SUPERINTENDING ENGINEER'S OFFICE,
5TH CIRCLE, MADRAS,
Chepauk, 8th March 1884.

No. 4207

From

THE SUPERINTENDING ENGINEER,
5TH CIRCLE,

To

THE Chief Engineer
S. D. D.

SIR,

Enclosures.

I have the honor to request that pro-
visional grant of Rs.
* Provincial Repairs Civil Buildings. = 2732 may be made
on account of Repairs to
the furniture &c in the
Government House at Guindy,
for the Viceroy's visit. The
work has been carried out
& paid the Private Secretary
to His Excellency the
Gover-

1/3/84

asks for the money for payment.

The Executive Engineer has not sufficient funds available.

The charges are for, Bills for repairing Chicks ..... Rs 1542.

Do. from Messrs Oakes & Co. for repairing halfpoots & Punkahs ..... " 612

Expenses of matting obtained from Calcutta for the department occupied by H. E. the Viceroy and Lady Ripon 578

Total 2732

I have the honor to be
Sir
Your Most Obed't Servant

Chittagong 30th April 84.

Superintending Engineer
Circle

No. 2148

From

THE SUPERINTENDING ENGINEER,

5TH CIRCLE,

To

THE Chief Engineer,
Public Works Department.

Dated 8th
Recd. 10 } March 1884.

ENCLOSURES.

No. 666 W. dy. March 11. 1884.

No. 4207.

Government House at Guindy.

Requests that an additional grant of Rs. 2732 may be made for repairing furniture &c. in the

No. 666W. PUBLIC WORKS DEPARTMENT.

PROCEEDINGS OF THE MADRAS GOVERNMENT.

UNDER date the March 11. 1884.

READ the following

From the S. Engr V Circle — Ltr No. 4207 d/8th Inst.

A further sum of Rs. 2732 is appropriated from the Provincial Reserve with Government for repairs to the Government House at Guindy.

C.W. 10/3/84

W. 11-3-84

S. Engr V Circle
Exp pw a
Private Secy to

Recd 11/3/84

dated 27th February +
Report on Bangalore
Water Supply ex
-pected end of March +
will be submitted
as soon after as
possible —

Telegram Rec'd 11. 3. 84

Cy.
11-3-84

11-3-84

No 666 W a/11-3-84
A

No 666 Wat. Mar: 11. 1884

No. 2794 W. 5:10.83
3454 W. 3.12.83

J.
The Mily Depte
"
"
12/3

Sub Secy Receipt Register

Fwd

No. 666 W
A

Proceedings of the Madras Government
under date the 11th March 1884

Read the following -

Letter from Government of India Military Department — } N E No. 272 C dd 27th Feby 1884 -

Endorsement thereon by the Military Departt. — } N. E No. 1166 dd 8th March 1884

Telegram from Coll I. Mullins - R. E. } NE dd 10th March 84

Ordered that the following reply be telegraphed to the Government of India.

To Military Calcutta -

Your letter 272 - C dated

TELEGRAMS OF CHARGE FOR INLAND TELEGRAMS.

The address (including name of sender, and name and residence of addressee) is transmitted free.

	First 8 words	Each additional word.
Deferred Message	... 8 Annas	... 1 Anna.
Ordinary "	... 1 Rupee	... Annas.
Urgent "	... 2 Rupees	... Annas.

A group of 3, or less figures, is reckoned as one word.

No charge for delivery within a distance of 5 miles.

No 2178

Rec 11/3/84.

No. 666 W dd 11-3-84
A

Class. DS. | INDIAN TELEGRAPH. | Local No. 9800

To (Station) Madras. | From (Station) Bangalore

Words.	Days.	Hour.	Minute.	Official Instructions.
18	10	15	47	

To (Person) Madras Works

From (Person) Col J. Mullins

1

2 report on Bangalore

3 water supply will

4 be ready by.

5 end of March

6

7

8

9

10

12

13

14

RECD. FROM L. N. | SENT TO L. N.

AT Hrs, Mts., By | AT Hrs. Mts., By

MADRAS 10-3-84

Telegraph Master.

S. P. No. 4000—G. T. Press,—No. 240,—25-6-83,—1000000.

Telegram to Col. J. Mullins. R.E.
Bangalore. ay 10th March/84

Report on Bangalore
Water Supply has been called for
by Government of India. Please
expedite. If not Complete, name
date for submission

(Signed) J. Stewart Col RE
Secy to Govt. P W D.

MILITARY (1884) DEPARTMENT.

No. 1107

From

THE GOVERNMENT OF INDIA,

No. 272C

Dated 27 Feb:/84

Recd. 4 March/84.

Registered

Former papers.

PG 15 Nov/83 & 840/841.
—— 5 Dec/83 - 11-13 A
—— 16 Dec/83 - 144-145 A

N.B.—THIS MATTER SHOULD TAKE PRECEDENCE OF EVERYTHING BUT *REALLY URGENT* BUSINESS OF OTHER KINDS—*VIDE* O.G. (MILITARY), No. 5385, Dated 9th OCTOBER 1882.
REQUESTED TO BE RETURNED WITH REPLY.

No. 1166

Referred to the Public Works Department for favor of the required report, with advertence

O.G. No. 2794 W. dt. 5 Oct/83.
—"— No. 3454 W. dt. 5 Dec/83.

} to the correspondence marginally cited.

(Byrden)

A Kennedy Herbert Lieut-Col.
Offg. Secy. to Govt.

Fort Saint George
8th March 1884.

ENCLOSURES.

P.G., No. , dated
No. 666 W dt 11-3-84
A

Requesting to be furnished with a brief report shewing what progress has been made up to date with the scheme for the improvement of the water supply at Bangalore.

Respd

progress has been made up to date with
the scheme for the improvement of the water
supply at Bangalore.

64 Rev 1
2156/84.

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

Captain,
Offg: Asstt: Secy: to the Govt of India

M. D. 18.
HEALTH

Sanitary
Reports & Returns.

No. 272 L.

GOVERNMENT OF INDIA,

MILITARY DEPARTMENT.

It is requested that the above heading, with number and date of this communication, may be quoted in any subsequent correspondence on the subject.

Fort William, the 27th February 1884.

To

THE SECRETARY TO THE GOVERNMENT OF MADRAS,
MILITARY DEPARTMENT.

SIR,

I am directed to acknowledge the receipt of the proceedings of the Government of Madras communicated under your docket No. 6525 dated 3rd December 1883, containing a report on the health of the British troops serving in the Madras command in 1882.

2. With reference to the remarks of the Surgeon General Her Majesty's Forces, Madras, in the last paragraph of his report under the heading of "water supply", I am to request that under the orders of the Governor in Council, the Government of India may be furnished with a brief report shewing what progress

GOVERNMENT OF MADRAS.

PUBLIC WORKS DEPARTMENT.

Buildings and Roads.
Military Works.

READ—the following papers:—

From Brigade-Surgeon G. BIDIE, M.B., C.I.E., Officiating Sanitary Commissioner for Madras, to the Chief Secretary to Government, dated Ootacamund, 5th May 1883, No. C-1.

Having learned that the water-supply of the cantonment of Bangalore was running short, I lately paid a visit to the station, so as to ascertain the actual state of affairs, and have now the honor to submit the following remarks on the subject to the Right Honorable the Governor in Council.

2. Being situated on the crest of the water-shed between the basins of the Arkavati and South Pennér rivers, the water-supply from local sources must always be limited, and more or less precarious, being entirely dependent on the rainfall * in the immediate neighbourhood of the station; and it is greatly to be regretted that a civil community has been gradually allowed to settle down in and around the cantonment in numbers much beyond the resources of the existing tanks and wells.

* About 36 inches per annum.

3. A still more deplorable fact is the imprudence which here, as elsewhere, has allowed followers and a civil population to house themselves in the valley above the principal tank of the station, so that its gathering grounds lie to a great extent in crowded native bazaars. In other words, by the neglect of our predecessors, the chief water-supply of the station is contaminated to such an extent that it is now necessary to maintain, at great expense, pumping machinery and filtering beds to render the fluid fit for the use of the troops.

4. The water-supply of Bangalore is got partly from tanks and partly from wells. The European garrison receives its supply from the Ulsoor tank and the Dhobies' wells close behind its *bund*, while native troops and the civil population draw water from three small reservoirs known as Miller's tanks and from various wells. Miller's tanks are situated in the same valley, but higher up than the Ulsoor tank. The wells in the bazaar are all of great depth, running down through a variable thickness of decayed gneissic strata to the live rock on the surface of which, in favorable sites, there is a limited and capricious percolation of potable water which frequently dries up in the hotter months of the year.

5. In addition to the above, a large impounding reservoir was recently constructed, at a cost of over five lakhs of rupees, in a valley near the 3rd milestone on the Bellary road. The gathering grounds of this tank consist chiefly of low rounded uncultivated hills covered largely with a tufted grass, an *Andropogon*, and are clean and all that could be desired. This scheme was to provide ten gallons of filtered water per diem to each person in a population of 90,000, but unfortunately it has never been completed, and is therefore practically useless.

6. As already stated, the gathering grounds of the Ulsoor reservoir consist largely of the inhabited area within cantonment limits; but, in addition to the water collected there, it formerly received supplies from the north side of Muntapum hill, an eminence some miles north of the station. These, it appears, have been, to some extent, diverted into the new tank referred to in the preceding paragraph, so that for some time they have been partly lost to Ulsoor and its sister tank, the Sampanjee, which used to receive any surplus flow and act as a safety valve to Ulsoor. At the same time, it further appears that, in the northern outskirts of Bangalore, the old channel leading from this distant collecting area to Ulsoor and Sampanjee has been interfered with in passing through private grounds, so that practically, by these measures, nearly all supplies from the north have been cut off from the station tanks.

7. At the time of my visit to Bangalore there was only a very small supply of water remaining in Miller's tank and in the various wells on which the native troops and the civil community chiefly depend. As regards the wells, the small quantity of water that accumulates in them during the night, when drawing is purposely stopped, is rapidly exhausted, and then numbers of people may be seen waiting till enough has again percolated to allow of its being scooped up with a special tin which they have invented for the purpose. In the Ulsoor tank, at the date of my visit, the average depth of the water was under five feet, representing a supply which ought to be sufficient till rain comes. In the present strait, however, in addition to the troops, large numbers of the civil population also draw water from the Ulsoor lake, so that its reduction, when we further take into account the great amount of evaporation, must, failing timely rain, be very rapid.

8. It will thus be seen that the civil population of the cantonment of Bangalore are now suffering greatly from a deficient and impure water-supply. Hitherto it appears to have been too much the custom to treat the matter as if the military and civil populations had conflicting interests in the water-supply; but, I am of opinion that, from a sanitary point of view, these must, as matters now stand, be regarded as identical. It is no doubt to be regretted that the civil population of the cantonment were allowed to outgrow the available water-supply and to pollute its sources, but the evils have been accomplished, and the most that we can now do is to mitigate their effects. An insufficient and bad water-supply must tell rapidly on the health of the civil population; and if they suffer from epidemic disease, we can hardly hope to restrict its ravages to the limits of the bazaar. Hitherto the station has been a fairly healthy one for troops, and it enjoys climatic and other advantages quite exceptional in the tropics, but we must face the possibility of a defective water-supply, rendering it, in course of time, untenable as a military position, if some remedy be not provided.

