

- (1) பக்கங்கவின் எண்ணிக்கை 130
 (2) புதுக்கித் திருப்பிய நாள் 10/89
 (3) ஆதாரங்குறிப்பவர் சுருக்கொப்பம் 10/89

தமிழ்நாடு ஆவணக் காப்பகம்.

(56)

தமிழ்நாடு அரசு

P W 22 துறை

அரசாணை எண்.	<u>1326</u>	அச்சகம்
மு. கோப்புத் தாள் எண்.	<u>1327</u>	பலவகை
நாள் :	<u>18-5-1889</u>	<u>198</u>

புதுக்கோட்டை கணபதி கையாள்வோர் கூடரது

65 sheets

பி.வி.

மன. 20-1-18, 888-18-8-87.

sheet no 34, 36, 37, statement.

13TH MAY 1889, Nos. 1326, 1327 W., PUBLIC WORKS.

GOVERNMENT OF MADRAS.
PUBLIC WORKS DEPARTMENT.

Buildings and Roads.
Military Works.

READ—again the following paper:—

G.O., dated 16th July 1888, No. 2147 W., Public Works.

Note by the Chief Engineer, Public Works Department, dated 7th July 1888.

Order—dated 16th July 1888, No. 2147 W., Public Works.

The investigations made of late years with the object of obtaining a pure water-supply for the troops stationed at Bangalore having failed to produce an efficient and economical scheme, the Government resolved to offer a reward of Rs. 1,000 for the best essay on the subject on the conditions specified in the notification published in the *Fort St. George Gazette* of the 1st November 1887 and subsequent issues, the award being left to the Chief Engineer, Public Works Department.

2. A number of essays have been received in compliance with this invitation, and have been carefully examined by the Chief Engineer, who awards the prize to Mr. Standish Lee, Sanitary Engineer, Mysore. The sum of Rs. 1,000 will accordingly be paid to Mr. Lee by the Executive Engineer at Bangalore, and will be adjusted against Military Works under instructions from the Examiner, Public Works Accounts.

3. The essay submitted by Mr. A. H. Garratt, Executive Engineer, Bellary, is, in the opinion of the Chief Engineer, a very good one, and does him great credit. The essay of Mr. S. Tomlinson, Deputy Chief Engineer, Bombay Water Works, is also, in Colonel Hasted's opinion, a very creditable paper. Both these essays came near to winning the prize.

4. A copy of these Proceedings will be published in three successive issues of the *Fort St. George Gazette* for the information of competitors.

(True Extract.)

(Signed) J. O. HASTED, Colonel, R.E.,
Secretary to Govt., P.W.D.

READ—also the following papers:—

From Sir H. N. D. PRENDERGAST, K.C.B., V.C., Officiating Resident in Mysore, to the Chief Secretary to the Government of Madras, dated Bangalore, 22nd December 1888, No. 4366/371-8.

I have the honor, with reference to your letter No. 479, Political Department, dated 14th July 1888, to forward copies of a letter* from the Dewan, and of a memorandum by the Secretary to Government, Public Works Department, Mysore, on the subject of Colonel Hasted's note on the Bangalore water-supply.

* No. 19, dated 3rd December 1888.

2. I am of opinion that Sankey's reservoir is capable of improvement, so that it might be far more useful than at present, and there is no doubt that water from the Hebbal tank can be raised to supplement the supply for the civil and military station and the garrison, or that a supply for the civil and military station and troops can be pumped from one of the tanks near the head of the Pennakini river, or that a good supply, far more to be relied on than any of the above, can be stored in the Hassar-gutta tank in the Arkavathy valley; but the object of the Madras Government seems to be to obtain the purest water available for the troops at a moderate cost, and I think that the cleanest source of supply within ten miles of the barracks is the streamlet, an affluent of the Arkavathy river, that might conveniently be impounded near the 5th milestone on the Mágadi road.

3. Mr. Larminie has been deputed to examine the projects for obtaining water from the Arkavathy and Pennakini valleys; when his reports give the means for ascertaining which project is capable of giving the needful supply at the cheapest rate, it will be possible to determine whether one reservoir should supply the troops and the civil and military station, or the troops and the pettah, or the troops and both station and pettah.

4. When a project has been selected for execution, it will be a fit time to settle the respective rights of the Government of India and of the Government of Mysore to the water in Sankey's reservoir.

ENCLOSURES.

From K. SHESHADRI IYER, Esq., c.s.i., Dewan of Mysore, to the Resident in Mysore, dated Mysore, 3rd December 1888, No. 19.

In reply to your office letter No. 2448/288 of the 18th July 1888, forwarding, for the opinion of His Highness the Maharajah's Government, copy of a note by the Chief Engineer, Public Works Department, Madras, on the subject of the water-supply of Bangalore, I have the honor to forward herewith, for your information, copy of a note thereon by the Superintending Engineer of Mysore, which gives expression generally to the views entertained by the Durbar regarding the merits of the various schemes proposed.

2. I fully agree with Colonel Hasted in his opinion that Sankey's reservoir cannot contain a pure supply so long as the rifle ranges remain in their present position at the head of the basin. Their removal, I would add, appears equally necessary, whether the reservoir is intended to supply the pettah or cantonment. But this reservoir by itself is, in my opinion, quite insufficient for the supply of the pettah. Colonel Hasted (in para. 22) estimates that it will supply a population of 50,000 at 4 gallons a day. Experience in the Mysore city, where only a few fountains have yet been erected, goes to show that about 6½ gallons would be the lowest rate per head which any proper water-supply scheme should provide for. The Durbar are already carrying out some works intended for a supply to a part of the pettah by means of the leakage from Sankey's reservoir. The supply thus obtained has to be considerably supplemented before a suitable scheme for the pettah can be worked out. Both by reason of proximity and the lower lift required, the Mágadi valley is more appropriate for the supply of the pettah than that of the civil and military station, but the Durbar will refrain from any further investigation of the capabilities of this valley for the pettah supply until some definite decision is arrived at by the British Government as to utilizing it for the civil and military station and the troops.

3. On the subject of the use to which Sankey's reservoir is to be put, I have nothing to add to the observations in Mysore Public Works Department Secretary's letter to Assistant Resident, No. 1548/268, dated 14th April 1888, nor do I consider it necessary in this place to refer to the very unreasonable views entertained by the station municipality on this subject. The Durbar will gladly agree to any arrangement which is convenient to the British Government. They would gladly have the full use of this reservoir so as to be able to utilize it for the partial supply of the pettah, and in that way obtain some return, however small, for the large capital sunk in it. Or, if the British Government prefers to utilize it for the supply of the troops and the station in accordance with the original object of its construction, then in that case the Durbar will be satisfied with receiving some moderate return therefrom, as contemplated in the orders of the Government of India in letter No. 384 C., dated 25th June 1869.

4. Under such circumstances it appears to be somewhat premature now to discuss the question of any exchange as between this reservoir and the Mágadi valley, which is mooted

by Colonel Hasted in para. 22 of his note, and I have only to add that the Durbar will offer every facility in their power for the investigation and execution of the Mágadi valley or any other scheme by the British Government.

NOTE.

The Chief Engineer's note on the Bangalore water-supply deals with the several essays submitted in response to the notification of the Madras Government offering a premium for the best solution of the water difficulty. In so far as Colonel Hasted's recommendations affect Mysore, I have to offer the following remarks.

2. The first point requiring consideration and settlement is the right to Sankey's tank, the subject of paras. 2, 3, 4 and 5 of Colonel Hasted's memorandum. In my note of 14th April 1888, I endeavoured to explain, so far as I could, the position of the Mysore Government in regard to this tank, my remarks concerning which appear to me still to hold good. Colonel Hasted observes, however, that whilst the expenditure by the Mysore Government of nearly 5½ lakhs on the works constitutes a decided claim on their part to the tank-supply, the contention of the municipality that the surplus revenues of Bangalore may be assumed to have met the expenditure should not be lost sight of. In disposing of this argument it must not, I think, be forgotten that prior to the rendition the surplus revenues of the province as a whole were given to the Public Works generally, according to the necessities of the various claims and in the order of their relative importance, and the net result of this expenditure of the surplus revenue was, in consequence of the famine, a State debt of 80 lakhs at the rendition. It is not unreasonable for me to infer that, had the Oopparhully water-supply scheme never been attempted, either this debt would have stood at 74½ lakhs, instead of 80,* or that the 5½ lakhs spent thereon would have gone to other works

* This should be 80.

from which the Mysore State would now be deriving a direct benefit; or, had the scheme proved a success, the Municipality and the Military Department would now be paying to the Mysore Government a moderate percentage on the outlay incurred. As it is, not only does the burden of the outlay rest on Mysore, but the municipality claim sole right and title to the results of that outlay and decline to meet any charges whatever therefor. However, an early settlement of this question is most desirable. As matters now stand, the Public Works Department of Mysore are hampered by the rival claims of station and pettah and have to incur an annual outlay on the maintenance of its feeders, without being able, at same time, to improve them in any way.

