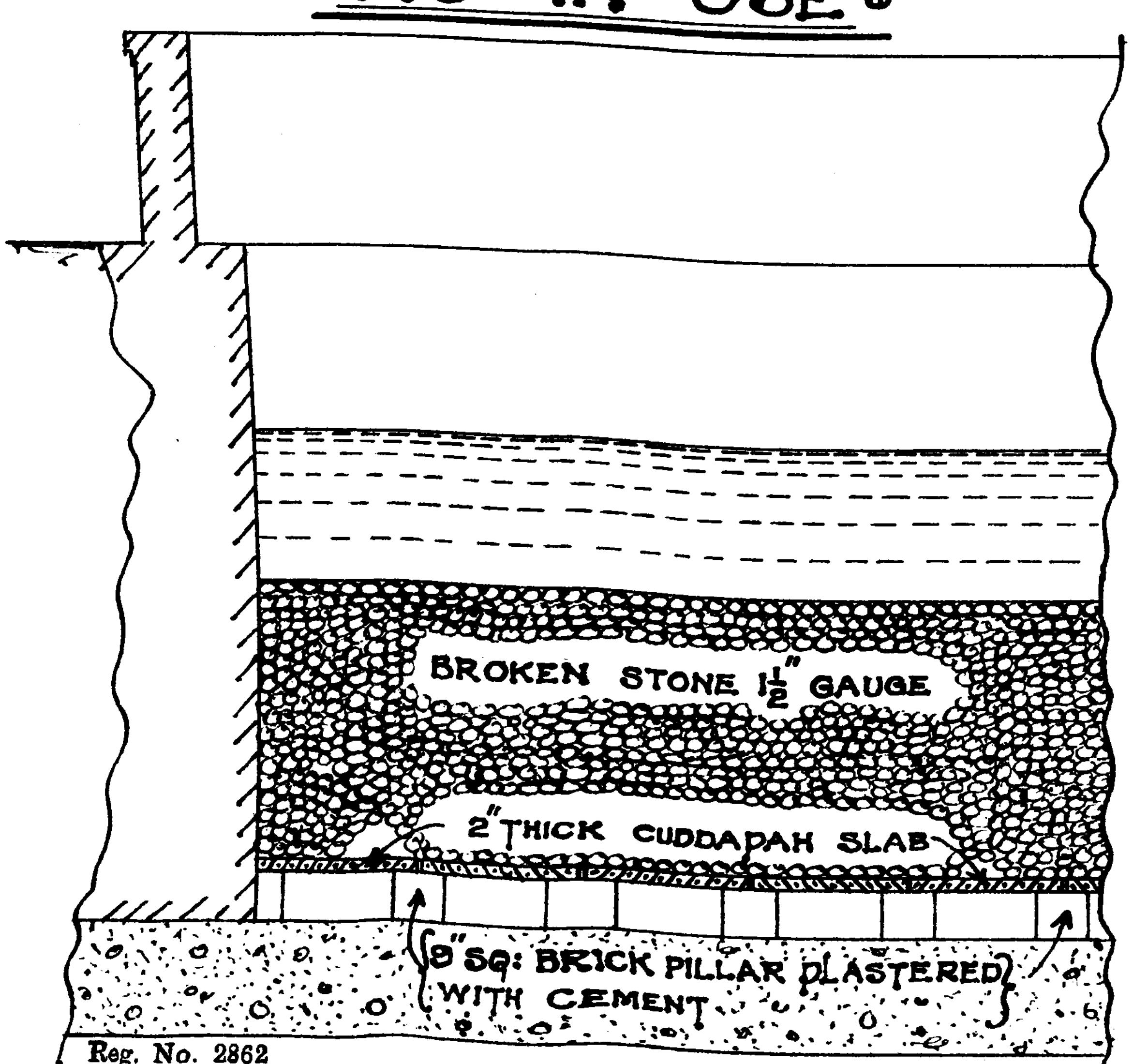
Reg. No. 2861
Copies 60

Vandyke., Survey Office, Madras.
1918.