9. The arrangements made for the separation of sewage from storm-water in the channel leading to the Ulsoor tank from the cantonment bazaar are very ingenious and as efficient as practicable, and so are those in connection with the north tank or settling basin, but we cannot shut our eyes to the fact that this reservoir must always be liable to dangerous pollution. No doubt the supply of water formerly received from the north beyond cantonment limits and from clean gathering grounds tended to reduce this risk by dilution, and I am therefore disposed to regard the loss of the northern feeder as one of very serious consequence, not only with reference to pollution, but also with regard to possible failure of supply.

10. The lake itself is fairly conserved, but still there is room for improvement, as I observed a good deal of human ordure in the lower end of the cantonment bazaar channel and also in the upper tank or settling basin. On two occasions also, in a small inlet below the cantonment bazaar, I found people engaged in washing piles of dirty clothing and puckallies complacently filling their bags from the same source. On inquiry, I was told that this water was being collected for sale in the bazaar. Surely, when water is *so scarce* and *so precious*, a little more care might be exercised in its protection. The shallow margins of the tank are fringed with *Cyperus articulatus* (and two other species), *Panicum paludosum* (and two other species), *Jussidæ repens*, *Herpestes monniera*, *Polygonum glabrum*, *Marsilea quadrifolia*, &c. The body of the tank is now teeming with *Vallisneria spiralis*, *Potamogeton*, and *Hydrilla verticillatæ*; and

Pistiastratiotes and *Trapa bispinosa* have been introduced. These are all beneficial when kept within moderate bounds, and their presence seems to have almost entirely banished the objectionable *Confervöideæ*, once so plentiful. The waters are also tenanted by one or two species of *Carp*, several *Siluridæ* and an *Ophiocephalus*; and the *Gourami* has lately been introduced. In 1882-83, filtered water was supplied to the European troops from the tank and Dhobies' wells to the extent of 53,445 gallons per diem, at a cost of 1,796 gallons per rupee.

11. As regards the quality, the water has, under the order of the Surgeon-General, Her Majesty's Forces, been periodically analysed and declared potable on filtration. The pumping and filtering arrangements are all most carefully attended to by the Engineer in charge, Mr. Smith, and the instructions given in paragraph 4 of G.O., No. 3578, * of 13th July 1882, have been punctually carried out. I was therefore surprised to find that, notwithstanding such injunctions regarding the conservancy of the rock on which the filter bed and pumping machinery are located, a pathway was being constructed up the back of the declivity from near the boat-house. This is intended, I understand, to allow the people of the station to view the boat races from the summit of the rock, and, of course, there will be the usual refreshment arrangements and congregation of native servants. I have to recommend, therefore, that the pathway under construction be at once stopped, and that no one, except on business, be allowed to enter the enclosure containing the pumping and filtering apparatus. I am also of opinion that the boat-pier and boat-house are too near the feeding pipe of the filter bed. Indeed, I was told, on good authority, that both men and dogs sometimes bathe here, within a few feet of the great feeding pipe through which the water is raised from the lake. Clearly we should scrupulously avoid everything likely to impair the quality of the water, and exercise a most fastidious cleanliness in a matter of such vital importance.

* Military Department.

12. It now remains to say a few words regarding the future water-supply of the station. The demands on the existing tanks and wells are more likely to increase than diminish, while, on the other hand, their normal yield will doubtless be reduced by the withdrawal of the supply which used to be delivered at a high level by the channel coming in from the north, referred to in paragraph 6. Not only did this channel aid in feeding Miller's tanks and the Ulsoor lake, but also helped to keep up the supply in various wells in the lower parts of the cantonment. This, therefore, is a matter that requires early attention, although its remedy will only give partial and temporary relief. It is further most desirable that the works connected with the new tank on the Bellary road be completed as early as possible. This project, as already stated, was calculated to supply ten gallons of water per diem per head for a population of 90,000. It is possible that the yield may fall short of this estimate; but, on the other hand, if completed, it is apparently capable of delivering in the station a liberal supply of water of unexceptionable quality.

No. 890, Public

Transferred to Military Department, with the Hon'ble Colonel Sankey's demi-official note of 7th May.

OOTACAMUND,
7th May 1883.

(Signed) C. G. MASTER,
Chief Secretary.

No. 2641, Military.

Transferred to the Chief Engineer, Public Works Department, for favor of the necessary action.

OOTACAMUND,
8th May 1883.

(Signed) E. L. HANKIN, Colonel,
Secretary to Government.

Proceedings of Government, Military Department, dated 19th September 1883, No. 5092.

Read—the following letter from Brigadier-General R. C. STEWART, Quartermaster-General, to the Secretary to Government, Military Department, dated Ootacamund, 29th August 1883, No. 699 :—

The impurity of the Ulsoor tank as a source of water-supply to the troops at Bangalore has been realized by the Commander-in-Chief since his first visit to that station in December 1881, and the recent outbreak of enteric fever, of which there have been no less than forty-eight cases amongst the British troops between 1st January 1882 and 31st July 1883, of which eighteen have terminated fatally, seems to His Excellency to show that early measures should be adopted for remedying matters.

2. I am accordingly desired to forward, for submission to Government, the proceedings (A) of a special committee which assembled last year under the Commander-in-Chief's orders to report on the present source of supply, with a strong recommendation that early and earnest consideration may be given to the subject.

3. Sir Frederick Roberts is satisfied that the present supply is impure and dangerous to the health of troops and civil population, for it is impossible, in his opinion, that water taken from a reservoir, the gathering ground of a large part of one of the main feeders of which is covered by a dense bazaar, can be made safely drinkable.

4. The normal condition of the feeder referred to, and of the drains leading into it, is described in letter, copy attached (B), of a medical officer who recently inspected them, and so long as water liable to be thus contaminated is permitted to find its way into the tank, His Excellency the Commander-in-Chief feels sure that nothing will be gained by attempting to improve the supply from that source.

5. Sir Frederick Roberts has lately caused three different samples of the water distributed to the troops from the Ulsoor Tank to be analysed, as under :—

I. Water direct from the Ulsoor tank.
II. Water taken after passing through the filter bed.
III. Water taken from the Dhobies' wells.

The result of the analyses of these samples is that "all three contain a very large amount of organic impurity."

6. With reference to the above analyses, I am desired to remark that Sir Frederick Roberts has lately perused a paper in a scientific journal on this subject of analyses of water, from which it seems clear that, though organic impurities can, by analysis, be detected when present in water, science has not yet succeeded in demonstrating what portion of that organic matter is injurious to health.

7. For this purpose—to decide, in fact, as to the wholesomeness or otherwise of any particular water—it is necessary to be acquainted with the physical surroundings of its source, and no better proof of the dangerous quality of the Ulsoor tank water could, in His Excellency's opinion, be adduced than the personal experience of Dr. Waters, gained by his visit to the main feeder of the tank, the state of which is graphically illustrated in his report attached to this letter.

8. Government will observe, from the above-mentioned analyses, that one of the samples was taken after it had passed through the filter bed, and another from the Dhobies' wells. Both these samples were found to contain organic matter, and it would seem, therefore, that no amount of filtration can free water of impurity which may or may not be injurious to health in accordance with the condition of the source from whence the supply emanates.

9. It seems unnecessary to Sir Frederick Roberts to enter into discussion as to how a project for supplying the European garrison of Bangalore with water from so foul a source as the Ulsoor tank was ever originally contemplated or approved. What now concerns His Excellency is the best and most economical mode of supplying the troops with pure water, and in this he earnestly hopes to receive the support of Government.

10. The Government will perceive that in the proceedings of the committee which accompany this letter, and in the various reports which have been from time to time written on the Ulsoor water works, the matter is well nigh exhausted. None of the recommendations for the improvement of the water of the tank commend themselves to His Excellency, believing as he does that the only true course to pursue is to obtain water for the troops from another source.

11. The Commander-in-Chief thinks there are three courses open to the Government, which he now begs to submit :—

First.—To extend the scheme originated by Major-General Sankey, C.B., R.E., when Chief Engineer in Mysore, for supplying the town of Bangalore with water, and to apply it to the use of the garrison. It is understood that two or three lakhs of rupees have already been expended on this project. With what result His Excellency is not in a position to judge, but it seems to Sir Frederick Roberts that it is a work which, if successful, would be of such enormous benefit to the garrison that it is worthy of the closest examination and the most earnest consideration.

Second.—By the construction of a channel along the south margin of the tank into which the drainage of the town would be diverted and ultimately discharged alongside the waste weir.

Third.—To undertake the construction of a series of wells in the vicinity of the European barracks from which the garrison would be supplied with drinking water.

12. His Excellency would deprecate the assembly of any further committees, but he would advocate the appointment of a specially selected officer to confer with the Government of Mysore as to the possibility of elaborating Major-General Sankey's scheme, as well as of considering the other two propositions herein mentioned.

13. The second of these would commend itself to Sir Frederick Roberts, were it possible to divert the whole of the drainage of the town from the tank, but His Excellency very much fears that a large portion of the drainage from the polluted ground to the west and north-west would still find its way into the tank, and that this scheme would not have the effect of cleansing the water of all impurity.

14. The third proposal seems to Sir Frederick Roberts to hold out the best hope of affording to the garrison a satisfactory supply of drinking water, for the wells would be under regimental supervision and free from all possible contamination.

ENCLOSURE.

PROCEEDINGS of a Committee assembled at Bangalore on the 8th August 1882, *et seq.*, by order of Lieutenant-General W. PAYN, C.B., for the purpose of making replies to certain questions regarding the Ulsoor Military Water Works :—

President :

Lieutenant-Colonel W. H. BURTON, R.E.

Members :

Surgeon-Major WATERS, A.M.D.
Mr. SMITH, Engineer, Ulsoor Water Works.

The committee having assembled, pursuant to order, on the 8th instant, read the paper placed before it, viz., the memorandum marked "A," hereto annexed. On the 9th, 10th and 11th and 15th the committee again met and inspected the following localities and works connected with the Ulsoor water-supply :—The Ulsoor tank, cantonment bazaar supply channel, and bazaar street surface drains, the three Miller's tanks, Ooperhally village, Muntapum hill and gathering ground near the railway station. The tanneries, the Dhobies' wells, the Cavalry, Royal Artillery, and Royal Horse Artillery lines and wells mentioned in appendix "B":—

1. The committee find that, during the 12 months immediately preceding 1st August 1882, the quantity of water actually used (as stated by Mr. Smith) was as follows in column VIII, the strength of the garrison entitled to the use of the Ulsoor water during that time being as shown opposite each month, columns I—VI, the quantities and strength being the daily average of the months named :—

Period.	European. Officers and Men.	European. Women.	European. Children.	Native Followers.	Horses.	Average quantity required at 16 per man, woman and child, 12 per horse, 2 per Native follower.	Average quantity actually used daily.	Quantity unaccounted for, daily gallons.	
I	II	III	IV	V	VI	VII	VIII		IX
1881.							As stated by Mr. Smith.	Weather	
July	..	..	..	..	..	..	..	..	..
August	1,332	167	301	772	466	35,936	53,268	Dry ..	17,332
September	1,332	202	322	774	465	36,664	62,851	Dry ..	26,187
October	1,336	209	328	796	494	37,488	50,829	Wet ..	13,341
November	1,296	206	326	713	425	35,774	46,280	Dry ..	10,506
December	1,286	199	326	714	422	35,468	46,003	Dry ..	10,535
1882.									
January	1,291	200	330	714	419	35,592	41,536	Dry ..	5,944
February	972	144	279	404	232	25,912	55,750	Dry ..	29,838
March	1,104	154	283	404	232	28,248	53,955	Dry ..	25,707
April	1,856	164	310	718	774	48,004	57,601	Dry ..	9,597
May	1,870	169	310	718	778	48,356	54,126	Wet ..	5,770
June	1,860	166	303	718	772	47,964	60,849	Wet ..	12,885
July	1,869	164	301	717	769	48,006	48,516	Wet ..	510
						463,412	631,564	..	168,152
Daily average throughout the year ..						38,617	52,630	..	..
Unaccounted for, stolen or wasted daily ..						..	..	..	14,013

We wish to point out that, whilst the quantities in column VIII are the quantities noted in the records of the Ulsoor water works engine-house, they bear no relation either with the strength of the garrison or the season of the year against which they are noted. It is therefore doubtful if column IX really represents the quantity of water wasted or unnecessarily used. Again, it is purely a matter of opinion whether the quantities stated in column VII as "required," are less or more than sufficient for legitimate requirements of the troops. Still it is a matter of fact that we saw this expensively steam-pumped water running to waste through the horse foot bath in Royal Artillery lines, and evidences of its being used elsewhere also for irrigation purposes as well as by the inhabitants of the populous village called Grass-cutters' lines.