3. I may note here an error in para. 4 of the memorandum, into which Colonel Hasted has apparently inadvertently fallen, as regards the possible reduction of loss by leakage. It was to 16 million cubic feet, not to a mean between 12½ and 15 million, that Major Kensington thought, might be reduced the loss from evaporation and leakage combined, which General Mullins computed to be 20½ million cubic feet.

4. As regards the merits or demerits of General Fischer's Hebbal scheme and Mr. Standish Lee's Mágadi road valley scheme, I have already submitted brief notes embodying my views. Both these involve the cession of land appertaining to Mysore, but until it is decided finally whether one or other of them is to be taken up, the question of compensation need not be worked out.

5. As regards the second Pennakini drainage scheme, Major Kensington's, I have not had the opportunity of going into it carefully, but I have personally expressed to Colonel Hasted what I thought about it. I agree in his remarks thereon, paras. 13, 14 and 15. I doubt whether on this scheme being thoroughly worked out it will have any special advantages over a modified project for the Hebbal tank. Here again compensation would be a serious element, and the interference with the supply of other tanks will have to be considered.

6. The only other point in the papers in which Mysore is directly interested is the decision of Colonel Hasted, recorded in his para. 22, that the troops and the civil and military station should receive their supply from the Mágadi road valley, Sankey's tank being left for the supply of the pettah. The Mágadi road valley, it is clear, is the most suitable place for the supply of the pettah, and this being the case and Sankey's tank not affording an ample supply, however much we may improve it, it is not obvious why the pettah should relinquish its claims to this valley in favor of the civil and military station. The troops only might certainly draw their supply from this valley without detriment to the pettah, and if the Mágadi road reservoir is to be constructed, it might be utilised for the troops and the pettah, not for the troops and the civil and military station, the cost being borne by the Military Department and the Pettah Municipality, in the proportion of the quantity of water drawn off by each. I presume the Pettah Corporation will not object to such an arrangement, and will be prepared to meet their share of the outlay necessary.

7. The proposal that the rights to Sankey's tank should be a set-off against the grant of the Mágadi road valley by Mysore for less than the actual value of the land is hardly a fair one, as the title to Sankey's tank stands on grounds altogether apart from the question now raised. This would be equivalent to making Mysore pay more for Sankey's tank than they have paid already without obtaining therefrom any adequate return.

8. If what I have advanced above meet with approval, the project to be worked out would be the construction of a service reservoir near the pettah to be supplied from the Mágadi road valley with water sufficient for 50,000 people, *minus* what can be sent down from Sankey's tank, plus 60,000 gallons for the troops. The cost of this to be borne by the Military Department and the Pettah Municipality in the proportion of the water given to each. The Military Department would then set up their Ulsoor engines, pumps, and mains to send up the water from the above service cistern to the service cisterns in the barracks.

BANGALORE,
27th July 1888.

(Signed) C. BOWEN, R.E.,
Supg. Engineer, Mysore P.W.D.

Transferred to the Public Works Department.

(Signed) J. F. PRICE,
Chief Secretary.

9th January 1889.

REPORT by J. C. LARMINIE, Esq., dated 2nd February 1889.

Report to accompany the estimate for Water-supply to the Cantonment and Garrison of Bangalore and to the estimate for supply to the Garrison alone.

In accordance with No. 3 reference, instructions were given for the investigation of two schemes for the supply of water to Bangalore.

References.

- (1) Letter from the Government of India, No. 1182 M.W., of 14th June 1887, recorded in G.O., No. 1924 W., of 18th July 1887.
 - (2) G.O., No. 2810 W., of 20th October 1887.
 - (3) Chief Engineer's note printed with G.O., No. 2480 W.—A, of 14th August 1888.
 - (4) Chief Engineer's note printed with G.O., No. 25 W., of 8th January 1889.
- First, that proposed by Mr. Lee, to whose essay was awarded the reward of Rs. 1,000 (reference No. 2), and second, that proposed by Major Kensington.
2. The instructions given were general, and were to the effect that every item composing the estimates was to be gone into in minute detail and most carefully estimated for.

3. Accordingly, some time was devoted to consideration, from every point of view, of each detail. Mr. Lee's, commonly called the Mágadi road scheme, being the most promising, was first taken in hand.

4. The country was carefully examined to secure the best site for the dam, as also for the best and most economical line for the supply main to Bangalore, and endeavours were made to obtain further data regarding rainfall and run-off.

5. Some time was also devoted to the preparation of a fairly accurate survey with levels and contours of the proposed Mágadi road reservoir, site and the design of the masonry dam was made out in detail.

6. According to somewhat modified instructions received in December, approximate estimates, to admit of a comparison of the various schemes, were considered in the first instance sufficient. Had it

been understood that sketch-plans and estimates were only required, the work could have been done much sooner; as it is, the projects are now submitted well within the two months mentioned (reference No. 4). However it is hoped that the time which has been devoted to minor detail will be of value hereafter; for, of the estimates herewith submitted, that for the Mágadi road scheme has been prepared in considerable detail, and is believed to be a very close approximation of what the work may be expected to cost.

7. To the Nagavaram scheme, that for the Hebbal tank, and for the smaller scheme for the garrison supply (instructions regarding the two latter received in December last) it has not been possible to devote so much attention. The surveys and estimates are, however, believed to be close approximations.

8. The accompanying comparative statement gives the leading features of the several schemes and their estimated cost. Each scheme will now be reviewed in detail. They have all been based on the same general data as laid down in the Chief Engineer's note, and regarding which a few observations may, it is hoped, be permitted (*vide* paras. 12 to 18).

9. The more correct name for this scheme would be Maligal, near which village * it is proposed to construct the reservoir.

Mágadi road or Maligal scheme. The catchment area of 9 square miles (as measured on the Topographical Survey, *vide* sheets 42 and 63) extends 3 miles to the north and 1 mile to the south of, 2 miles of the road from Bangalore to Mágadi ($4\frac{1}{2}$ to $6\frac{1}{2}$ miles).

10. In every particular except cost, it is by far the most promising of the three schemes investigated for the supply of the cantonment and garrison. But, provided a scheme is admitted to be promising in other particulars, the mere question of even a few additional lakhs to the cost should not, it is thought, weigh much against it. The comparative statement shows the small additional quantity of water† (some 20 M.C. feet extra for a year's supply) which has to be stored to provide for loss from evaporation, leakage, &c., owing to the favorable conformation of the reservoir site, a narrow deep valley, the area of waterspread at F.S.L. being 85 acres.

Advantages of Maligal scheme.

11. The other advantages are—

- (1) The whole of the catchment may be considered free.
- (2) Probably not more than one-sixth of the area is at present under cultivation; there is, however, a growing tendency to extend it, chiefly casuarina plantations; so the Mysore authorities have been requested to check its further extension for the present.
- (3) The catchment area chiefly consists of steep, bare lateritic hills, from which personal observation showed that even moderate showers are very quickly run off (*vide* also para. 18 of Chief Engineer's note, reference No. 3). In this connection also *vide* paras. 17 to 19 regarding percentage of run-off.
- (4) Analysis of the water taken from the stream under unfavorable circumstances—shortly after a flood—shows it to be remarkably pure, and the accompanying table compares it with water from the other sources, as also with that now pumped up for the use of the Bangalore garrison. Even in the driest season there is, it is stated, a small stream of pure water always flowing.
- (5) A supply for more than one year can be more advantageously stored here than elsewhere.

12. Regarding the quantity of water to be stored, *i.e.*, 40 M.C. feet or only one year's supply. As a comparison between the various schemes, it may suffice to estimate for storing this quantity; but it is considered that with only one year's supply in store a bad season or two cannot possibly be tided over.

13. The minimum supply, 7 M.C. feet per square mile of catchment, which according to the accepted Mysore data might always, it was thought, be expected to flow off, cannot, it is *now found*, be counted on as a certainty.

* Situated about one mile below the bridge over the stream at furlong stone $\frac{5}{8}$ on the Mágadi road.

† 40 M.C.F. required for supply of the cantonment and garrison, so 60 M.C.F. must be stored for a year's supply.

14. Seven M.C. feet means 3.01 inches of rain run-off each square mile. Taking 17" as the lowest rainfall, 3.01" would be almost 18 per cent. of that total fall, while there is abundant evidence to show that, to obtain so high a percentage, the fall must be in sharp heavy showers. Everything depends on the character of the rainfall. In the course of only an average year's fall (36 inches) *provided* that some of the falls come down in quick heavy bursts, the 18 per cent. might safely be counted on, while light continuous rain, although the 24 hours' fall might be high, would yield a much smaller percentage.

15. The lighter the annual rainfall the smaller and fewer are the chances of obtaining heavy showers of short duration, so that in a season of minimum fall it may happen, and very probably will, that the run-off, instead of being 7 M.C. feet per square mile, will be almost *nil*. (This it is known on the best authority has already been experienced at the Mysore water works.) Consequently how essential would it not seem to store as large a supply as can consistently be done?