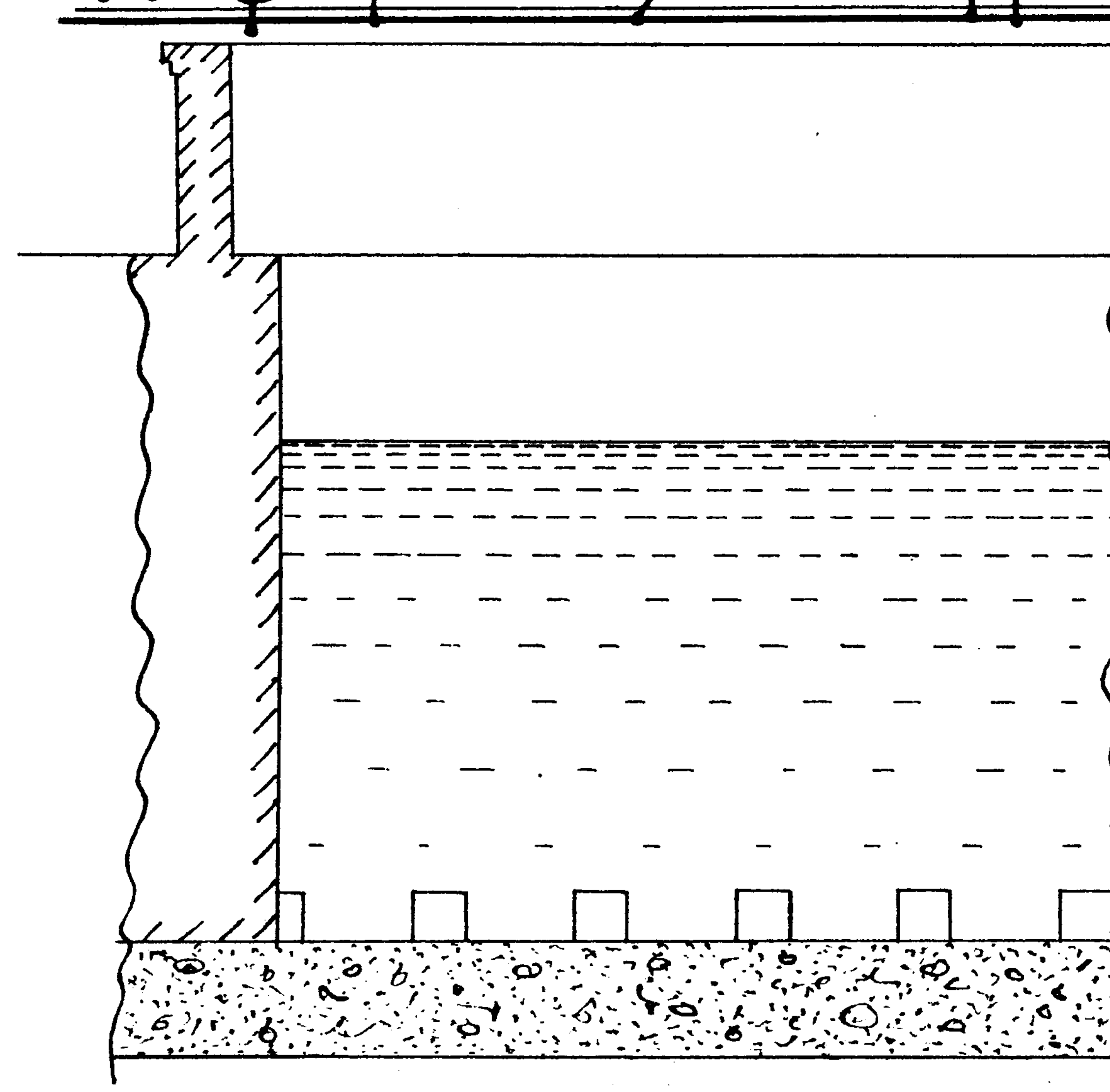
MADRAS · WATER · SUPPLY

SECTION · OF · ROUGHING · FILTER

AS · IN · USE



AS · PROPOSED · BY · COMMITTEE