The increase of this village, which may be seen by a comparison of the maps of 1870, with its present area, is very rapid and must have a prejudicial effect on the proper water-supply of the troops.

2. If the horses were watered at the wells hereafter mentioned, and the 750 native followers entitled to water (the number of followers is from the present extent of the Grass-cutters' lines, &c., population of which probably approximates to 7,000) were only allowed to use well water, as is feasible, the quantity of Ulsoor water necessary would be under 30,000 gallons per diem and if annual strength of garrison be as it was last year. The details of these calculations are in appendix C.

Plan. Mounted Parade.

3. The existing wells in or near the lines are shown in appendix B.

Wells,* if provided with bullock ramps and watering troughs, will be suitable for the horses of I/3, R.A.—these are distant from the lines 600 yards: the wells No. 29^a and No. 28^b would similarly be sufficient for the horses Q/1, R.A., the lines of which are distant 610 and 860 yards, respectively; an encroachment at present exists round the well 29^a, which should, in any case, be removed at an early date: that well No. 29^b would similarly be sufficient for British cavalry horses, the stables of which are nearer to this well than to the existing Ulsoor water watering trough. It is very doubtful during which months in the dry season these wells would supply water, if constantly used as above, by the troop horses. There are no wells conveniently near which could be similarly used by Royal Horse Artillery, the nearest being 2,223, Dumboor tank, distant 1,600 yards.

* Nos. 25 and 26.

4. The only well actually "in the lines" which could be made use of is No. 29^b

viz., in the British cavalry lines. The Dhobies' wells water has been analysed by Surgeon Pedlow, A.M.D. This is clear, palatable, and of good quality and contains only a small amount of organic matter which could, in a great measure, be accounted for by surface washings running into the wells direct from the surface of ground.

5. Owing to these wells not being in constant use, the water being stagnant, a fair sample, for analysis could not be obtained; but we have reason to believe it is of good quality.

6. The existing quantities now in each of these wells is shown in appendix B, column of remarks.

7. On account of these wells being pumped under varying conditions and circumstances and at uncertain periods, it is not possible to give reliable and useful answers to this question. The quantity tested by us on the 9th, 10th, 11th August 1882, averaged 18,300 gallons daily.

8. The Dhobies' wells were last thoroughly cleansed of all silt, &c., in November 1876. From the wells being constantly pumped dry, viz., on three or four days a week, the height of water in them is a variable one. The wells having been constantly pumped for seven years last past, it is impossible to say how high the water will stand if not pumped in wet or dry season. The yield is greatly affected by height of water in tank and the local rainfall. The wells would dry three or four weeks before the tank dried.

9. It is desirable to surround each well with a 12-inch parapet wall to prevent contamination by surface washings.

10. About 32,000 gallons per diem can be filtered artificially at the Dhobies' wells filter. During the last six months ending 31st July 1882, the supply from the Dhobies' wells has been almost daily supplemented by means of this filter; it is more convenient to use this filter in preference to the rock filter on account of economy of fuel.

11. The water in the Dhobies' wells filter has been analysed by Surgeons Pedlow and McLaughlin, A.M.D. The water is clear after filteration and no traces of nitric or nitrous acids are shown by the ordinary tests, and only a small quantity of chlorine and oxidisable organic matter.

It is usable at present after filtration, but its composition varies, the organic matters being now in a state of extreme dilution in the tank in consequence of the late rains.

12. If the Government would acquire the plot of municipal land near the road marked B,

Vide plan II, shown in yellow.

there would be ample room in the laterite bed for five new wells which, together with the three existing ones in this plot and with three new wells which might usefully be added to the system in the Government tope adjacent, there is reasonable hope of adding 6,000 gallons per diem to the supply; but this would not suffice for the use of the garrison.

13. The bed of laterite within and without the Government land is insufficient to supply, by means of wells, the total quantity required for the daily use of the troops.

But if, in lieu of sinking more wells in this laterite, a longitudinal tank or cistern were constructed (as shown in plan II attached), its inner side made of dry stone walling, and its outer side of stone in lime mortar and cement plastered, there is every reason to believe, from the nature of the soil and surrounding circumstances, that a largely increased supply of laterite filtered water over and above what new wells would supply, will be obtained after the municipal tract of ground (B) has been acquired by Government. We would strongly recommend this in preference to sinking any more wells.

It is to be considered that the cistern will not only yield an additional supply of water over and above what a few wells could give, but it could be extended, as shown in dotted lines, so as to enclose the whole of the laterite bed, when enough laterite filtered water would, in all probability, be obtained, sufficient in fact to supply the whole garrison.

14. Eight wells and the necessary underground galleries or channels between them, will cost about Rs. 3,000. The, in our opinion, more effective cistern method would cost about Rs. 4,000, viz., if built on plot B only.

15. The Engineer's establishment, which works the steam machinery and supervises the distribution of the water in barracks, cost Rs. 537 per mensem.

The cost of fuel, all wood, for the twelve months ending 31st July 1882, was Rs. 3,463.

16. The quantities range between 30 to 35,000 gallons per diem.

17. In order to keep as much of the surface filth of the catchment basin as possible out of the tank, it will be necessary and practicable to—

(*a*) Surround the tanneries by an open ditch and bank, the ditch inside the bank, and made so as to discharge its contents into an underground masonry sewer to below the tank at a cost approximating to Rs. 25,000.

Large plan.

(*b*) Surround the Muhammadan burial ground N.N.W. of the railway station by the completion of existing bund and ditch, to ensure, by military inspection (viz., by means of a sanitary inspector acting under the orders of the Lieutenant-General), that all burials in it and other adjacent burial grounds, take place six feet below

the surface as well as to prevent bazaar sweepings being deposited, as is now the case, anywhere within the catchment basin.

(*c*) Stop all the drain holes in the side walls of the main or paved feeding channel; this will prevent the greater part of the sweepings and filth of the adjacent side streets from passing directly into the channel, as is now the case, and to cause the channel to be daily cleaned.

To cut off the whole of the streets, bazaars, &c., of the cantonment bazaar and sites of houses of European population by an intercepting storm-water channel will too much reduce the natural or legitimate drainage area of the Ulsoor tank, which has already been considerably diminished (without the contemplated beneficial result to the garrison anticipated at the time) by the Bangalore new water works and by the raising of the weir of the lower Miller's tank one foot.

The reduction of legitimate drainage area here alluded to is indicated on the map hatched and tinted blue.

This reduction is the more to be regretted by the military authorities, as the gathering ground taken thereby from the Ulsoor tank was the only gathering ground it had, which was untainted by any impurity.

A perusal of appendix C, an extract from the memorandum of the Chief Engineer, dated 9th September 1868, on Mr. Humphrey's project, will show that it was the intention to fully supply the garrison with water from this tank upon its completion: this may now be said to be found impossible, and, therefore, we are of opinion that the drainage area thus taken from the Ulsoor tank should be restored to it, more especially as it is the supposed intention of the Mysore Government to divert the water of this tract from Mr. Humphrey's to the Damanbaddy or Petta tank.

(*d*) The parapet walls of the paved channel in many parts are too low to prevent filth and surface washings of the adjacent roads being swept, &c., into it.

(*e*) Two silting traps are very necessary, one at the end of the west feeder (paved channel) and one at the end of the south feeder.

(*f*) If the silt trap, proposed for safeguarding the tank from impurities coming into it by the south feeder, is made, the angle of the tank can thereby be cut off by a bund and waste weir built over the existing filth channel: this filth channel will then be wholly without the tank, and this bund would obviate any engineering difficulty of rebuilding the filth channel outside the tank.

(*g*) We think the sanitary supervision of the cantonment bazaar is conducted without due regard to the purity of the water in the Ulsoor tank. Some of the feeding channels are publicly resorted to by the natives and used as latrines; filth of all description is frequently seen in them, and, during the rainfall, washed into the tank even in the main or paved channel; old cloths, dead animals, human excreta, and filth of all description are to be seen at all times, except, of course, immediately after the heavy rain-storm.

18. The completion of a suitable paling round the lower tank and a cactus or aloe hedge round the upper tank, will be both practicable and very essential in order to preserve the water and beds of the tanks from constant direct contamination in all seasons; convenient arrangements, at certain places, being, at the same time, made to enable the native population to freely draw water into their hand vessels. Such places to be flagged and approached by a flight of steps and always kept in a proper sanitary state.

		GALLONS.
19. (*a*) The Agram or Cavalry cistern should contain		280,000
(*b*) The Ulsoor or R.H.A. do.		179,000
(*c*) The parade or B. Infantry do.		112,500
(*d*) The hospital iron cistern do.		11,495

But the Agram cistern will now contain only 184,000 gallons, and the Ulsoor only 148,000 gallons, both owing to constructive errors.

The parade and hospital cisterns contain their proper quantities respectively.

(Signed) W. H. BURTON, Lieut.-Col., R.E., President.
(„) R. WATERS, M.D., Surgeon-Major, A.M.D., } Members.
(„) J. SMITH, Engineer in Charge, "Ulsoor Water Works." }

CHEPAUK,
31st August 1882.

No. 430.

BANGALORE,
29th September 1882.

(Signed) W. PAYN, Lieut.-General, Commanding Bangalore Division.

APPENDIX "A."

Ulsoor Tank Water-supply.

What quantity of water is required daily for the troops at Bangalore, who are supplied with water from the Ulsoor tank?

2. What quantity would suffice, supposing that water was supplied to human beings only, and that horses and other animals were watered from other sources?

3. What other sources are there, and that what distance from the several lines?

4. Are there any wells in the lines which receive water from the Ulsoor tank which could be made use of to assist the supply?

5. Has the water in the wells been analysed and with what results?

6. What quantity of water could be drawn from them daily on an average?

7. What quantity of water can the Dhobies' wells supply on an average throughout the year, without any assistance from the water in the filter tank near them?

8. Have the Dhobies' wells ever been pumped out, deepened and thoroughly cleaned? If so, give the last date. At what height does the water stand in the wells in the dry and in the rainy season, and does the height correspond with the height of the water in the tank? When the tank is dry or low, do the Dhobies' wells continue to yield a fair supply of water?

9. Is it not desirable on sanitary grounds to have each of the Dhobies' wells surrounded by a low parapet wall to prevent contamination by surface washings, and to have the covers ventilated?