16. Two and even three years' supply have been advocated. The reports that have during these investigations from time to time been submitted regarding the Mágadi road scheme advocated the storing of 1½ years' supply (60 M.C. feet), which requires, allowing for waste, evaporation, &c., as near as can be 100 M.C. feet in the reservoir (*vide* table of consumption and waste).

17. That this quantity can be impounded in an average year is hardly open to question. The Mysore data gives 11 M.C. feet per square mile as the *average*, as deduced from Sankey's tank, a most unfavorable catchment. As noted in para. 18 of Chief Engineer's note,* the run-off of the Mágadi road catchment must be higher, and observations made during the course of these investigations give the following approximate results.

18. During the period 11th September to 2nd October last, the total fall from certain selected showers was 5.4 inches. This fall over the catchment (taken as only 8½ square miles) means 106.63 M.C. feet.

The quantity that passed down the stream was approximately computed to be 42.71† M.C. feet $\frac{42.71}{106.63} = 0.4$ or 40 per cent. average. Individual falls gave for half an inch in 1½ hours (*after a long*

period of draught) 3 per cent. Even on this occasion the stream began to increase half an hour after the rain commenced.

For a 2 inch fall ...	PER CENT.
" 1.3 " ...	53
" 1.1 " ...	29
" 0.5 " ...	40
	30 Catchment by this time well wet.

All these were falls of short duration from 1½ to 3 hours.

19. But although the data is admittedly very approximate, still it suffices to show what may be expected in an average year. The year under reference was, however, under the average, as the total fall was only 34 inches.

20. To impound 1½ years' supply, 100 M.C. feet, 4.78 inches of rain must run-off the 9 square miles of Mágadi road catchment, or only 13.3 per cent. of an average year's fall.

21. The dam, to impound this quantity, should be 9½ feet higher than that for one year's supply now estimated for (see section), and the *additional* cost, as per detailed estimate, for a masonry and concrete dam for the full width of this section would be Rs. 77,630.†

RS.
‡ 2,70,370
1,92,740

77,630

22. The advantages of the scheme are detailed in para. 11. The chief disadvantage will now be alluded to: it is that the run-off being so very quick the water, even in small freshes, comes down

highly charged with silt. It is consequently proposed not to draw off water below 13 feet above bed of stream at site of dam (level 33.48 on survey), thus utilizing a length of the river bed as a silt trap; with a view to keep this clear it is proposed to place two or more 3-foot iron pipe scouring sluices worked by equilibrium valves in the foot of the dam, and a special design for these valves has been partly worked out. But even with all possible precautions it is feared that silting up will go on.

23. Messrs Richardson and Cruddas, the well-known Engineering firm of Bombay, have taken considerable trouble in furnishing particulars and cost of the best description of pumps and engines to work against the heavy heads involved in the three schemes, that of Mágadi road being greatest. The heads in each case have been deduced as follows, Mágadi road being taken as an example:—

Top water-level in settling ponds ...	3,090.0 M.S.L.
Lowest off-take at reservoir ...	2,741.71
Actual lift ...	348.29 feet.
Pumps can be placed 25' above draw-off ...	25
	323
Head allowed to overcome friction in supply main to Bangalore at 6' per mile ...	33
Total head to pump against ...	356 feet.

24. It was specified that the pumps should be able to throw up a week's supply in six days of twelve hours, or at the rate of 66,540 gallons per hour.

25. For this work Messrs. Richardson and Cruddas recommend three sets of engines, pumps and boilers, any two of which working together shall work up to the required quantity, leaving a third (engine, pumps and boiler) in reserve.

26. They recommend direct acting, compound condensing engines and pumps.

High pressure steam cylinder ...	21 inches diameter,
Low pressure ...	36 "
Pumps 48 inches stroke ...	12 " diameter, and
Lancashire boilers each of 35 H.P. nominal.	

Their estimate for three sets of the above delivered in Bangalore is Rs. 53,000.

27. An idea of the combined pump and engine can be obtained from the woodcut at page 35 of Messrs. Richardson and Cruddas' catalogue. The woodcut, however, does not represent a compound engine. It is extremely compact, each pump and engine only occupying a space of 28' × 3½', so the three pumps can be arranged alongside in a room measuring about 48' × 35'. These pumps are made for lifts from 250 to 1,500 feet for quantities of water from 3,000 to 50,000 gallons per hour.

28. A provision of Rs. 12,000 has been made for engine and boiler houses. A detailed estimate has not been made out, as one amounting to Rs. 9,260, based on very liberal rates, was framed in connection with the Agram tank scheme; rather more accommodation will be required in this instance, for which the extra Rs. 2,940 will be sufficient provision.

29. The Agram tank scheme estimate for quarters, Rs. 14,000, has also been adopted; provision is made therein for quarters for one European Engineer and two European or Eurasian drivers, for native stokers, and for a store-room and office, the whole surrounded by a wall, &c. At Mágadi road (Maligal) a good site for the quarters will be on the hill-top above the right end of the dam.

30. As in Maligal reservoir with one year's supply stored there will be 31½ feet difference of level between highest and lowest water-levels, and as pumps cannot be placed more than about 25 feet above

Site for engines and pumps.

the lowest level to be pumped from to avoid the necessity of placing the pumps below engine level, it has been decided to place the pumps in rear of the dam; the site marked on the survey will be a suitable one. Although perhaps not so safe as if placed above the dam and above M.W.L., the arrangement admits of the cheaper and more compact form of engine described.

31. To store one year's supply a dam 45 feet above present bed of stream at the proposed site will be required. At the centre section a height of 50½ feet has been allowed for; the cross section of the

Dam of masonry and concrete.

valley at site shows the various levels of foundations proposed; they are probably lower than will be found necessary.

32. The site selected is a little higher up the stream than that intended by Mr. Lee. At the latter, the line of strike of the rocks, with all the joints and fissures, are parallel to the axis of the stream, while higher up the line of strike is perpendicular to the river, and the bed of rock is much harder and sounder as far as can be judged by gullies, trial pits and other indications. This bed of rock extends all over the valley at no great depth.

33. Taking the Bhim Tal dam near Naini Tal as a precedent, it is proposed to form this dam of two outer skins or walls of coursed rubble in cement mortar, thus obviating the necessity for supporting planking when carrying up the concrete hearting of the dam. It was intended to use Portland cement for the entire mass of concrete, but the Chief Engineer being of opinion that an outer casing of cement concrete would be sufficient, the estimate has been framed accordingly, allowing for the rubble casing in front and rear, and a thickness of 2 feet of the concrete in rear of the front rubble-face to be in cement mortar. The remainder of the concrete to be of ordinary lime mortar. The additional cost of the dam, laying all the concrete in cement, would be Rs. 77,353.* Probably a lighter section than has been estimated for near the flanks would suffice.

* 3,223 at Rs. 24, the difference of rates for cement and lime concrete.

34. A diagram showing the section of the dam with the curves of prestress, and a table of weights and pressures and also the required dimensions if calculated by Molesworth's formula, accompanies the estimates.

35. After some consideration the right end of the dam was fixed on as the best site for a surplus weir; there is evidently a bed of rock at no great depth below the surface; a trial pit shows rock at level

Surplus arrangements.

55.0. The weir has been designed for a drop, still 5 feet lower, of a type which has been found to answer well and is much less expensive than a clear drop.

36. As designed, the 150 feet of weir with a depth of 3 feet passing over will discharge half an inch of rain per hour from the catchment of 9 square miles.

37. According to Mysore Public Works Department experience, as much as 1 inch per hour from a catchment of this area and description may occasionally be expected; but to provide a weir for so exceptional occasions seems unnecessary, as an arrangement might be made to pass such excessive rain fall over the dam. The staff in charge of the pumping machinery could easily look after and work any simple arrangement decided on. Water so surplussing will fall on the rear slope of the dam up to depth over crest of 3 feet.

38. As shown on the reservoir survey, the weir bye-wash bed is placed at + 50 and carried along till this level runs out of cutting, where the surplus can be passed over the rock into an existing ravine. It is believed, however, that a rocky bed will be met with above this level (i.e., + 50).

39. The left embankment of the bye-wash can be formed from the cutting; provision is made for a substantial, grouted and pointed revetment to it for a length of 400 feet below the weir rear wings.

40. The pump valves will be placed at level 58.48, or 25 feet above the lowest take-off level in the reservoir; from the pumps the supply main to Bangalore will be carried round the left side of the

Supply main to Bangalore.

reservoir for a short distance and thence strike away in a north-easterly direction, crossing the road from Bangalore to Magadi near furlong stone ¼; thence the line will run, with three slight bends, to the Mantapum hill, where it is proposed to place settling ponds, filters and service reservoir.