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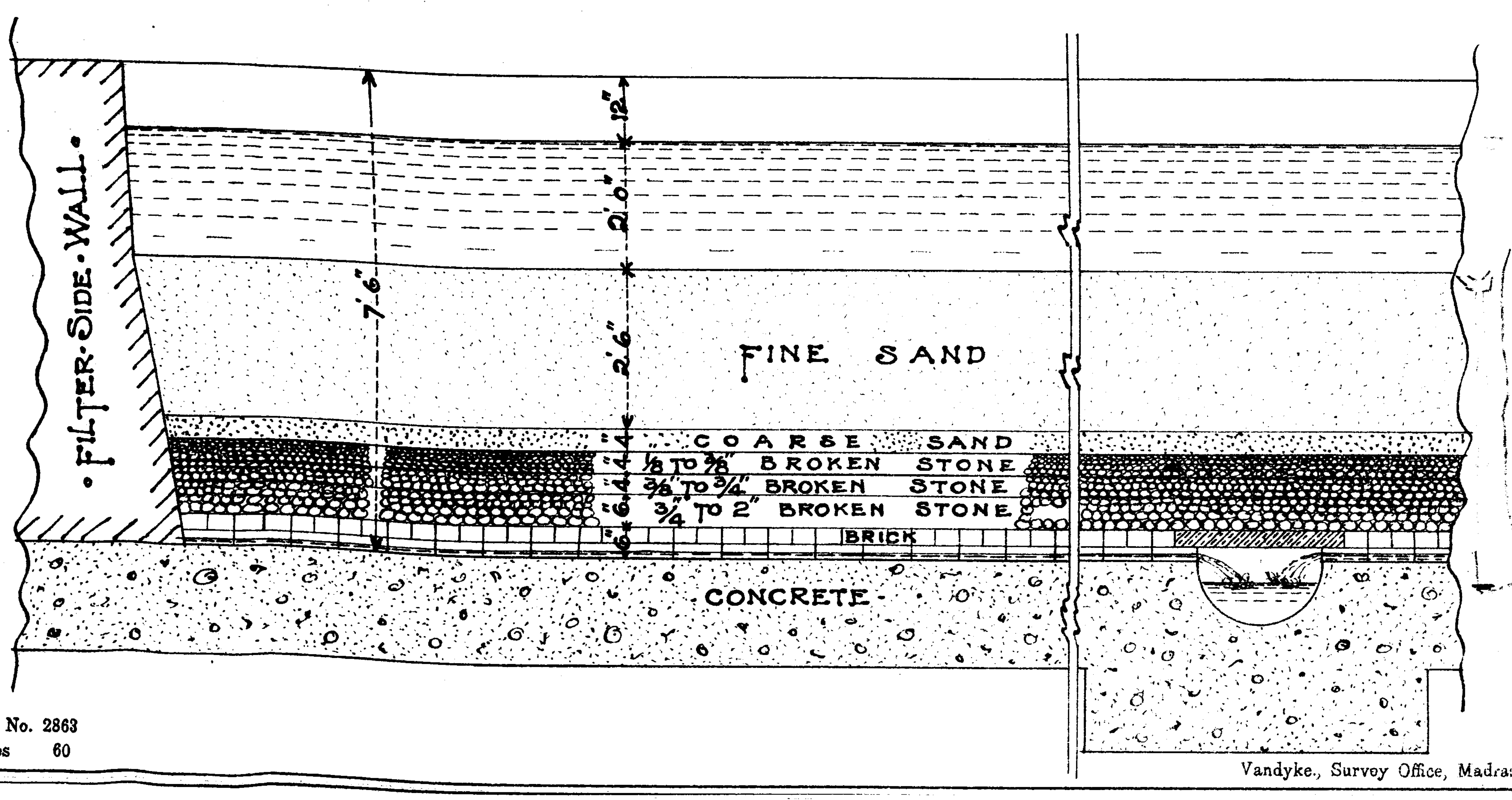
MADRAS · WATER · SUPPLY