10. What quantity of water can the filter tank supply, and how often during the last six months has it been found necessary to resort to it to supplement the supply drawn from the Dhobies' wells?

11. Has the water in the filter tank been analysed, by whom, and with what result?

12. If the wells in the municipal tract of ground immediately adjoining the Dhobies' wells belonging to Government were made over for the use of the station, would the total quantity of water then available suffice for the use of the garrison?

13. If not, how many more wells would be required, and could room be found for them in proper soil, where the Dhobies' wells now are, or in the municipal tract of ground immediately adjoining?

14. What would be the approximate cost of sinking the number of wells required?

15. What is the cost to Government of the establishment now employed in arranging for the water-supply, and what is the average annual expenditure of fuel?

16. What amount of water is drawn on an average from the Ulsoor tank to supplement the supply from the Dhobies' wells?

17. As the impurity of the water in the Ulsoor tank is chiefly due to surface filth of every description being washed into the tank during the rains, could the tank be supplied from higher tanks or higher ground than is the case to a considerable extent at present, and the surface filth and washings of the streets, bazaars, &c., intercepted by a circular storm water channel?

18. Is there any engineering difficulty in carrying the filth channel outside the tank instead of under it as at present?

19. Would it be practicable to have the tank completely surrounded by a low wall or suitable paling, in order to preserve the water from contamination by natives directly resorting to it, and to make convenient places on a lower level with delivery taps? These places to be flagged and approached by a flight of steps.

20. What amount of water in gallons can be stored in the several reservoirs in the lines, and are these all water-tight?

(Signed) W. H. BURTON, Lieut.-Colonel, R.E., President.

31st August 1882.

APPENDIX B.

LIST of Military Wells which can assist the Water-supply from Ulsoor Tank throughout the Year.

No. of military wells marked on map.	Situation of well.	Distance from Royal Horse Artillery stables as walked by horses.	Distance from Cavalry stables as walked by horses.	Distance from 2/1st Royal Artillery stables as walked by horses.	Distance from Q/3rd stables as walked by horses.	Diameter of well.	Total depth from surface of ground.	Depth of water in hot weather.	Depth of water, 9th August 1882.	Quantity of water now in the wells.	Remarks.
I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
		YDS.	YDS.	YDS.	YDS.	FEET.	FEET.	FEET.	FEET.	C. FT.	GALLONS.
1	Cavalry barracks, family quarters ..	..	600	..	..	..	..	..	..	..	
2a	Lime-kiln, south of	..	1,760	1,500	1,260	12	33	Not	16	1,809	
2b	Agram hospital ..	..	1,760	1,500	1,260	$6\frac{1}{2} \times 5\frac{1}{2}$	$24\frac{1}{2}$	known. Do.	$7\frac{1}{2}$	268	
3a			2,050	1,780	1,550	$4\frac{1}{2}$	$15\frac{1}{2}$	Do.	11	174	
3b			2,050	1,780	1,550	$4\frac{1}{2}$	$15\frac{1}{2}$	Do.	11	174	
3c			2,050	1,780	1,550	$4\frac{1}{2}$	$15\frac{1}{2}$	Do.	11	174	
22	Dumloor tank, west	1,600	2,290	2,020	1,790	12	16	Do.	13	1,470	$9,187\frac{1}{2}$
22d	margin.		2,200	1,900	1,700	12	18	Do.	16	1,809	
23			2,130	1,860	1,630	12	31	Do.	$24\frac{1}{2}$	2,770	$17,312\frac{1}{2}$
24	Gopaul Moodellier's chattram near Dumloor tank ..	..	2,230	1,960	1,730	$9\frac{1}{2}$	23	Do.	$18\frac{1}{2}$	1,311	
25	East of road on Lower Agram road,	..	1,200	930	600	12	25	Do.	20	2,261	$14,131\frac{1}{4}$
26	south of Agram barracks ..	..	1,200	930	600	12	34	Do.	28	3,166	$19,787\frac{1}{2}$
27	Slaughter-house, in-	..	1,260	1,000	760	4	$13\frac{1}{2}$	Do.	$9\frac{1}{2}$	1,193	
28a	side	..	1,260	930	700	4	$13\frac{1}{2}$	Do.	$9\frac{1}{2}$	1,193	
28b	Do. outside ..	..	1,130	860	600	12	23	Do.	16	1,809	$11,306\frac{1}{2}$
29a	Near Dhobies' village behind the Cavalry followers' lines near Neelasundrum road	..	880	610	380	12	29	Do.	9	1,017	$6,356\frac{1}{4}$
29b	Between Cavalry stables and Cavalry forge	..	..	..	..	12	46	6	$7\frac{1}{2}$	1,979	$2,368\frac{3}{4}$
10	South-west corner of Ulsoor tank ..	For British Infantry, 400 yards from single men's barracks.				$9\frac{1}{2}$	25	1 to 2	3	212	
11	Do. ..					13	23	Do.	IN. 6	796	
12	Do. ..					14	19	Do.	FEET. 3	461	
13	Do. ..					15	19	Do.	3	530	

CHEPAUK,
31st August 1882.

(Signed) W. H. BURTON, Lieut.-Colonel, R.E.,
President.

APPENDIX C.

Period.	Europeans. Men.	Women.	Children × 16.	Natives × 2.	Gallons.	Horses × 12.	Gallons.	Grand Total.
I	II	III	IV	V	VI	VII	VIII	IX
1881.								
August	1,332	167	301	772	..	466	..	..
			1,800					
	Gallons ..		28,800	..	1,544	..	5,592	35,936
September	1,322	202	322	774	..	465	..	..
			1,846					
	Gallons ..		29,536	..	1,548	..	5,580	36,664
October	1,336	209	328	796	..	494	..	..
			1,873					
	Gallons ..		29,968	..	1,592	..	5,928	37,488
November	1,296	206	326	713	..	425	..	..
			1,828					
	Gallons ..		29,248	..	1,426	..	5,100	35,774
December	1,286	199	326	714	..	422	..	..
			1,811					
1882.	Gallons ..		28,976	..	1,428	..	5,064	35,468
January	1,291	200	330	714	..	419	..	..
			1,821					
	Gallons ..		29,136	..	1,428	..	5,028	35,592
February	972	144	279	404	..	232	..	..
			1,395					
	Gallons ..		22,320	..	808	..	2,784	25,912
March	1,104	154	283	404	..	232	..	..
			1,541					
	Gallons ..		24,656	..	808	..	2,784	28,248
April	1,856	164	310	718	..	774	..	..
			2,330					
	Gallons ..		37,280	..	1,436	..	9,288	48,004
May	1,870	169	310	718	..	778	..	..
			2,349					
	Gallons ..		37,584	..	1,436	..	9,336	48,356
June	1,860	166	303	718	..	772	..	..
			2,329					
	Gallons ..		37,264	..	1,436	..	9,264	47,964
July	1,869	164	301	717	..	769	..	..
			2,334					
	Gallons ..		37,344	..	1,434	..	9,228	48,006

CHEPAUK,
31st August 1882.

(Signed) W. H. BURTON, Lieut.-Colonel, R.E.,
President.

APPENDIX D.

Extract from Chief Engineer's memorandum on Mr. Humphreys' project for Bangalore Water-supply, dated 9th September 1868.

* * * * *

56. The President of the Board does not consider the census of 1863 to be reliable, and probably it is not so; but that of 1862, to any one acquainted with Bangalore, exaggerates the population absurdly.

57. My own opinion is that, including European troops, followers, &c., the total will not be found to exeed 80,000 in all.

58. It will never in any case be necessary to provide a water-supply for the whole of the residents at the station, as even now along the lowest points of the several drainage lines, and below the different reservoirs, well water is always obtainable by the inhabitants in the immediate neighbourhood, and the facilities in this respect will be very much increased the moment a sufficient supply is brought in, for the use of the residents on the upper grounds. Nothing can perhaps exceed the purity of the well water below the Ulsoor, Shoolay and Sumpenjee tanks, and consequently, taking all the circumstances into consideration, we may fairly strike 20,000 out of the above enumeration, leaving 60,000 who may now be said absolutely to require an extraneous supply, and who will at least be able to pay a small cess for having it brought within their reach.

Number of souls to be provided for.

59. To meet all reasonable demands of the future, it will, I think, be sufficient if we add 50 per cent. to the above, and say that the scheme shall provide 10 gallons of filtered water per diem for a population of 90,000 souls. This Mr. Humphreys' project will do.

* * * * *

Arrangement of the delivery mains.

69. A glance at the topographical features of the ground will at once show that the general parade ground occupies a distinct ridge, with population on either side of it, while Mootcherry and St. John's Hill lie along high ground to the north. To command, therefore, all the ground, as also to pass on supplies, if necessary, to the new Cavalry barracks and Artillery, and further allow the Sumpenjee, Shoolay and Ulsoor tanks to pick up all the tail or waste weir (which, if desired, may be employed for flooding the parade grounds occasionally or upon any other useful object), two distinct sets of iron mains will be needed (one along each of the ridges above mentioned), and from these delivery may take place in any way deemed most suitable hereafter. As the water flowing simply by gravitation will be delivered at a summit level of 80 feet above the waste weir of Ulsoor tank, it will easily command all the ground mentioned, leaving only a very few residents on the "High Ground" unprovided for. Any slight lift by pumping would give even these an ample supply.

* * * * *

74. Had the Ulsoor water-works, now being carried out, not been commenced, it would have been a simple corollary to the above proposition that the Madras Government should bear a proportion of prime cost for the benefit of the European and Native troops and followers; and even now it is much to be hoped that, in case the scheme now working out does not prove as successful as was originally anticipated, some joint action on that which I venture to put forward may yet be found practicable.

* * * * *

From Surgeon-Major R. WATERS, A.M.D., Senior Medical Officer, North Station Hospital, to the Deputy Surgeon-General, Her Majesty's Forces, dated Bangalore, 8th August 1883, No. 447-83.

Amongst the causes which contribute to the pollution of the water-supply at this station, I desire to bring to your notice the foul condition of the main channel or principal feeder of the Ulsoor tank, from which is derived, in conjunction which the Dhobies' wells, all the water used by the British troops.

2. This main channel, about 30 feet wide, runs through the bazaars and receives the surface water therefrom, the overflow of the tanks on the higher ground, and the water from the collecting grounds beyond; it is flagged throughout, and has a wall on each side, so that there need not be the slightest difficulty in keeping it clean. But to all appearances there has been no attempt made in respect to its cleanliness. Yesterday I examined it carefully and found the bottom of the channel covered with accumulation of filth of every description, putrid mud, human hair (thrown in by the barbers who sit and carry on their trade at the side of the

channel), dead animals, baskets, chatties, old shoes, hats, straw, rags, vegetable debris, and refuse of every description; whilst throughout, from end to end, I found excreta of men, horses, cattle and goats. I also found the top of the walls covered in numerous places with human excreta; the channel being used as a latrine, the people sitting, for this purpose, on the low parapet walls. The roads alongside the channel are almost equally polluted, excrement and filth being deposited there and washed through the openings in the walls into the channel on the occurrence of rain.

3. On the floor of this channel, at its very commencement, at the end next the Ulsoor tank, I found yesterday within the space of a few yards sixteen deposits of fresh human excrement; one had a close resemblance to the pea-soupy character of enteric fever excreta.

4. The channel is perpetually polluted, and the filth is washed into the tank on the occurrence of every shower. I have repeatedly examined it and walked from end to end as I did yesterday, and never found it otherwise than in the condition above described.