41. The line will not pass near the pettah, and in selecting it (the line) the objects kept in view were to secure the shortest route, subject to facilities of laying and the avoidance of sudden rises and dips; two or three small ravines will have to be crossed, for which a lump sum provision has been made in the estimate; the cheapest arrangement will be to support the pipes on the roughstone posts so universally used, or on light bridges formed of old rails. The line crosses the Mysore State Railway to Tumkur about a mile north of the Pettah terminus.

42. As the pipes nearest to the reservoir have the heaviest head to withstand, a heavier section of metal has been allowed, 1" in thickness for the first mile, ¾" for the next, and ¾" for all the rest. For practical reasons the pipes cannot well be of less thickness than ¾". A sufficient number of scour cocks, air and back or reflux pressure valves have been allowed for. All the items and rates have been carefully considered.

43. As noted in para. 23, the size of the main has been calculated (as also for the other schemes) taking a head of 6 feet per mile, the week's supply being pumped up in 6 days of 12 hours

Size of supply main.

2.96, say 3 cubic feet, required discharge per second. An 18" pipe by Kutter's formula will at 6' per mile discharge rather more, or 3.4 C. per 1". However a 17" pipe would be too small, discharge 2.86 feet per 1"; so the larger size has been adopted.

Messrs. Richardson and Cruddas, in connection with the engines, considered the size 18" as specified suitable.

44. It is proposed to construct these on the Mantapum hill. The only disadvantage of this site is that it necessitates about a mile extra of supply pipe to the cantonment, but there are several counterbalancing advantages.

- The site is at the highest available level.
- It is well away from all dwellings and their accompanying sources of contamination.
- The land can easily be made available and no existing rights of any consequence will be interfered with.
- The only other suitable sites are either the golf ground or the high ground; for the former floor of service reservoir should be placed at level 3,030, for the latter 3,040, thus reducing the head for distribution, and neither site affords the same facilities for construction, and they are besides much used as recreation grounds by the officers of the garrison and other European residents. The constructions in question would completely spoil either.
- The site selected on the slope of the hill admits of the settling ponds, filters and service reservoir being arranged at suitable levels with reference to one another (*vide* plan No. 14).
- For either Hebbal or Nagavaram schemes the one disadvantage noted disappears.

(g) Borings to a depth, lower than necessary for excavation, show the soil to be pretty similar to that visible on the surface, i.e., hard compact lateritic soil; mixed with water the clay from the borings seemed almost fit for puddle, so that there can be no objection to constructing ponds, filters and service reservoir as proposed, i.e., in cutting, with a good facing of cement concrete laid on the slopes, cut into steps, if constructed with masonry sides, the works would be considerably more expensive.

45. The question of placing these works near the supply reservoir has been considered and the idea abandoned as it would involve additional pumping, as there is no suitable site below the reservoir where they could economically be constructed. The pumps proposed are specially adapted to the pumping of muddy water. The plan shows the general arrangements.

46. The settling ponds have been designed for a depth of 8 feet of water, of which 7 feet can be drawn off leaving 1 foot of depth for silt accumulation, each pond to hold one day's supply. It will

Details.

be a question for future consideration if a greater number of ponds should not be provided. With a view to deliver the water into the ponds as quietly as possible, the supply main from the pumps will deliver into a large circular well, whence the water will be conveyed by iron pipes, regulated by valves, to masonry chambers, and thence by overfalls which can be regulated by shutters, into the ponds.

47. From the ponds the water will be drawn off by means of adjustable (or floating) suction pipes, which the drawings will fully explain, into the filters.

48. Two have been provided for, each capable of filtering a day's supply in 24 hours, at the rate of 50 gallons per square foot per 24 hours. A liberal allowance as 75 gallons is commonly taken as the

Filters.

duty of a filter. The draw-off sluices from the filters to the service reservoir are arranged so that the necessary head on the filters can be arranged to any required extent, from 1 inch up to 3 feet; probably 18" will be found sufficient; the arrangements for turning the water from either settling pond to either filter are shown on the plan.

49. Designed to contain rather more than three days' supply. With a view to keeping the water as cool as possible, a roof formed by a series of flat-brick arches has been provided. It is now generally

Service reservoir.

admitted that service reservoirs should be so covered in. The roughstone pillars allowed for are universally used in Mysore and they are cheaper, cleaner and occupy less space than brick arches would. Rolled iron beams have been allowed for, but old railway rails would do equally well and would probably be cheaper.

50. Town distribution will now be described when the Mágadi road scheme will as a whole have been considered.

The remarks regarding the settling ponds, filters, service reservoir and distribution will be common to the other two schemes for the supply to cantonment and garrison, so there will be no need to recapitulate them.

51. The distance fixed, 600 feet, in a straight line, nearer than which water need not be brought to any house, greatly simplifies the system.

The proposed lines of piping are shown on the accompanying two sheets of the Topographical Survey of the cantonment, and the statement of distribution details gives particulars of the various lines proposed.

52. The original intention was to have worked out the system in greater detail, by taking careful measurements and levels for each line, as also by the preparation of detailed drawings and estimates for each special curve and connection required (as was done for the Ootacamund distribution). But under recent instructions it was not possible to do all this, so the estimate is based on the survey; some

of the lines have been levelled and many of the survey B.Ms. checked, and, with one exception, the latter have been found to agree well with recently taken levels; some differences have also been found between the levels of the troop supply cisterns.

53. All the levels connected with the various schemes are taken from B. M. No. 2 at the N. E. corner of the golf ground opposite this office (No. 6 Bellary road) gateway; this B. M. was recently moved, but has been again put in at the same level as that given for it on the Topographical Survey 3057.48 M.S.L. A connecting level to the S. W. corner of the office plinth gives a value to the latter of 3056.83. A list of the levels of various other points which have been levelled to accompanies.

54. For purposes of calculation the population has been taken—Europeans 5,000, natives 100,000; this latter figure is probably 6,000 over the actual at present, but the allowance of 6,000 for increase is not excessive. It has been decided * to

* Reference No. 3.

allow two cubic feet per day for Europeans and one cubic foot for natives. To properly proportion the pipes statements of the population, street by street, would be required, but no such information is available in the Municipal office; all that could be obtained was a statement of areas and population, and even this is very incomplete and does not include the whole of the population; however it has been used to some extent and partly by guess the population has been divided amongst the various lines as shown in the distribution statement, and the sizes of the pipes thus deduced seem reasonable enough and are capable of distributing the required quantities in eight hours.

55. The statement of distribution fittings gives the particulars of the various fittings allowed for each line. The European Infantry barrack cistern will be supplied by No. 2 branch of main line No. 4. This latter line will at its termination near Trinity Church join the existing supply pipes to the Cavalry and Artillery barracks.

56. Probably here and there short lengths of extra piping will be required to bring certain localities within the limit of distance, but there is ample provision in the estimate for such contingencies.

57. The rates allowed for actual pipe-laying are much lower than were allowed at Ootacamund, but they are believed to be sufficient, each item, lead, yarn and excavation have been separately allowed for.

58. Of the two lines for the main from the reservoir to the bifurcation of the distribution mains, the alternative line to the west is some 700 feet shorter and will probably be preferable; the estimate has been made out for the other, but no great difference would result, as though the grade would be increased from $\frac{1}{4}$ to $\frac{1}{8}$ the discharge of the pipe would not be materially increased, and so its size 15 $\frac{1}{2}$ " could not well be reduced.

59. From the comparative statement of cost and other particulars this scheme would at first sight seem most promising.

Hebbal tank scheme.

The tank also is well calculated to attract popular attention, situated as it is on the high road to Bellary at no great distance from the station and at a higher level than any of the other sources of supply, a fine looking sheet of water, of 204 acres in extent, at present weir level.

60. The total catchment area is 13 square miles, of which only 5 square miles are free, as marked by a dark green line on the map, and in considering these schemes it has been decided that only free catchment can safely be counted on, and in connection with the run-off, even from free catchment, the remarks in paragraph 15 should not be lost sight of.

61. The catchment can hardly be considered a steep one, and in the middle it is very flat.

62. The tables of capacity and areas and the table of consumption and waste show that to store one year's supply (40 M. C. feet) it is necessary to impound 123 M. C. feet, so that 83 M. C. feet

Supply required.

would be wasted and lost in evaporation owing to the great water-spread of the tank, which at the level, ($7\frac{1}{2}$ feet above weir) required to store 123 M. C. feet is some 261 acres in extent.

Supply available.

Miles.
 $5 \times 7 = 35$ M. C. feet available in a bad season.
 $5 \times 11 = 55$ M. C. in an average season.
 $5 \times 17 = 85$ Maximum supply.

64. In a year, however, of average fall, with the character of the rainfall at all favorable, there can be little doubt that the required quantity could be impounded, as then the run off from the entire catchment of 13 square miles could be counted on. During the progress of these investigations the tank has surplused several times, but if it be decided, as is believed, to be absolutely necessary, that at least 18 months' supply should be stored, over 200 M. C. feet would be required, involving the raising of the tank about 20 feet and the submerging of a large area of valuable land.

* Vide contour survey of tank.