SECTION · OF · FILTER · BED · AS · IN · ORIGINAL · SCHEME



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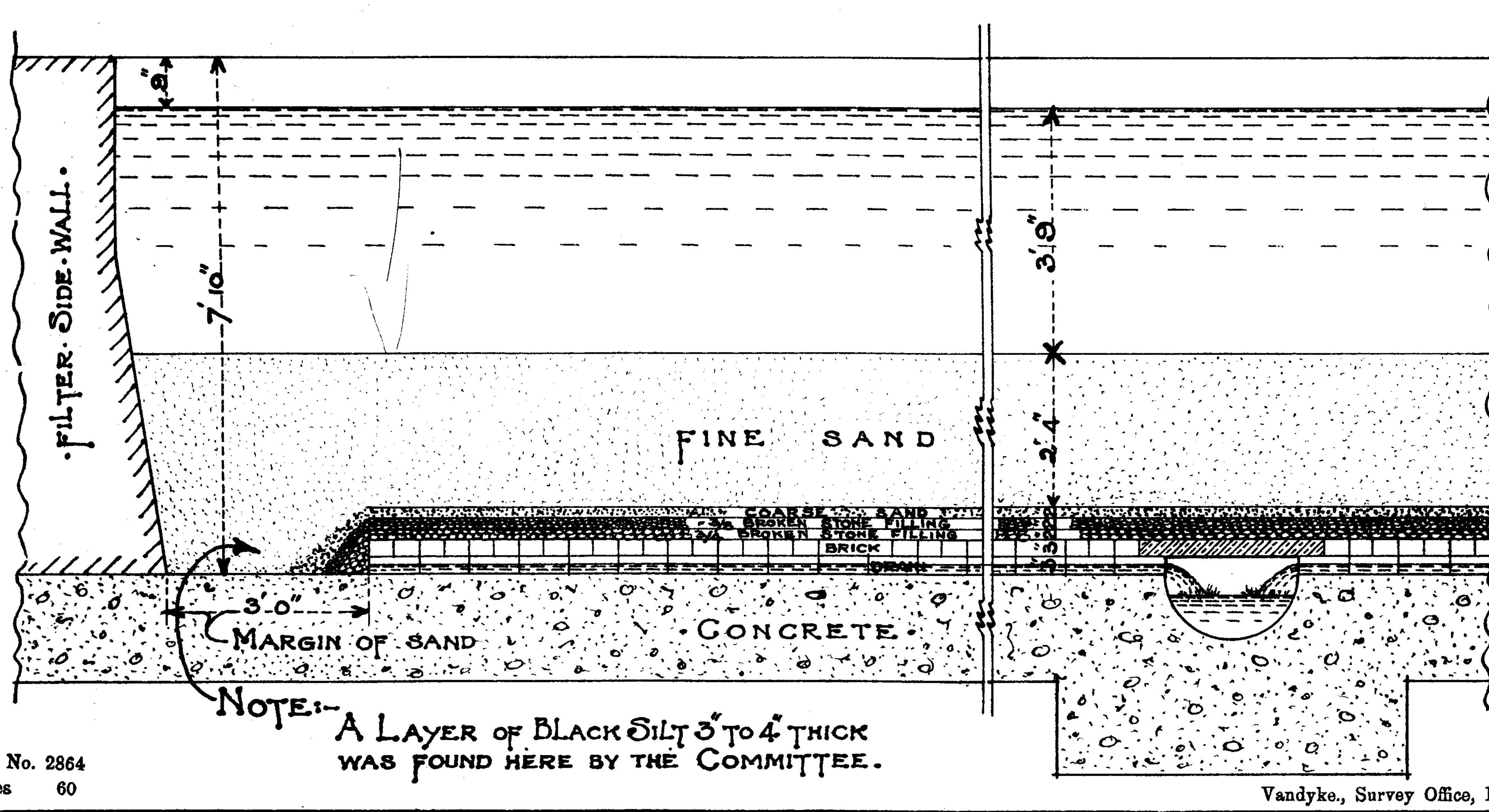
MADRAS · WATER · SUPPLY