5. As respects the Ulsoor tank itself, the same foul practices continue that were formerly reported. Yesterday I saw it used for *bathing* and ablution purposes, for watering and washing horses and cattle, washing of clothing, &c. I also saw during the short time I was there twelve men *bathing* in it, and others without number performing their ablutions with all their attendant filthy practices; of these latter, I saw one urinating at the edge of the water, and on a former occasion I saw a man urinating whilst standing up to his knees in the water washing himself.

6. I wish to bring this to your notice, as such a condition of the main channel and tank is not only horrible and repulsive, but is attended with great danger to the lives of the troops.

From W. S. MURRAY, Esq., Deputy Surgeon-General, Her Majesty's Force, Bangalore Division, to the Assistant Quartermaster-General, Bangalore Division, dated 8th August 1883, No. 1043.

Forwarded for submission to the Lieutenant-General Commanding.

I am able from my own observations to corroborate the general statements brought forward by Surgeon-Major Waters, and consider it of essential consequence to the health of the troops that effectual steps should be taken to obviate the evil conditions represented.

P.S.—Requests favor of information as to the result of steps taken.

Order—dated 19th September 1883, No. 5092, Military.

The Right Honorable the Governor in Council entirely concurs in opinion with His Excellency the Commander-in-Chief that the question of the water-supply to the troops at Bangalore imperatively demands immediate and most careful consideration and the earliest possible action, in view either to the removal of the causes that now so largely contribute to the contamination of the water of the Ulsoor tank, or to the adoption of such other measures as may be deemed desirable for securing an adequate supply of pure drinking water to the troops at Bangalore.

2. The question is, however, essentially a professional one, and will be referred for early consideration in the Public Works Department, in continuation of Military Department No. 2641, dated 8th May 1883, with the suggestion that a specially selected officer be deputed to the duty indicated in paragraph 12 of the Quartermaster-General's letter; as also to consider and report, without avoidable delay, which of the measures proposed by His Excellency the Commander-in-Chief in paragraph 10 affords the greatest promise of securing the object in view.

3. The necessary further orders will then be issued in the Public Works Department.

(True Extract.)

(Signed) E. L. HANKIN, Colonel,
Secretary to Government.

Memorandum on the Water-Supply of Bangalore.

The importance of this question has of late forced itself so much on public attention, that several schemes have been put forward for meeting the admitted want of an adequate water-supply for this large and rapidly expanding community. The

APPENDIX D.

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Number of souls to be provided for.

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69. A glance at the topographical features of the ground will at once show that the general parade ground occupies a distinct ridge, with population on either side of it, while Mootcherry and St. John's Hill lie along high ground to the north. To command, therefore, all the ground, as also to pass on supplies, if necessary, to the new Cavalry barracks and Artillery, and further allow the Sumpenjee, Shoolay and Ulsoor tanks to pick up all the tail or waste weir (which, if desired, may be employed for flooding the parade grounds occasionally or upon any other useful object), two distinct sets of iron mains will be needed (one along each of the ridges above mentioned), and from these delivery may take place in any way deemed most suitable hereafter. As the water flowing simply by gravitation will be delivered at a summit level of 80 feet above the waste weir of Ulsoor tank, it will easily command all the ground mentioned, leaving only a very few residents on the "High Ground" unprovided for. Any slight lift by pumping would give even these an ample supply.

Arrangement of the delivery mains.

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Order—dated 19th September 1883, No. 5092, Military.

The Right Honorable the Governor in Council entirely concurs in opinion with His Excellency the Commander-in-Chief that the question of the water-supply to the troops at Bangalore imperatively demands immediate and most careful consideration and the earliest possible action, in view either to the removal of the causes that now so largely contribute to the contamination of the water of the Ulsoor tank, or to the adoption of such other measures as may be deemed desirable for securing an adequate supply of pure drinking water to the troops at Bangalore.

2. The question is, however, essentially a professional one, and will be referred for early consideration in the Public Works Department, in continuation of Military Department No. 2641, dated 8th May 1883, with the suggestion that a specially selected officer be deputed to the duty indicated in paragraph 12 of the Quartermaster-General's letter; as also to consider and report, without avoidable delay, which of the measures proposed by His Excellency the Commander-in-Chief in paragraph 10 affords the greatest promise of securing the object in view.

3. The necessary further orders will then be issued in the Public Works Department.

(True Extract.)

(Signed) E. L. HANKIN, Colonel,
Secretary to Government.

Memorandum on the Water-Supply of Bangalore.

The importance of this question has of late forced itself so much on public attention, that several schemes have been put forward for meeting the admitted want of an adequate water-supply for this large and rapidly expanding community. The

most direct and comprehensive of these proposals is one entered in the Department Public Works budget of the current official year, which (long delayed for want of proper establishment) is now being elaborated by Mr. H. T. Humphreys, C.E.

2. Before, however, describing generally the scope of the project, it appears desirable to note the past and present condition of the water-supply with the opinions of those who have taken the greatest interest in the question.

Distribution of drainage.

3. From the Muntapum hill, which is the highest point in the immediate neighbourhood of Bangalore (and elevated 3,107 feet above sea level), diverge the two drainage areas, along which the densest portion of the population has grown, viz. (1) the Ulsoor catchment-basin, and (2) that, at the head of which, stands the Durmamboody tank (which forms the main water-supply of the old pettah of Bangalore). The first of these leads off naturally south-east-wards to the Pennér river; and the second would, on the other hand, have led to the Arkavutti in a south-westerly direction, but for the catch-channel supplying the Durmamboody tank, diverting the water back into the Pennér basin.

Pettah supply excluded.

4. As the old pettah does not appear to have increased very much, particularly of late years, and as its water-supply is generally considered to meet its requirements, the subject need only be incidentally considered. The main question, therefore, is more directly connected with the Ulsoor valley, and the two subsidiary ones of Shoolay and Sumpenjee, the drainage of which eventually joins it.

5. A glance at the map of Bangalore will show better the general distribution of the population than any description. The cantonment bazaar being the chief centre of population, Ulsoor and Shoolay are the next, while the mass of the well-to-do military and civil communities is scattered over all the elevated portions excepting those reserved for the parade grounds of the European and native troops.

Earliest existing tanks.

6. When the station was first formed in 1810 (it had apparently no existence before British occupation, all prior to that of any importance being confined to the pettah and fort) the Ulsoor, Sumpenjee and Shoolay tanks were, it is understood, the only reservoirs in existence. The remains of a few old ponds or "cuttays" higher up the valleys show that some of these minor works existed previously (especially in the Bederhully valley), but they were probably of little use, and chiefly intended for cattle. Below these three tanks were, and are to this day, several others, such as the Coramungul, Sonakul, Dumaloor, &c., but as all population here has the tendency of spreading up, not down, the several drainages, there is no practical use in taking these lower reservoirs into account with reference to the immediate subject in hand.

7. It may be as well here to note that apparently from prescriptive usage, the waters of the Ulsoor and Sumpenjee tanks have all along been considered as exclusively appropriated for the use of the garrison, and to this end, the irrigation sluices belonging to each were long ago closed. All cultivation under these tanks has hitherto been from wells. At the present day it is difficult to understand the reasons for the Sumpenjee tank having been devoted entirely for military purposes, as it never has been, nor indeed could be, used by the garrison.

8. In early days the old Sumpenjee supply channel, which diverts much of the water that would otherwise flow down from the Muntapum hill by both feeders of the Ulsoor tank, was looked upon as the great * safeguard of that reservoir. In fact the Resident, Mr. A. Cole, in 1814, expressed his fears that the breaching of the channel bank would be likely to destroy the "bank of the Ulsoor tank." Clearly, therefore, at this time Bangalore had more water at command than it altogether liked.

* It is impossible now to say when the main Sumpenjee catch-channel, north of the Muntapum hill, was constructed; but by General Wetherall's letter in reply to Mr. A. Cole, dated 25th August 1814, it seems that the southern bifurcation of the channel, which drains the southern side of the Muntapum hill, was completed in 1809. The extension of irrigation under the Sumpenjee tank appears to have been the origin of both channels; and probably it was only afterwards (as the cantonment bazaar began to rise and encroach on the west corner of the Ulsoor tank) that its use as a safeguard to the tank and town was discovered.

Miller's tank.

9. A change with the growth of population gradually took place; and in 1854 Captain (now Colonel) Miller, Commissary and Superintendent of Police, undertook, first at his own cost, the construction of the tank at the head of the cantonment bazaar which still most appropriately bears his name. The Commissioner, Sir Mark Cubbon, afterwards approving of the work, paid for it from the public funds. This, it is believed, was the first effort to meet the growing wants of the place; and the work has proved itself to be one of the many benefits conferred on the community by the above-named active and philanthropic officer.

Water-supply for the new cavalry barracks.

10. The next occasion on which the question of water-supply appears to have attracted serious attention was in connection with the new cavalry barracks on the old race-course in 1859, and Captains Wilkieson and Mayne, of the Royal Engineers, jointly reported* that for the object directly in view, a store of water could be maintained in six wells, 40 feet deep and 25 feet in diameter, sufficient for 2,000 souls at five gallons each per diem; but that the means of maintaining the supply (which, however, they had not investigated) would cost a large sum.

Sir Arthur Cotton's objection.

11. Sir Arthur Cotton being called on for his opinion by the Madras Government reported, in his No. 320 of the 9th August 1859, that he was unable to concur with the Commissioner's (Sir Mark Cubbon's) suggestion that the supply for the proposed wells should be pumped up from the Ulsoor tank. His objections were: "1st., the insuperable one, that this tank receives the drainage from a large portion of the cantonment, containing a considerable town, which must render the water unfit for use; 2nd., the great expense of constantly pumping from such a depth."

12. He argued that the general supply of water for the cantonment should be considered, and that the levels would admit of water being led in from the direction of Nandidroog (31 miles north).

His first proposals.

13. Colonel Cotton's calculation was as follows:—"For 100,000 people at 20 gallons a day, the quantity would be $4\frac{1}{2}$ million of cubic yards, and taking the rainfall at 36 inches, and the quantity flowing off at $\frac{2}{3}$ of that, or 2 feet, one square-mile of ground would provide 2 millions of cubic yards, or $4\frac{1}{2}$ millions would be provided by $2\frac{1}{2}$ square miles; and allowing 50 per cent. additional for loss by evaporation, &c., $3\frac{1}{2}$ square miles would supply sufficient." He added also a calculation for flooding 1,000 acres of garden land in the cantonment, which would raise the area whose drainage should be stored to $7\frac{1}{2}$ square miles.

14. The general plan proposed was to run two small parallel banks on each side of the ridge between the cantonment and Nandidroog, half a mile apart for a length of 15 miles and terminating in a cross bund uniting the two, and so forming the tank, the whole cost being roughly estimated at Rs. 25,000. The scheme was to yield large annual returns: first in saving of the carriage of water as at present, and second in irrigating the compounds and other lands.

15. Captain (now Major) Puckle, at that time Executive Engineer, Bangalore division, was placed at Colonel Cotton's disposal for conducting the requisite surveys, &c., and Colonel Green (the then Chief Engineer) in conveying instructions on the subject † observed that Sir Mark Cubbon was prepared to increase the capacity of Miller's tank in connection with the project for constructing a sewer which was to carry off the cantonment bazaar drainage and prevent its contaminating the Ulsoor tank.

Colonel Green's explanation of several projects.