65. These do not seem to call for particular notice, the tank bund carries the Bellary road, hence the necessity for the top width allowed. The present weir is crossed by a bridge of 7 vents of 9 feet

each. Provision is made for removing two of the piers and raising the remainder, replacing the arches with rolled iron beams and buckled plates, and raising the weir body wall in rear of the bridge as shown on the sections.

66. The nature of soil in rear of bund is shown on the bore hole diagram.

67. The distance of the tank from the filters and service reservoir being so much less than Magadi road reduces the cost of the supply main, and this shorter distance and smaller lift materially reduces the first cost of the engines and the working expenses. The same establishment would however, it is considered, be necessary as for the more powerful engines required at Magadi road.

68. This tank is in the same valley as the Hebbal, about $1\frac{1}{4}$ miles lower down to the east. The weir is 23 feet lower than that of Hebbal. Correctly speaking, its free catchment is only 3.6 square miles,

its total catchment being Hebbal catchment of 13 square miles + 3.6 = 16.6 square miles to obtain the $8\frac{1}{2}$ miles of free catchment alluded to in G.O., No. 25 W., of 8th January 1889; the 5 square miles of Hebbal free catchment must be reckoned on.

Major Kensington proposed to increase the catchment and take up the surplus of Jukkur tank by a catch channel, but the unfavorable opinion reported regarding a work of the kind has been endorsed by the Chief Engineer, so the proposal has not been carried further; indeed the Mysore experience of catch channels is not encouraging, and in this instance, as the tank should be raised $11\frac{1}{2}$ feet, the fall available from the Jukkur tank would not then be sufficient.

69. The tables of capacity and consumption show that for a year's supply (40 M. C. feet) 106 M. C. feet must be impounded, and to do this weir level must be raised $11\frac{1}{2}$ feet, the water-spread being

increased from 86 to 334 acres, the land which would be submerged is valuable, being under wet and garden cultivation. The comparative statement gives (as also for the other schemes) the approximate cost of compensation, and if for this scheme the Hebbal tank were deprived of the water from the five square miles of its free catchment, it would happen that in bad years the Hebbal tank could not supply the land irrigated by it; hence in both estimates appears the same sum Rs. 10,770 compensation for land deprived of water.

63. It only remains to apply the data of run-off, per square mile, of free catchment—

70. Applying the data as in para. 63—

Supply available.

Miles.
 $8.5 \times 7 = 59.5$ M. C. feet minimum.
 $8.5 \times 11 = 93.5$ M. C. F. in an average season.
 $8.5 \times 17 = 144.5$ M. C. F. maximum against 106 M. C. F. required.

As in the case of Hebbal tank (para. 64) in an average year a supply from the total catchment might be counted on.

71. To impound $1\frac{1}{2}$ year's supply, though the area submerged, while it would not be so great as at Hebbal, would involve the acquisition of much valuable land.

72. The estimates seem to call for no remark, as they have been prepared on the same lines as the others. The bore hole diagram gives the results of two borings made below the bund.

73. The catchment areas of both Hebbal and Nagavara tanks cannot by any means be considered clean; they are both highly cultivated, and being close to Bangalore receive a considerable amount of night-soil manure; parts of the Nagavara catchment are most offensive. Neither catchment can be nearly so clean as that of the Hessargatta tank, which has been condemned as a source of supply partly for this reason.*

* Reference No. 4.

74. As shown, both Hebbal and Nagavara tanks fail when reviewed in the light of the data available. So, as has been reported, the only cheap alternative to the Magadi road scheme would be the

Rachanhalli (or Dhasarhalli) tank; this is at the same level as the Nagavara tank, and only $\frac{3}{4}$ mile further out to the north. It is in a narrower and deeper valley than the Nagavara and so the water-spread would be smaller, and to store a year's supply it need only be raised about 8 feet. Its total catchment is 36 square miles, of which 15 square miles may be considered free, as the tanks in this area are shallow and unimportant; and the chief one, the Jukkur, irrigates but a small area. A more detailed report and approximate estimate for a supply from this source will shortly follow.

75. To briefly summarize for the three schemes which have been worked out for the supply of the cantonment and garrison:—

Summary.

MAGADI ROAD.

Pros.

Cons.

Most advantageous catchment basin, valley steep and narrow, insuring a rapid and high percentage of run-off, the whole catchment being free.

2. Catchment now only cultivated to a small extent, and that with crops but slightly manured.

3. Advantageous site for the formation of the supply reservoir, a deep narrow valley, height of dam to store one year's supply 45 feet above river-bed, area of water-spread at that level 85 acres. Height of dam to store 18 months' supply 54 feet, area of water-spread at that level 124 acres. A still larger supply could be stored if necessary.

4. Analysis shows the quality of the water from this source to be much purer than any of the others.

5. Constantly flowing stream of limpid water flow, said to continue even in the driest weather to a small extent.

1. Cost of the project and annual working charges.

2. Possible difficulties with the reservoir owing to the amount of silt brought down by floods.

3. Possible difficulties in obtaining permission from the Mysore Government to carry out the works as the supply of the Pettah from this source has been talked of; however there should not be great difficulty from this cause as Sankey's tank has been handed over to Mysore.

76.

HEBBAL AND NAGAVARA SCHEMES.

Pros.

Smaller initial cost with lower annual cost for working. Distance to sources of supply being less as also heads to be pumped against. These advantages are also in favor of the Hebbal scheme as compared with Nagavara, while there is but little counterbalancing advantage in favor of the latter, as here the compensation for land submerged would be much more costly. The latter tank is now rapidly drying up. Rather than reserve the 5 square miles of free catchment belonging to Hebbal to supply the Nagavara tank for supply of the town, it would be better to adopt the Hebbal tank as a source of supply and increase its free catchment by taking up some of the tanks above it.

Cons.

1. Water not so pure as that of Mágadi road.
2. Shallow tanks of great water-spread involving the storage of a large volume of water to meet loss by evaporation and leakage.
3. Catchment basins not large enough to furnish required supplies in any but favorable seasons of rainfall.
4. Catchment basins highly cultivated and manured and generally not favorable to a rapid run off.
5. Cost of compensation for land submerged and deprived of water would be expensive, as land in both localities is valuable.

77. *General Summary.*—All in favor of Mágadi road. To reserve the free catchment areas would be very expensive. The cost has not been brought into the estimate for each scheme, but has been added, at foot, in the general abstract. The amount for Mágadi road has been made out in detail by the Mysore Revenue Department, for the other schemes approximate values deduced from total areas and average value of the land have been entered.

78. A statement accompanies showing how the annual working charges have been arrived at. As in previous estimates 15 per cent. interest and depreciation has been allowed on the machinery,

Cost of working.

but only 7 per cent. on all other iron-work, pipes and fittings, &c., and 4 per cent. on the balances of the estimates. The entries for establishment should suffice, and in making them out the cost of working the elaborate engines which drive the cotton spinning mills at this place has been looked into. These are worked very inexpensively by a far smaller establishment than had now been allowed for, but even this latter is only about half of the present Ulsur establishment, where also the cost of firewood is greater than at the cotton mills, the reason assigned being that the mills are at liberty to make advances to contractors which a Government department cannot do. At Ulsur works wood fuel has been costing from 217 lb. to 270 lb. per Re. 1. At the cotton mills, Re. 1 per 316 lb. 300 lb. per rupee has been taken as the cost for these calculations, the consumption of wood per hour has been taken as quoted by Messrs. Richardson and Cruddas for each engine. Of course the comparatively antiquated engines and pumps of the Ulsur works could not be as economically managed as the more perfect machines now in the market.

And in considering the cost of working the schemes under reference, the cost of the present Ulsur supply for the troops alone (Rs. 16,565 for establishment and working *plus* allowance for interest on first cost, this latter has been calculated to amount to Rs. 31,889, total Rs. 48,454*)

* Cost for 1,000 gallons Rs. 2½.

should be deducted, it represents almost an annual dead loss to Government. If a combined supply to garrison and cantonment were carried out, the annual total cost could easily be met by a very low water-rate, about Re. 1 per head of the population, who already probably pay as much or more for their present unsatisfactory supply. As far as has been ascertained a water-rate would be cheerfully paid.

SUPPLY SCHEME FOR THE GARRISON ALONE.

The importance and urgency of obtaining a pure and unfailing supply of water for the garrison, in the event of its not

Reference No. 4.

being found possible to carry out a supply scheme for the garrison and cantonment combined, being recognized, the estimates, amounting to Rs. 2,34,130, have been prepared; the comparative statement gives the cost and other particulars side by side

with the large schemes. The annual working expenses are estimated at Rs. 20,000, cost per 1,000 gallons being Rs. 0-14-0 against Rs. 2½ per 1,000 gallons, cost of the existing Ulsur supply.

2. It is proposed to draw the supply from the same source, as for the combined supply from Mágadi road, only in this case a smaller catchment area being required, a point has been selected $\frac{3}{4}$ of a mile *above* the bridge over the stream at $5\frac{1}{2}$ miles of the road from Bangalore to Mágadi. Above this point the catchment area is 5 square miles, as colored by a pink line of deeper tint on the Topographical Survey.