SECTION · OF · FILTER · BED · IN · USE



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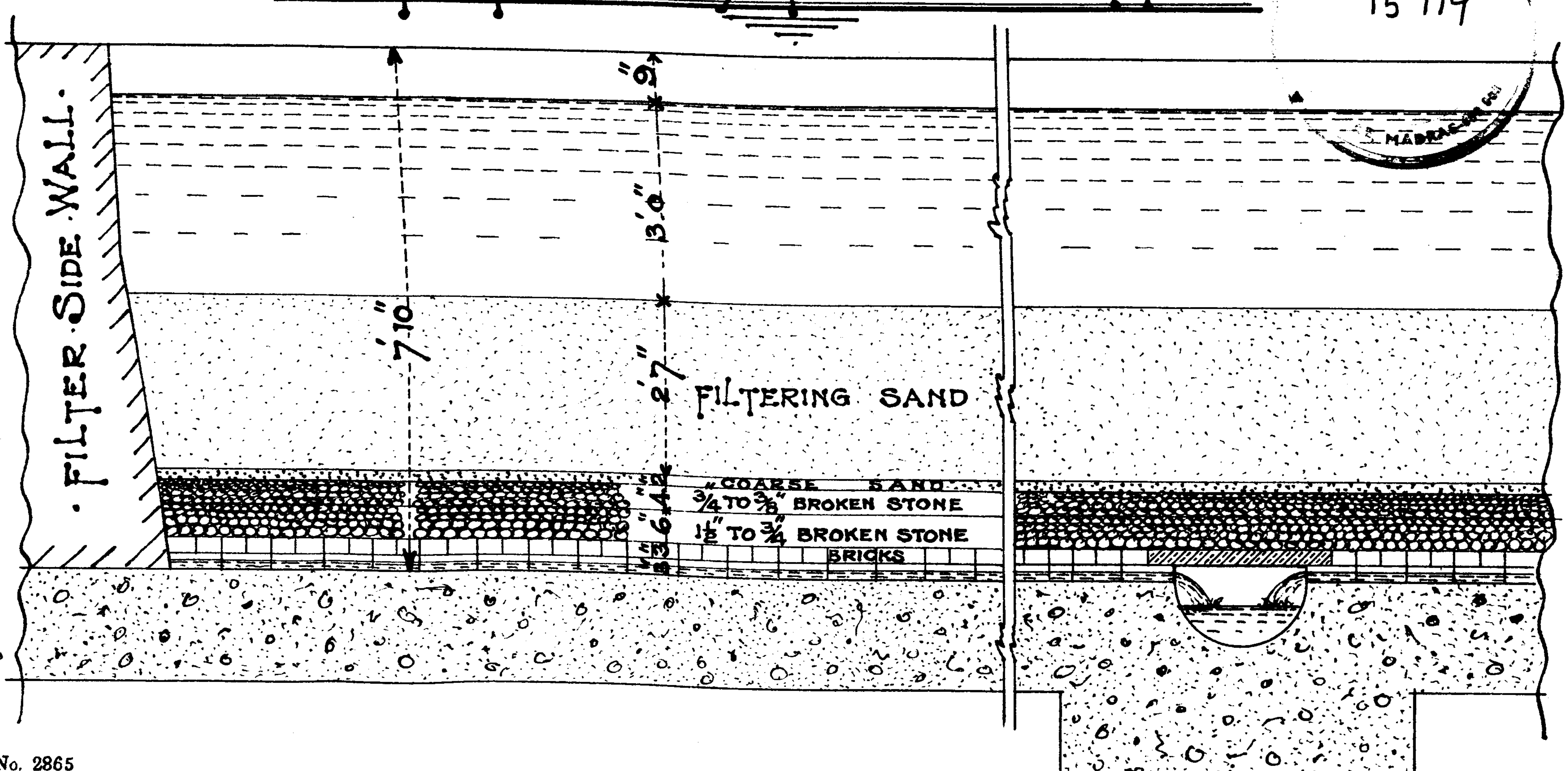
MADRAS · WATER · SUPPLY

SECTION · OF · FILTER · BED · SHOWING · FILTERING · MATERIAL · AS · PROPOSED · BY · THE · COMMITTEE

15719



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