16. This increase of Miller's tank (which was 63 feet above Ulsoor) Colonel Green considered essential in connection with the drainage project, at the same time that it would be necessary to keep up the supply of the Ulsoor tank by a feeding

* 14th May 1859.
† Letter No 1155 of 4th October 1859.

channel to the eastward. Colonel Cotton's project, he explained, was (as he understood it) to construct a reservoir at a level intermediately between the two above mentioned, so as to command the barracks and be fed by channels carried in the direction of Nandidroog.

Length of Nandidroog channel.

17. Captain Puckle in reporting proceedings stated that if the levels were extended to the 30th mile near Nandidroog, the contour line would probably exceed 150 miles in length; and subsequently it was found on actually laying out 30 miles from the starting point (the floor of the old race-course barracks) the line, which wound in an extremely tortuous manner to the eastward, had returned to a point known as Mootapah's chatrum close to Mootacherry church. The direct advance towards Nandidroog was therefore very little.

Sir Arthur Cotton's final conclusions.

18. On the completion of the levels to this extent, Colonel Cotton, in replacing Captain Puckle's services, reported, December 17th, 1859, that the following conclusions had been "fully established":—

"1*st*. That an ample supply of water can be obtained on the west side of Nandidroog without the least injury to the present supply, by making a tank of large capacity which will store the water of copious monsoons to supply the deficiency of a following bad year.

"2*nd*. That the present Mailkota tank, the calingulah of which is 50 feet above the race-course, will be a suitable site for such a tank as is proposed.

"3*rd*. That a tank there to contain 10 millions of cubic yards will supply sufficient water with a large surplus—even in very bad years.

* * * * * *

"7*th*. That the expense of this will not be excessive, perhaps Rs. 1,40,000 including compensation; but this is a rough estimate."

Colonel Green's objections.

19. Colonel Green* expressed strong doubts as to these conclusions. He did not consider that the Mailkota tank "could be very much enlarged even though the supply of other tanks be intercepted" nor that "50 feet would be found an adequate fall on a channel which would be at least 100 miles in length."

20. The term "copious monsoons" was incorrect as applied to the character of the seasons in that part of the country. The fall of the channel would be insufficient and its direction tortuous; it would intercept in the whole of its great length the rain water from the fields and tanks lower down the slopes; it would become breached in many places accidentally, and in still more places designedly.

21. As the channel would be in "the predicament of a long tank full of water, the bund would need to be replete with waste-weirs or expensive outlets." Finally, the estimate of $1\frac{1}{2}$ lakhs for this work, carried through a country intersected by deep nullahs and studded with rock, would be quite insufficient.

Proposal to pump up from the Ulsoor tank.

22. Colonel Green was of opinion that the race-course barracks would most readily be supplied by picottahs raising water in 4 lifts of from 8 to 10 feet each from the Ulsoor tank; or, if preferable, by 2 small donkey engines. Although the Ulsoor tank received impurities, he considered that the supposed deterioration of the wells adjacent to the tank to be exaggerated, and came to the conclusion that after the "improvement to Miller's tank, and the still more important and more desirable sanitary project connected with the Ulsoor tank," &c., he did not think Bangalore would have anything to complain of on the score of good and pure water.

23. This, with a letter much to the same purport addressed to Colonel Cotton, appears to have finished the discussion, and so far as can now be discovered the project of bringing in water from Nandidroog has been completely shelved. There can, however, be little doubt that the investigations then made were of considerable utility, and have in a great measure led up to the conclusions now arrived at.

* Letter No. 1770 of 4th January 1860.

24. The sewer conveying the filth of the bazaar away from and under the Ulsoor tank was completed in due course in 1864, and the work of following the cantonment drainage system to its legitimate conclusions is now being prosecuted by this department.

Works by the Madras Government for supplying new cavalry barracks.

25. The Madras Government, moreover, undertook in 1863 to raise a water-supply for the new cavalry barracks from the Ulsoor tank, by steam pumps and pipes much in accordance with the idea put forward by Colonel Green as shown above, on a plan matured by Captain Tulloch, R.E.

26. In 1865, Colonel Lawford, when Chief Engineer, being led to believe that it was the intention of the Madras Government to endeavour to have the last-named project applied to the whole of the station and bazaars with a view to Mysore sharing in the outlay, drew up a memorandum, dated 6th July 1865, which, although submitted to the Government of India,* bears so directly on the various schemes proposed that it must be here shortly adverted to.

Colonel Lawford's objections.

27. Colonel Lawford after showing the general scope of Captain Tulloch's project, and that it was supposed to cost $1\frac{1}{2}$ lakhs of rupees, observes: "It appears that in all the schemes hitherto put forward for the water-supply of this station, the very simple plan of retaining the surface drainage in reservoirs on the highest possible levels has been strangely neglected, and the consideration is overlooked, but not only does the water contract greater impurities from the wider area which it drains on its passage to the main reservoir, but that the necessity of raising it involves the most costly and precarious plans. If nearly the whole population of Bangalore is to depend on a supply received from the Ulsoor tank through the working of steam pumps, they may possibly suffer extreme distress from accidental causes which no one can foresee or prevent."

Proposed construction of high-level reservoirs.

28. He shows that the failure of the old wells being entirely attributable to the great increase of population and the character of the soil, the spring level should be raised by constructing reservoirs on the highest levels, (1) by the enlargement of the railway tank (reservoir No. 3) below Miller's, and (2) the formation of one above the latter, (this has since been constructed). He adds that "one if not more reservoirs could be formed on the upper (*i.e.*, northern) feeder of the Ulsoor tank, along which the population tends to spread." This had reference to the railway or so-called Bederhully reservoir, which Colonel Lawford often expressed a wish to see carried out, and which has lately been proposed by the Municipal Board, though in a different form. The remainder of the communication being taken up with a proposal not now likely to be carried out (though extremely good in itself) of supplying the cavalry barracks from wells to the S. W. containing a pure supply of water, and at a shorter distance than the Ulsoor water-works, it is unnecessary to follow it further.

29. The principle, however, laid down here of fixing the empounding reservoirs at the highest possible point, is that which has been consistently acted on by this department, within the limited means of the local administrations, under sanction of the Commissioner.

Works already executed on this principle.

30. Among other works thus carried on in the station of late years, chiefly under Colonel Lawford, the following may be enumerated:—

Enlargement of Miller's tank, completed in 1863.
Construction of the railway, or No. 3, reservoir in 1864.
Do. of No. 1 reservoir (above Miller's) in 1866.
Do. of No. 4 reservoir (below all the above) in 1867.

* Replied to in Colonel Dickens' letter No. 1320*d* of 1st December 1865.

31. These form a continuous chain at the head of the bazaar nullah, and not only receive a fairly pure supply of water, but tend to keep up the spring level in their neighbourhood. The three upper ones are kept free from immediate pollution, under special regulations; and their several capacities with the relative heights of high-water level, above the waste-weir of the Ulsoor tank, are given in the margin. Though of course distribution could be effected from these reservoirs which, from their relative height, command much of the cantonment bazaar, it has not appeared desirable to carry this out:—

Names.	Capacity in cubic feet.	Height above Ulsoor, feet.
No. 1 Reservoir ...	4,500,000	64·05
No. 2 do. (Miller's) ...	6,000,000	61·05
No. 3 do. (Railway) ...	3,500,000	56·61
No. 4 do.	500,000	28·8
Total capacity in cubic feet ...	14,500,000	

Distribution from any of these undesirable.

1st., as neither in collective capacity, nor in relative command, are they able to do *all* the work required; 2nd., as notwithstanding the purity of the water compared with that of Ulsoor tank, it is not so unobjectionable as could be desired; 3rd., as the town may, at some future day, be expected at least to spread up to Miller's tank, and thus, in spite of the best regulations, add to the contained impurities.

32. In addition to their present value, in affording a comparatively pure water-supply to the upper portions of the cantonment bazaar and native infantry lines, the two lower reservoirs, Nos. 3 and 4 (and especially the former), have the special object of flushing the main sewer. The attainment of this latter object has always been steadily kept in view by this department, in dealing with the several portions of the work, as follows:—

The connection of reservoirs Nos. 3 and 4 with the main drain of the cantonment bazaar.

First.—The oviform sewer carried along and eventually under the end of the Ulsoor tank. The whole of this with its out-fall arrangements and accessories was completed in 1864 at a total outlay of Rs. 1,36,000.

Second.—The extension of the sewer upwards, through the cantonment bazaar (and provided with self-acting arrangements which separate the sewage from storm-waters) was commenced last year, and is now, it may be said, completed at a total outlay of Rs. 61,500.

Third.—The completion of the system as far up as No. 3 reservoir is being estimated for, with a view to the insertion of the project in next budget.

33. In a year and-a-half more, the whole arterial drainage should thus be finished and placed in immediate connection with the series of small reservoirs forming the present water-supply.

34. The principle advocated by Colonel Lawford has been further acted on, in the construction of several minor works, *viz.*, (1) the small reservoir and well at Mootacherry; (2) the reservoir at corner of the Government house compound; (3) that near the Executive Engineer's office; (4) the reservoir on the road of approach to the public offices; (5) one near the new cavalry barracks, &c. Some others have also been carried out by the cantonment municipality, and two more, lately undertaken, have nearly been finished by this department.

Minor reservoirs connected with the water-supply.

35. To complete the general list of such works, it may here be mentioned, that the Shoolay tank was effectually dealt with by this department in the years 1861 and 1863, and not only the water-supply but the whole neighbourhood improved. The Durmamboody tank had also a great deal laid out on it in 1863 under the Commissioner's sanction. The Ulsoor tank itself has also been largely improved by reclamations, &c., at different periods.

36. The gradual growth of opinion and practice following fairly on a knowledge of the wants of the community may be gathered from the foregoing; and it only remains to advert to the projects which the rapidly increasing requirements of the station within the last few years (and particularly since the opening of the railway) have given birth to.

37. The *first*, which is the Madras scheme, for pumping up water from the Ulsoor tank for the use of the European troops (commenced in April 1863) has already been sufficiently noticed for my present purpose. The works are now rapidly approaching completion and will ere long be fully tested; but whether they end in success or failure, as regards their particular object, I cannot consider them adapted to meet the wants of the general community.

The Madras project.

38. The *second* is the scheme put forward by Major Puckle, President of the Municipal Board, in his printed memoranda of 1st October 1867 and 20th April 1868, respectively; and this project, both from the acknowledged ability of its author and his long local acquaintance with the subject, make it the more necessary to notice its main features in detail.

Major Puckle's project.

39. In the first of the above memoranda, the following observations occur:—

* * * * *

"4. The Commissioner's house on the high ground is nearly, if not, the highest in Bangalore; the foot of the flag staff is 3031 feet above high-water mark at Madras, and is almost on the crest of the water-shed ridge that divides the Pennér from the Arkavutti rivers both of which rise at Nandidroog, the culminating point.

"5. For about one-fourth of the distance from Nandidroog, this ridge commands the flag-staff point; but thereafter there is a long interval, where the crest is on a general level with and in one part lower than it. The Muntapum (1 mile from the flag-staff) is 80 feet higher, but this is on a low conical hill, and the dip between it and the flag-staff is great. If water were pounded below Nandidroog, the difficulty of bringing it in for storage at any high level, would be great, on account of the necessity there would be of constructing long and lofty aqueducts; and even then, all the houses on the high ground would have to be served by force pumps.