3. Taking as laid down the required supply at 10,000* cubic feet per day the tables of capacity and consumption show

Reference No. 4.

(evaporation and waste as before, 0·7 feet per month) that for the year's supply of

3·65 M. C. feet 8 M. C. feet must be stored in the reservoir, the height of dam required being 28 feet above river-bed.

4. The dam is colored pink on the cross section of the valley, the section of the dam for so much of the height from the top to be the same as designed for the large reservoir. The estimate provides for cement right through as it is proposed to surplus over the dam, provision being made for a mass of rough stone in rear.

5. For the reasons set forth in paras. 12 to 18 of the report on the combined supply, it is thought that 18 months' supply should here also be stored, also that a supply for the native troops in garrison should be included. The supply of 10,000 cubic feet per day is based on the requirements of the European troops; only a slight addition to the height of the dam would be needed, the engine power and main provided for is capable of pumping up a larger supply.

6. Provision is made for two sets of direct acting compound engines, pumps and boilers, either of them capable of pumping up a week's supply in three days of ten hours through a 10-inch main.

Engines and pumps.

7. The size of the main has been calculated as before, a head of 6 feet per mile being allowed, seven days' supply pumped up in three days of ten hours, *i.e.*, $\frac{70,000}{3 \times 10 \times 60 \times 60} = 0\cdot648$ cubic feet per second, a quantity the 10-inch pipe will discharge.

8. The same arrangement of settling ponds, filters and service reservoir as for the larger schemes has been estimated for, the service reservoir to hold ten days' supply and to be roofed with brick arches supported by stone pillars and rolled iron beams similar to the one proposed for the larger schemes.

A suitable site will be on the South Parade as shown on the Topographical Survey of the cantonment. Borings show the soil to be a firm red clay with some sand. From the service reservoir the supply can be conveyed to the Infantry barracks cistern and on by the existing lines of pipe to the Cavalry and Artillery cisterns.

(a) In drawing up this report endeavours have been made to make it as concise as possible, consequently nothing has been noted regarding topographical peculiarities of the country, climate, rainfall, &c.; quite enough has already been written on these subjects.

Concluding remarks.

Chapter II of Mr. Lee's essay contains a general description of Bangalore, and in the same pamphlet is a diagram showing the rainfall for a series of years. The levels given in the pamphlet are incorrect and the estimates extremely sketchy, and with reference to the notification published with G.O., No. 2810 W. of 20th October 1887 (page iii of Mr. Lee's essay), it may be noted that the essay has not in any way been adopted as the foundation of the Mágadi road scheme as now prepared except so far as indicating the locality and source of supply.

* Over 11,000 cubic feet per diem have been pumped up from Ulsur in the dry season.

1326
1327

8

- (b) All the estimates which have hitherto been prepared for the water-supply of Bangalore made provision for stand-pipes, an obsolete expedient now hardly ever adopted, the necessary pressure to force the water through the mains is now-a-days always communicated by the engine through the medium of an air vessel.
- (c) For the sake of comparison a table is appended, giving the estimated amounts of the garrison supply estimate as now prepared and that drawn up by the late Captain Romilly for a garrison supply from the Agram tank.
- (d) The projects as now submitted are by no means as complete, particularly as regards plans as the undersigned could have wished; but as time was an object, most of the plans are sent just as they have been roughly drawn out in pencil.
- (e) The Hessargatta tank on the Arkavati river has been brought forward as a source of supply by Colonel Vibart and has been briefly alluded to in para. 73. It is thought that the objection to the impurity of the catchment is not a very serious one; the table of analysis shows the water to be good. There can be no question that a very large volume of water could be impounded in an ordinary year, as per figures given in this office report No. 74 of 26th November 1888. Notwithstanding the greater distance—11 miles from service reservoir site—the level of the tank being higher, the head to be pumped against would be 18 feet less than at Mágadi road. To impound a two years' supply the cost would not probably be much more than at Mágadi road, and at the latter locality would be the risk and chances of leakage attending the construction of a high dam. At Hessargatta the existing tank of a capacity of 91 M.C. feet with its massive old bund would be, as it were, a reliable foundation to start from.

2nd February 1889.

J. C. LARMINIE,
Executive Engineer.

BANGALORE WATER-SUPPLY.

COMPARATIVE Statement showing cost and other particulars, &c., of the various schemes proposed.

	Magadi Road Maligal.	Hebbal Tank.	Nagavara.	Garrison supply.	
Distances from source of supply to service reservoir.	5 miles.	2 1/2	3	5 1/2 miles.	Net distances.
Head to be pumped against	3/6	163	186	232 feet.	Includes head allowed to overcome friction
Lowest take-off level	2741.71	2218.0	2837.0	2793.27	in supply main at 8' per mile. Head calculated from level of pumps to delivery level in the settling ponds. Pumps placed 25' above lowest take-off.
Delivery level in settling ponds	3090.0	3090.0	3090.0	3014.62	
Areas of reservoirs at F. S. L.	84.75 acres.	361	334.6 acres.	18.22	
Capacities of do. at	60.54	123.4	106 M. C. feet.	8324	Required supply 40 M. C. F. + waste from all sources. For 1, 2 and 3 required supply 40 M. C. F.; for Garrison 4 M. C. F.
Total catchment area	9	13	13 1/2	5	
Free do. do.	9	6.0	3 1/2	5	
		<i>Abstract of Estimates.</i>			
Dam	1,32,740	25,650	30,500	50,000	To store 18 months' supply at Magadi road add Rs. 77,630.
Engines, pumps and boilers	63,000	40,000	41,000	13,000	
Connection with reservoir	1,000	..	..	..	
Pump wall	1,500	1,500	1,500	1,000	
Engine and boiler-house	12,000	12,000	12,000	6,000	
Chimney	5,000	5,000	3,000	2,000	
Quarters for establishment	14,000	14,000	14,000	5,000	
Supply main	2,57,000	1,15,400	1,51,900	1,12,300	18 inch main for 1, 2 and 3; 10 inch main for garrison supply.
Settling ponds	37,350	37,350	37,350	14,210	
Filters	36,860	36,860	36,860	7,610	
Service reservoir	63,430	63,430	63,430	21,510	
Town distribution	2,29,744	2,29,744	2,29,744	..	
	85 acres at Rs. 100.	100 acres at Rs. 100.	200 acres at Rs. 100.	18 acres at Rs. 50.	
		57 " at " 150.	50 " at " 200.		
Compensation for land submerged by reservoir	8,500	18,550	30,000	900	
Do. for land deprived of water	..	Assessment X 10.	10,770	..	Major Kensington states that the land now under Nagavara tank could be supplied by Echanhalli tank, so no allowance is made. As all the water from Hebbal free catchment would be required for Nagavara tank, none could be spared for irrigation, so the amount for land deprived of water is also entered against the latter estimate.
		10,770	16,770	..	
Annual cost of working	9,02,124	5,98,254	6,55,054	2,34,130	
Cost of water per 1,000 gallons	91,000	61,000	65,500	20,000	
	Rs. 0 6 9	Rs. 0 3 3	Rs. 0 4 3	Rs. 0 14 0	
Total					

• Including interest on cost of construction.

J. C. LARMINE,
Executive Engineer.

9

SUPPLEMENTAL REPORT by J. C. LARMINIE, Esq., dated 18th February 1889.

BANGALORE WATER SUPPLY.

Supplemental Report on the proposal to supply the Garrison and Cantonment from the Rachanhalli (or Basaralli Tank).

The report which has been already submitted treats of the question of obtaining a supply from three sources—

Reference.
Para. 74 of report which accompanies the estimates which have been already submitted.

1st—Mágadi Road.
2nd—Hebbal Tank.
3rd—Nagavara Tank.

The first named is likely to prove an expensive scheme, both for first construction and subsequent working, and is not besides without its drawbacks, the chief being the uncertainty attendant on the construction of a new masonry dam.

2. The two latter schemes completely fail when considered in the light of the data decided on, chiefly owing to the small areas of free catchments available; consequently a source of supply which, while combining the advantages of the two latter schemes, i.e., comparatively high level and proximity to Bangalore, with a larger catchment area, would comply with the necessary requirements. The Rachanhalli tank fulfils these conditions fairly well.

3. It is just $\frac{3}{4}$ of a mile further out, to the north, than the Nagavara tank and almost at the same level; the accompanying comparative statement compares its particulars with those of the three schemes for the combined supply as already submitted.

4. The conditions of the catchment basin are more favorable than those of either Hebbal or Nagavara tanks.

(a) As to the total area, i.e., 36 square miles, and here it may be remarked that under the conditions of rainfall prevailing in Mysore a large catchment, though even not free, is of value, as the chances then of catching local showers are so much better. Major Kensington, R.E., who has had considerable experience of Mysore, considers that, by far the best tank filling rains, are not those of the monsoons, but the local showers that fall before and after each monsoon; this quite agrees with the experience (limited of course) gained during these investigations, and it is from these very local showers, which usually come down in sudden heavy bursts of short duration, that the greatest percentage of run-off is obtained.