"6. *The fall from this ridge is too sharp to admit the possibility of collecting water in the Arkavutti valley for delivery at any commanding point in Bangalore* except by increasing the Mail-kota tank, close up to Nandidroog, which Sir Arthur Cotton in 1859 thought might be done, so as to enable the water to be conveyed along a contour line a little below the crest of the water-shed ridge, into the Ulsoor tank, which is 111 feet below the flag-staff datum, but the cost of the channel contouring round the spurs would be very great, and the supply was thought to be of too precarious a nature to warrant the work being undertaken.

"7. From the peculiar position of Bangalore, it is only from the northern side that water can be collected, *and the Arkavutti valley is too steep to admit of anything but a catch-channel close under its crest, being made.*" * * * * *

and the conclusion arrived at in para. 9, is—

"9. It has been ascertained by levels carefully taken, that water could be stored in Miller's tank (the present crest of the waste-weir of which is about 45 feet below the flag-staff datum) and in a newly proposed reservoir on the railway embankment, ¾ mile from the terminal station; *these are the highest points at which water could perhaps practically be stored with advantage.*" * * * * *

Although agreeing in much of this, I cannot but hold that a radical error is contained in the sentences which I have put in italics, and that on this is grounded the so-called Bederhully scheme.

40. The project, it is true, has undergone some slight modification, in consequence of the discussion to which it has been subjected; but as its scope as well as the objections to it are sufficiently summarized in my letter, No. 4089-439, of the 15th July 1866, to the Commissioner, I beg here to quote that communication:—

The project as lately modified.

"3. So far as I can gather from the President's letter No. 183, the proposed tank is to supply during the hot season, if possible, the Ulsoor, Shoolay, Coramungul, and Dumlur tanks; to feed the existing wells in the neighbourhood, both public and private, and the public fountains, wells and cattle troughs, to be constructed hereafter.

"4. The reservoir was also, from the President's printed memorandum, to be capable of laying water on to the race-course barracks.

"5. If the reservoir is to supply all the tanks mentioned, during a season of drought, as also fulfil the other functions enumerated,—its capacity must be the greatest possible under the circumstances; for when its services are most required, it will itself be correspondingly reduced by the effects of the season. Thus in seasons of the most severe drought, the Shoolay, Sumpenjee, and Dumlur tanks are almost quite dry, while the Ulsoor and Coramungul tanks would only perhaps be one-third full. The Bederhully tank will not be in a much better condition than these latter; and yet the small residue left in it, must be capable of not only making up for all the deficiencies of the others that supply public fountains, &c.

"6. In addition, moreover, to the great capacity required for this work, the tank must be placed at sufficient height to command the plateau of the race-course barracks, and means must be found by piping or an aqueduct to take the water, either under pressure or by gravitation, across the valley and over the ridge which separates the proposed reservoir from the Shoolay and Sumpenjee tanks.

"7. Such being apparently the extensive duties to be assigned to this work, I do not think I am wrong in saying, that it will be a most expensive project, and that the objects to be attained would be quite incommensurate with the cost, and that further, even supposing that all were done, which is proposed,—the mass of the inhabitants would be nearly as badly off for water as ever; for from the slight command of the work, none of the upper portions of the cantonment bazaar would be touched, nor any of the compounds of the European residents."

Objections entertained to it.

* * * *

41. It appears to me, therefore, that however useful such a subsidiary tank in the neighbourhood of Bederhully might prove, in the manner originally proposed by Colonel Lawford (*vide supra*) I cannot look on it as likely to meet the objects put forward by Major Puckle. In addition to the objections already urged, I would here observe—(1) That the valley is of such a form as only to admit of a comparatively shallow reservoir; the losses from evaporation would therefore be disproportionably great. (2) Population has clearly a tendency to spread up it, and thus in time, create difficulties in retaining a pure supply. (3) There are now grave-yards and old receptacles of town filth within the catchment-basin, which, unless specially dealt with, would pollute the tank, &c.

42. Were a series of small and inexpensive reservoirs constructed in the Bederhully valley, analogous to Nos. 1, 2, 3, and 4, at the upper end of the cantonment bazaar, I could have no doubt of their utility in raising the spring level, &c., and especially if so designed as to flush the main drain, which must at some future day be constructed to cut off the impurities of the growing town, from the Ulsoor tank.

A series of small tanks more desirable.

43. As forming, however, a single head for a pure and sufficient water-supply for the station, I am quite convinced the scheme will never answer.

44. The *third* and last proposal is that entered in the budget of this department, which I shall, however, only describe in the most general terms, as it will remain for Mr. Humphreys, who is now working out the project, to deal with it in detail.

Departmental project.

45. With a view to establishing a safe ground-work for any project which might be undertaken in future, either for water-supply or drainage, I had the whole station surveyed two years ago under the Commissioner's sanction. The cantonment bazaar was worked out in great detail, and the Sappers undertook to execute the general survey as also levels. The latter work was performed very satisfactorily.

Surveys and levels of the cantonment.

46. The next point—acting on Colonel Lawford's principle of empounding a sufficient supply of water at the highest possible level—was to obtain a survey of all the highest gathering grounds, both of the Arkavutti and Pennér rivers. From these investigations, it became clear that by making a cut to the depth of 20 feet through the narrow saddle near the new Muhammadan burial-ground (and past which the water was to be led in a brick culvert) an ample supply could be conducted

First trial.

into and embounded in the valley near the railway station, just above Messrs. Binny and Co.'s coffee works.

47. The gathering grounds lie all round the Muntapum hill extending close up to Hebbal tank (N.), Subadar's Chattram (N.W.), and then (S.) along the Arkavutti drainage—in all 3 square miles skirted by a channel 13 miles in length, with a slope of 9 inches in the mile.

48. Colonels Green and Lawford, as also Major Puckle, having adopted one-third of the average annual rainfall of 36 inches as a fair proportion of the amount that could be empounded, I accepted the opinion and found the total yield (making the most liberal allowance for all sources of loss) would be sufficient for daily supply of 10 gallons of filtered water per diem to a population of 105,000, delivered at 80 feet above the Ulsoor tank. This height commands all the station and barracks, leaving only the few residents on "High Ground" unprovided for.

49. Much of the gathering grounds have hitherto lain fallow, and as the small and comparatively valueless dry crops now raised can be easily put a stop to under a trifling compensation, the perfect cleanliness of the whole area (the soil being highly silicious) may be readily insured. The slopes on all sides are rapid, and the surface if left untilled soon acquires a hard glazed skin, off which the water flows with the utmost rapidity.

50. Mr. Humphreys, who has now been engaged on the project for three months, has, while adopting precisely the same gathering grounds, suggested two important modifications of the original scheme.

Mr. Humphreys' modifications.

51. Instead of placing the empounding reservoir in the railway terminus valley, he has selected, as a site, the dip of the Toomkur road, 2 miles beyond "High Ground," situated immediately south-west of, and close under, the Muntapum hill, in fact, as near as possible the centre of the gathering grounds. In lieu of one long catch-channel circling the whole area, four channels, none of which will be over 3 miles long, will deliver the surface drainage, thus reducing loss by evaporation and sinkage to a minimum.

52. His second improvement is, to score the whole of the gathering grounds over with channels, at different levels, constructed with slopes having maximum longitudinal falls consistent with the cohesive powers of the soil, by which arrangement the discharge of all surface drainage will be expedited to the highest degree.

53. Lastly, the form of Mr. Humphreys' reservoir has great advantages, its surface being everywhere up to the highest water-level extremely small for its depth and capacity,—loss by evaporation will thus be reduced to a minimum. In this respect the site is probably the very best which could be found anywhere in the neighbourhood of Bangalore.

54. Unfortunately the available returns as to the population of the station within municipal limits are most unsatisfactory, as may be seen from the following abstracts of the censuses taken in 1862 and 1863, obligingly furnished by the President of the Municipal Board:—

Census of population within municipal limits.

Population within the Municipal limits.

Classes.	Abstract of Census of 1862.	Abstract of Census of 1863.
Hindus	86,055	42,973
Muhammadans	26,856	13,129
Europeans	1,836	5,226
Eurasians	1,586	1,436
Total ...	123,533	62,764

ernment and its details approved of, and, therefore, at this stage of the question, it would appear undesirable to say more than a few words on the subject.

71. Though a very rising community, it cannot be said that Bangalore is at all a wealthy one, in the same sense as even many second-class cities of the Empire, and its Municipality has all along (though making the best use of the means at disposal) been unable, without Government aid, to carry out reforms which elsewhere are considered as purely local and provided for from local funds; I am unable therefore to see how the Municipality could be in a position to meet any of the outlay required for the scheme as above sketched. Government will, therefore, it appears to me, have in some shape to bear the cost of the head works and the two sets of arterial delivery mains referred to.

Share falling on the Municipality.

72. Were this done, it would most appropriately fall on the community to place themselves in connection with the system under, of course, certain well-defined restrictions, but generally in such a manner as best to suit the immediate requirements of the particular class or district which may choose to pay for the necessary sub-mains and other accessories.

73. While thus according an undoubted and lasting boon on the whole station, Government would, at the same time, while imposing proper restrictions, hold itself aloof from all minor details that could be infinitely better disposed of by the Municipal Board, carrying out with their own funds the distribution arrangements most suitable to the special wants of the community.

74. Had the Ulsoor water-works, now being carried out, not been commenced, it would have been a simple corollary to the above proposition that the Madras Government should bear a proportion of the prime cost for the benefit of the European and Native troops and followers; and even now it is much to be hoped that, in case the scheme now working out does not prove as successful as was originally anticipated, some joint action on that which I venture to put forward may yet be found practicable.

Bangalore,
9th September 1868.

(Signed) R. H. SANKEY, Major, R.E.,
Chief Engineer of Mysore.

Memorandum by Major-General R. H. SANKEY, R.E., C.B.

Owing to the supposed scarcity of water at Bangalore in the early portion of the present season, representations were made by the Municipality to the Mysore Government, and subsequently the station was visited by the Officiating Sanitary Commissioner, Dr. Bidie, whose report was transferred to me for remarks under endorsement, No. 2641, of 8th May 1883, by Secretary to Government in the Military Department.

2. In consequence of this reference I inspected the works at Bangalore in the middle of May, but delayed submitting my remarks, as before doing so I wished to be in possession of an analysis of certain specimens of water taken by me below the new (so-called Ooparhalli) reservoir, and forwarded to the Chemical Examiner for report.

3. Owing to a misadventure with reference to these specimens, I only received the report when I was too much occupied with other matters to take up the subject. Just now also on the eve of departure for England, I fear I can hardly do justice to a matter of such admitted importance.

4. In addition, moreover, to bring an extremely difficult subject from an engineering point of view, complications have been introduced with the rendition of Mysore, which were not foreseen when the original schemes of water-supply were designed.

5. All I can therefore hope to do is to take a general view of the present position of matters and offer some observations as to the policy which to the best of my judgment it would be desirable to follow.

6. From insufficient acquaintance with the history of the various efforts hitherto made to solve the very difficult problem of giving Bangalore a fair supply of water for domestic purposes, late writers have fallen into not a few misapprehensions. These I am at present unable to discuss, but the subject has been very fully dealt with in my printed memorandum of the 9th September 1868, submitting the general scheme for distributing water all over the station for the new Ooparhalli reservoir.

7. The annexed index map shows the broad features of this scheme. The rainfall of the catchment area, 1,600 acres in extent (with a small additional area of 170 acres to the south not yet connected), is collected in a storage reservoir situated in the third mile of the Toomkur road, and is led by an open masonry channel from A to B. All the work so far has been completed from Mysore Provincial Funds at a capital outlay of Rs. 5,40,169.

8. At B it was intended to have had a pipe head reservoir, from which distribution would be made by two mains, one, B C, serving all the north side of the cantonment bazaar, and B D the south. At D a bifurcation of the southern main was to have been made, sub-main D E serving, if necessary, the European troops, and D F the whole of the Shoolay quarter.

9. Chiefly owing to the restrictions imposed on all outlay in Mysore after the famine, it was decided, after placing the works in a safe condition, to defer completion.

10. Having been mainly responsible for the commencement of these works, it is natural that I should wish to see them finished, convinced as I am that they are designed upon the only sound and feasible basis.

11. Writing in 1859 Sir Arthur Cotton declared against the suggestion then made to supply the troops with water pumped up from the Ulsoor tank. A scheme which has since, however, been carried out. His objections were—"*first*, the insuperable one, that this tank receives the drainage from a large portion of the cantonment containing a considerable town, which must render the water unfit for use; *second*, the great expense of constantly pumping from such a depth."

12. That both one and other of these objections have, as might have been expected, proved true in practice it is needless now to affirm. The disadvantages of the position are borne out by every line of Dr. Bidie's report.

13. The inhabitants of the cantonment bazaar may be harried with endless restrictions, all kinds of works may be devised for separating sewage from storm waters along the several feeders of the Ulsoor tank, but the struggle against nature will in the future prove as hopeless and as expensive as has been the case in the past. The position is an impossible one, and should never have been accepted.

14. Dr. Bidie, in the end of his report, advocates the completion of the Ooparhalli scheme, observing that: "It is possible that the yield may fall short of this estimate (viz., 10 gallons per head per diem for 90,000 inhabitants); but on the other hand, if completed, it is apparently capable of delivering in the station a liberal supply of water of unexceptional quality."

15. In contradistinction to the polluted area which furnishes the supply of the Ulsoor tank, the catchment of the new Ooparhalli reservoir is in the first place free of even a single habitation. Most of it was, if I remember correctly, bought up for Government and thrown out of cultivation; and no doubt the rest can be readily acquired, if necessary.

16. The soil is of the usual red character, very sandy, and lateritic near the central point at the Muntapum. Unfortunately the tufted grass (an *Andropogon* according to Dr. Bidie) has been allowed to take possession of most of the area, and effectually stops the off-flow of rain-water.

17. Again, channels of quick delivery were not, as originally intended, carried out; and as a result of these combined causes, the new reservoir has not filled to the extent that it ought to have done.

18. Very careful returns have been maintained in the Chief Engineer's office in Bangalore of the deliveries into the new reservoir. From these I extract the following results :—

Year.	Fraction of the Total Rainfall on the Catchment as stored in the new Reservoir.
1878	$\frac{2}{11}$ ths.
1879	$\frac{1}{9}$ th.
1880	$\frac{1}{10}$ th.
1881	$\frac{1}{7}$ th.
1882	$\frac{1}{9}$ th.

Average of the five years above nearly 13 per cent. of the total rainfall.

19. Numerous experiments were carried out to ascertain the off-flow from the surface when in different conditions, and, although unable at the moment to quote figures, the difference observed between the results when the soil was maintained free from rank vegetation, and especially where it had attained the hard-glazed condition which with proper arrangements seems to be attainable, was such as to remove any doubts as to the adequacy of the total supply. Though ploughed ground and crops absorb and evaporate frequently nine-tenths of the rainfall, the careful experiments made by Mr. Binny for the Nagpore reservoir showed that the results were altogether reversed with surfaces in a denuded hard condition.

20. By stopping all cultivation, removing and keeping down the grass, particularly the "*Andropogon*," there should, I hope, be no reason to fear short supply. Cattle should, of course, be kept off the ground, and all means used for getting the surface into the most favorable condition, with quick delivery channels, &c.

21. Should unfortunately these efforts fail to produce all the desired results, there are clearly auxiliary methods which are at command.

22. The *first* of these (a method which I believe has already been partially adopted on a special occasion) is the pumping of a supply of water from below sluice level into the sluice cistern. Probably a 10 or 12 horse power engine and centrifugal pumps lifting to a maximum height of 15 feet would here do all that would be necessary.

23. The *second* auxiliary method was, however, the one to which I devoted most attention when last at Bangalore, and certainly at first sight it promised very satisfactory results.

24. The applicability of this method depended on turning to account certain defects in the execution of the works possibly, and certainly in the soil, which I will now very briefly explain.

25. When carrying out the central core of the bund for the new reservoir, consisting of a concrete wall sunk in places to 30 feet below the surface, the soil in places proved to be very rotten. It was soft decaying stuff, and the stoppage of the springs proved to be a most serious difficulty, if indeed it was ever fully overcome.

26. Returns for the past five years now before me show that under the combined action of evaporation and leakage the reservoir surface was lowered between 0·43 to 0·66 of an inch per diem, whereas under evaporation only it should not have fallen more than 0·30 of an inch at the outside. Captain Kensington calulated from this that the losses due to leakage alone would amount to 41,382 cubic feet per diem.

27. An examination of the main bund showed that this leakage might very well be going on either entirely under the concrete wall or round the flanks; but although the whole soil, a short way below the bund, was full of water, there was no indication of any danger or any element of weakness in the work itself.

28. Two points naturally suggested themselves in connection with this leakage—

(1) Will the sediment in the water so puddle the bed, as often occurs, in such a way as gradually but effectually to stop the leakage?

(2) Will it continue and thus present an opportunity for lifting by steam pumping the whole supply required, or in any case a good proportion, from a series of wells established below the bund?

29. Looking to the general character of the soil, I confess I was disposed to the second view, and, judging from the clear and sparkling specimens of water collected from immediately below the main bund, I was in hopes that we had at hand a means of giving practically a supply of filtered water to Bangalore.

30. The analyses (hereto attached) of the specimens collected do not bear out this conclusion in such a manner as to render the adoption of this plan feasible without much further inquiry.

31. Notwithstanding the clearness of the specimens taken, and the fact that traditionally all travellers used the old well here constantly, only two out of the four specimens have been pronounced "*usable*" by the Chemical Examiner.

32. This comparatively unsatisfactory result may, it is true, be due to the presence of rank vegetation about the holes from which these specimens were collected, but whatever the cause, it would be undesirable to build on this pending further inquiry.

33. All therefore that I at this moment would wish to advance is that in the great leakage which now takes place may yet be found a large auxiliary supply of naturally filtered water which may be pumped up for distribution at no very prohibitive cost.

34. There is also a *third* auxiliary to the scheme (alluded to in paragraph 67 of my report of the 9th September 1868), viz., the possibility of bringing in supply from a fresh catchment area believed to measure two square miles in extent situated a little south of Yellavunka. This has not been examined in detail, and whether the supply from this detached area would be brought in without prohibitive cost remains to be decided. It should certainly be examined.

35. The scheme for the supply from the new Ooparhalli reservoir was originally calculated to give 10 gallons per head per diem to 90,000 inhabitants in the Bangalore cantonment, cantonment bazaar, and military station, to the nearly total exclusion of the Pettah, which, though not well supplied, was not at the time considered to be in anything like the same urgent need in this respect.

36. By the census of 1881 it seems that the following was the population all told as being directly or indirectly concerned:—

1. Cantonment bazaar, civil and military stations	89,274
2. Pettah	62,317
3. Troops	4,259
Grand Total ...	155,850

37. In delimiting the Bangalore Municipality under the late rendition arrangements, the whole of the catchment area of the Ooparhalli reservoir and the reservoir itself were left in Mysore territory; and although the original scheme as above mentioned did not contemplate any inclusion of the Pettah population, it may be thought that as regards the future some allowance on this account would be desirable.

38. This view may, moreover, on other grounds, be considered not unreasonable, as a small portion of the catchment area of the new Ooparhalli reservoir as a fact drained into the supply channel of the Durmamboody tank, on which the Pettah in great measure depends for its water. It has thus to some extent suffered by the construction of the new reservoir. The question is in fact one for discussion between the Governments of Madras and Mysore.

39. For the moment, however, I may, I think, fairly assume that if a supply for 15,000 or 20,000 people were passed down to the Pettah from the Ooparhalli reservoir, it is all probably that would even be either asked for or deemed desirable.

40. We may thus assume that the total population to be provided for will not exceed—

For Cantonment bazaar, civil and military stations and troops ...	110,000
Pettah	20,000
Total ...	130,000

This I should consider sufficiently liberal.

41. As regards the unit of supply, viz., 10 gallons per head, I have reason to believe that this may, as the experience since gained of large Indian towns, be at once halved, and that 5 gallons may be taken as the unit. To err on the side of liberality, the cubic foot $6\frac{1}{4}$ gallons might be accepted.

42. It may here be mentioned that Bangalore has in its chain of four reservoirs (at the head of the bazaar) in the Ulsoor tank, and innumerable wells, a very good supply in all ordinary seasons for personal ablutions, for watering cattle, &c.; so that the one cubic foot above really represents little more than the amount needed for drinking and culinary purposes. To this I may further add that investigations of a very pains-taking character in the town of Mysore brought out the fact that for these purposes the average amount actually used by natives only amounted to $1\frac{1}{4}$ gallons per head per diem, or just one-fifth of the quantity proposed to be given.

43. I will only add to the above that, to insure a perfectly pure uncontaminated supply, not only must all grazing and cultivation of the catchment area be stopped, but the supply must be conveyed from the reservoir sluice in closed channels and pipes to the points of ultimate delivery.

44. I wish much it had lain in my power to define in more concrete form the precise method of carrying out the Ooparhalli scheme to completion; but this is impossible. The services of a thoroughly professional officer will be necessary to frame the needful estimate after the two Governments concerned have decided on the general principles to be maintained in regard to construction and future administration of the works, the requirements and shares of the two populations concerned, and the incidence of the charges.

45. In Captain Kensington the Mysore Government have an officer not only of special intelligence in and training, but one who has for years devoted close attention to the registration of the facts connected with this work. His advice and assistance to any officer selected for getting up the project would be invaluable.

(Signed) R. H. SANKEY, Major-General, R.E.

23rd September 1883.

ORDER—dated 5th October 1883, No. 2794 W., Public Works.

The Government concur in the opinion expressed by His Excellency the Commander-in-Chief, that the first and most essential matter in connection with the Bangalore water-supply is the extension and completion of the scheme originated by Major-General Sankey, R.E., C.B., when Chief Engineer of Mysore in 1868.

2. With this object, the services of a thoroughly competent officer will be made available, as soon as possible, for the duty of making the necessary surveys, &c., and for framing the required estimates of cost.

3. The following letter will be addressed to the Resident in Mysore :—

(Here enter No. 2795 W., dated 5th October 1883.)

(True Extract.)

(Signed) J. SHAW-STEWART, Colonel, R.E.,
Secretary to Govt., P.W.D.

To the Military Department.
" Sanitary Commissioner for Madras.
" Superintending Engineer, Fifth Circle
" Public Department.

Exd. A. F. Goodall.

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BUILDINGS AND ROADS.
MILITARY WORKS.

Govt. of {1883} Madras.

PUBLIC WORKS.

Dated October, 5th.

Recd. *Encl.*

G.O., 5th Oct. 1883, No. 2794 W.

OCTOBER.

Bangalore Water-supply

Ordering the extension and completion of the scheme originated by Major-General Sankey, R.E., C.B., in 1868 for the —.