(b) The catchment is not so highly cultivated, and being further from Bangalore and more out of the way, receives but little (if any) of the clearances from the dust-bins. The good quality of the water is shown by the table of analysis.

(c) The catchment is steeper and narrower, and observation after heavy rain showed a rapid and copious run-off.

(d) The catchment of 15 square miles, which may be considered free, is colored burnt sienna on the 1 inch Topographical sheets which accompany the first report.

5. It is true that several tanks appear in this area, but the principal one, the Jukkur, would disappear, as its ayacut would be submerged by the raising of water level in the Rachanhalli tank, so under the head land compensation provision is made for taking up this area (only 87 acres). All the other tanks are shallow ponds of no importance.

6. The remaining 21 square miles of the total catchment extend away to the north of Yelahanka as marked by a blue pencil dotted line on the map. The Yelahanka is a considerable tank, which at times passes off much surplus.

7. The table of consumption shows that to store a year's supply, present full tank level must be raised $7\frac{3}{4}$ feet, when the three tanks will compare as under.

	Hebbal.	Nagavara.	Rachanhalli.
Extra depth required to store one year's supply ...	feet $7\frac{1}{4}$	$11\frac{1}{2}$	$7\frac{3}{4}$
Area of water-spread when so raised ...	acres 361	334	338
Corresponding capacity ...	„ 123.4	106	118

8. It has been already shown that of the two tanks, Hebbal and Nagavara, the balance of advantages is rather in favor of Hebbal, so only with this latter tank need further comparison be drawn.

9. For one year's supply the area of water-spread and required capacity are smaller at Rachanhalli, as shown by the statement (of particulars and cost); the amount of compensation for land submerged by the reservoir is Rs. 1,300 more at Rachanhalli, but it is believed that the former (Hebbal) is under-estimated and that more wet land would be submerged than is allowed for. There was no time to obtain exact particulars like those now given for Rachanhalli tank, while as a set-off against the land submerged in this case would be the land obtainable around the margin of the Jukkur tank, the weir of which might be lowered 6 feet, and as the tank would be no longer required for irrigation (*vide* para. 5), the stone now forming its revetment could be utilized for the Rachanhalli tank, and accordingly a lower rate for revetment has been allowed in the estimate for the latter.

10. But it is in the comparison of the run-off on the catchment area of Rachanhalli with that from Hebbal and Nagavara areas as compared with the required amount of water that the advantages of the former scheme become most apparent.

	Hebbal.	Nagavara.	Rachanhalli.
	M.C.F.	M.C.F.	M.C.F.
Required for one year's supply ...	123	106	118.
Available, i.e., free ...	5×7	3.6×7	15×7
Catchment $\times 7$ M.C.F. ...	35	25.2	105
Deficiency ...	88	80.8	13

11. But if it be admitted that it will not do to trust to obtaining invariably a minimum of 7 M. C. F. run-off, and that at least 18 months' must be stored, which in an ordinary year can easily be done, then the Rachanhalli tank has still further advantages over Hebbal for storing the greater supply, for, as the contoured survey of the tank shows, a further rise of level of the water would only submerge an inconsiderable area along the right and left margins; 18 months' supply could not be stored at Hebbal without submerging a large area of valuable land, raised $7\frac{3}{4}$ feet as shown, for one year's supply, the water-spread (of Rachanhalli) would then be 6 feet below the weirs of the Jukkur tank, so that this latter might be used as a supplemental reservoir to the other. It is a deep compact little tank, containing about 55 M.C. feet between weir crest and 6 feet below that level M.C.F. and is now only a few inches below F.S.L., notwithstanding a considerable draw off through the sluices, pointing to the existence of copious springs in the valley, as no rain worth noting has fallen since early in November.

12. If the Jukkur tank be utilized as a supplemental reservoir, the Rachanhalli tank need not be raised for any given supply to so great an extent, but the time available now will not admit of this question being worked out.

13. The quantity of water required, if stored in the Rachanhalli Tank for 18 months' supply, has however been computed and is shown in the consumption table, in one period of six months 210 M. C. F. would be required. Present tank level should be raised 13 feet (against $7\frac{3}{4}$ feet for a twelve months' supply) or to level 63 on the tank survey, colored green, and area of water-spread at that level would be 461 acres.

14. To obtain 210 M. C. F. 6 inches of rain should run-off the free catchment of 15 square miles. Much more than this would be available in ordinary years.

15. The water in the tanks in this valley is remarkably pure and clear looking (for quality see table of analysis), so the difficulties on account of silt, likely to be met with at Magadi road, would here be avoided.

16. The tank has two weirs of 80 and 90 feet in length; these could inexpensively be raised, for which a lump sum of Rs. 5,000 is allowed in the estimate for raising the bund.

17. The item of estimate, raising the bund (*i.e.*, dam), is less costly than either Hebbal or Nagavara, the bund being much shorter.

J. C. LARMINIE,
Executive Engineer.

18th February 1889.

SUPPLEMENTAL.

BANGALORE WATER-SUPPLY.

Comparative Statement showing cost and other particulars of the various schemes proposed for a combined supply to Garrison and Cantonment.

	Magadi Road. Maligal.	Hebbal Tank.	Nagavara.	Rachanahalli.	
Distance from source of supply to service reservoir.	5 miles.	2½	3	4	
Head to be pumped against ..	358	162	186	194	
Lowest take-off level ..	2741.71	2918.0	2897.0	2895.0	
Delivery level in settling ponds.	3090.0	3090.0	3090.0	3090.0	
Areas of reservoirs at F. S. L.	84.76 acres.	361.0	334.6 acres.	338 acres.	
Capacities of do. at do. ..	60.54	123.4	106 M.C. feet.	118 M.C.F.	
Total catchment area ..	9	13	16.6	36 sq. miles.	
Free do. do. ..	9	5.0	3.6	15	
Dam ..	1,92,740	25,650	30,500	16,000	
Engines, pumps and boilers ..	63,000	40,000	44,000	45,000	
Connection with reservoir ..	1,000	1,500	1,500	1,500	
Pump well ..	1,500	12,000	12,000	12,000	
Engine and boiler-house ..	12,000	3,000	3,000	3,000	
Chimney ..	6,000	14,000	14,000	14,000	
Quarters for establishment ..	14,000	1,15,400	1,51,900	1,94,400	
Supply main ..	2,57,000	37,350	37,350	37,350	
Settling ponds ..	37,350	36,860	36,860	36,860	
Filters ..	36,860	53,430	53,430	53,430	
Service reservoir ..	53,430	2,29,744	2,29,744	2,29,744	
Town distribution ..	2,29,744				
Compensation for land submerged by reservoir ..	85 acres at Rs. 100 8,500	100 acres at Rs. 100 57 acres at Rs. 150 18,550 Assessment X 10 10,770	200 acres at Rs. 100 50 acres at Rs. 200 30,000	68 acres dry at Rs. 100 87 acres wet at Rs. 150 19,850 Assessment X 10 13,500	87 acres wet at Jakkur tank submerged by raising of Rachanahalli tank.
Compensation for land deprived of water.	..	..	..	..	..
Total ..	9,02,124	5,98,254	6,55,054	6,76,634	
Annual cost of working ..	91,000	61,000	65,500	68,000	
Cost of water per 1,000 gallons ..	Rs. 0 5 9	Rs. 0 3 3	Rs. 0 4 3	Rs. 0 4 6	

SUPPLEMENTAL.

BANGALORE WATER-SUPPLY.

COMPARATIVE STATEMENT showing cost and other particulars of the various schemes proposed for a combined supply to Garrison and Cantonment.

	MAGADI ROAD, MALIGAL.	HEBBAL TANK.	NAGAVARAM.	RACHANAHALLI SCHEME.			Remarks.
				For 12 months' supply.	Supply for 12 months.	Supply for 18 months.	
Distance from source of supply to service reservoir.	5 miles.	2½	3.	4	4	4	
Head to be pumped against ..	358	162	186	194	194	194	
Lowest take-off level ..	2,741.71	2,918.0	2,897.0	2,895.0	2,895.0	2,895.0	
Delivery level in settling ponds ..	3,090.0	3,090.0	3,090.0	3,090.0	3,090.0	3,090.0	
Areas of reservoirs at F.S.L. .	84.76 acres.	361.0	334.6 acres.	338 acres.	461 acres.	935 acres.	Of this 685 acres belong to Rachanahalli water spread.
Capacity of do. do. .	60.54	123.4	106 M.C. ft.	118 M.C. ft.	210 M.C. ft.	339.44	Of this 400 acres belong to Jakkur.
Total catchment area ..	9	13	16.6	36 sq. miles.	36	36	
Free do. do. .	9	6.0	3.6	15	15	15	
Height of bund above present weir level.	..	..	..	14½ feet.	20 feet.	25½ feet.	Top of bund 7 feet above F.S.L.
Dam ..	..	Rs.	Rs.	..	..	..	To store 18 months' supply of water
Engines, pumps and boilers ..	1,92,740	25,650	30,500	16,000	30,500	52,000	Magadi road add Rs. 7,530.
Connection with reservoir ..	63,000	40,000	44,000	45,000	45,000	45,000	
Pump well ..	1,000	..	..	..	..	..	
Engine and boiler house ..	1,500	1,500	1,500	1,500	1,500	1,500	
Chimney ..	12,000	12,000	12,000	12,000	12,000	12,000	
Quarters for establishment ..	3,000	3,000	3,000	3,000	3,000	3,000	
Supply main ..	14,000	14,000	14,000	14,000	14,000	14,000	
Settling ponds ..	2,57,000	1,15,400	1,51,900	1,94,400	1,94,400	1,94,400	
Filters ..	37,350	37,350	37,350	37,350	37,350	37,350	
Service reservoir ..	36,860	36,860	36,860	36,860	36,860	36,860	
Town distribution ..	53,430	53,430	53,430	53,430	53,430	53,430	
Compensation for land submerged by reservoir.	2,29,744	2,29,744	2,29,744	2,29,744	2,29,744	2,29,744	
	85 acres at Rs. 100.	100 acres at Rs. 100.	200 acres at Rs. 100.	68 acres dry at Rs. 100.	191 acres dry at Rs. 100.	315 Rachanahalli, 245 Jakkur, 87 wet at Rs. 150.	
	..	67 " at " 150.	50 " at " 200.	87 acres wet at Rs. 150.	87 acres wet at Rs. 150.	87 wet at Rs. 150.	
	8,500	18,550	30,000	19,850	32,150	68,500	Twice the assessment of small up-tanks.
	..	Assessment X 10.	..	Assessment X 10.	Assessment X 10.	Assessment X 10.	• Vide para. 8 of addendum to report.
Compensation for land deprived of water.	..	10,077	10,770	13,500	13,500	13,500	Ten times the assessment of land under the Rachanahalli tank (vide para. 8 of addendum to the report).
Total ..	9,02,124	5,98,254	6,55,054	6,76,634	7,06,634	7,64,484	
Annual cost of working ..	91,000	61,000	65,000	68,000	69,200	71,600	
Cost of water per 1,000 gallons ..	Rs. 0 5 9	0 3 3	0 4 3	0 4 4	0 4 5	0 4 7	

(Signed) J. C. LARMINIE,
Executive Engineer.

4th March 1889.

BANGALORE WATER-SUPPLY.

COMPARATIVE STATEMENT of annual working expenses for the Rachanhalli Tank Project.
Estimates to store a supply for three different periods.

	ESTIMATE PERCENTAGES AND WORKING EXPENSES.								
	For 12 months' supply.			For 18 months' supply.			For 24 months' supply.		
	Item of estimate.	Per cent.	Annual charge.	Item of estimate.	Per cent.	Annual charge.	Item of estimate.	Per cent.	Annual charge.
Machinery	Rs. 45,000	15	6,750	Rs. 45,000	15	6,750	Rs. 45,000	15	6,750
Iron piping valves, &c. ..	1,94,140	7	13,589	1,94,140	7	13,589	1,94,140	7	13,589
Do. distribution ..	2,29,744	7	16,082	2,29,744	7	16,082	2,29,744	7	16,082
Balance of estimate on which ordinary interest is charged ..	2,07,750	4	8,310	2,36,750	4	9,470	2,95,600	4	11,824
Total of estimates ..	6,76,634	..	..	7,05,634	..	..	7,64,484	..	..
Establishment.									
One Head Engineer on Rs. 200 ..	..	..	2,400	..	..	2,400	..	..	2,400
Two engine-drivers on Rs. 20 ..	..	..	480	..	..	480	..	..	480
Four stokers on Rs. 8 ..	..	..	384	..	..	384	..	..	384
One Superintendent of Filters and Distribution on Rs. 15 ..	..	..	180	..	..	180	..	..	180
Four lascars or turn-cocks on Rs. 7 ..	..	..	336	..	..	336	..	..	336
Cleaning filters and settling ponds ..	..	..	5,000	..	..	5,000	..	..	5,000
920 lb. per hour.	..	..	11,482	..	..	11,482	..	..	11,482
Small stores ..	3,744 hours	..	1,900	..	..	1,900	..	..	1,900
Total annual cost of 250 million gallons ..	..	..	66,893	..	..	68,053	..	..	70,407
Contingencies, repairs, &c. ..	..	..	1,107	..	..	1,147	..	..	1,193
Total cost for 250 million gallons ..	..	..	68,000	..	..	69,200	..	..	71,600
Rate per 1,000 gallons delivered .. Rs.	..	..	0 4 4	..	..	0 4 5	..	..	0 4 7

(Signed) J. C. LARMINIE,
Executive Engineer.

4th March 1889.

From Sir J. A. HANBURY, M.B., K.C.B., Surgeon-General, Her Majesty's Forces, to the Secretary to Government, Public Works Department, dated Ootacamund, 25th March 1889, No. 822.

In reply to your letter No. 1223 C., dated 9th instant, I have the honor to inform you that, basing my opinion on the statement of analysis received from you, I consider the water of good quality and fit for the use of the troops and townspeople.

From Surgeon-Major J. A. LAING, Sanitary Commissioner for Madras, to the Secretary to Government, Public Works Department, dated Ootacamund, 10th April 1889, No. O/1.

With reference to your letters, Nos. 1222 C. and 1620 C., received 11th March and 1st April, I have the honor to state that I have visited Bangalore and inspected the catchment basins mentioned in Mr. Larminie's reports,* and submit the following remarks as regards the quality of the waters.

* Herewith returned as requested with map.

2. In deciding upon a water-supply, the value of the supply must be determined by a local examination of such proximate and remote conditions as may affect its

purity. The cleanliness and nature of the gathering grounds, extent of cultivation, the amount of manuring, &c., and points of a similar kind have to be considered and supplemented by a chemical examination. In the schemes mentioned in Mr. Larminie's report, the tanks or reservoirs are to be filled with the rain-water that runs over the surface; so the cleaner that surface is the purer will be the water collected. In none of the schemes, however, will the water be entirely free from the risk of contamination from surface drainage, as in each catchment area there are villages and manured cultivated lands. The gathering ground of the Magadi road scheme is one which is least objectionable and which is most promising as regards the purity of the water. In this catchment area there are very few villages (and those are small ones), very little cultivation, and that with crops but slightly manured. The catchment area of the Hebbal, Rachanhalli and Nagavaram schemes cannot be considered at all clean, and, as they at present stand, could not be expected to give a wholesome supply of water. Cultivation is carried on in them to a considerable extent, and in places with crops which are highly manured and in the Hebbal and Rachanhalli catchment areas there are also many villages. The waters of the Hebbal, Rachanhalli and Nagavaram tanks or reservoirs would therefore be liable to dangerous contamination as they would not only flow over highly-manured cultivated lands, but the tanks would also receive the surface filth of the villages situated in their catchment areas.

3. While at Bangalore I requested the Deputy Commissioner to favor me with the number of villages, population of each, extent and kind of cultivation in each catchment area; but this information has not yet been received. I will forward it immediately I receive it.

4. From an examination of the catchment areas the Magadi road scheme, as mentioned above, is the one which will give, as regards quality, the best water, and this is also borne out by the chemical analyses, copies of which I have received this morning from the Chemical Examiner and herewith enclose. It is not stated at which part of the stream (Magadi road) the sample was taken, but, if this was known, the amount of nitric acid, &c., found on analysis might be explained. According to Mr. Larminie's report, dated 2nd February 1889, *vide* para. 11 (4), the water of the Magadi road scheme, which was analysed, was taken from the stream under unfavorable circumstances, yet the results show it to be a much better water than either that of the Hebbal or Dhasarhalli (Rachanhalli) tanks. The remarks made regarding the Magadi road water apply also to the Hebbal and Dhasarhalli tank waters, but to a much greater extent. From an examination of the catchment areas and from the chemical analyses, the Hebbal and Dhasarhalli water-supplies are shown to be subjected to annual pollution, and as there is always danger lurking in a water which is known to be contaminated with animal matter, they are not in my opinion advisable sources of drinking-water supplies. The scheme therefore which I would recommend is the Magadi road one, as from a sanitary point of view it undoubtedly would give purer water than either the Hebbal or Dhasarhalli.

ENCLOSURES.

					Magadi road.
Total solids	...	Grms. per litre	...	...	0.250
Volatile solids	...	Do.	...	...	0.070
Chlorine	...	Do.	...	...	0.011
Total hardness	...	Clark's scale	...	...	2.450
Permanent hardness	...	Do.	...	...	0.875
Free ammonia	...	Mlgrms. per litre	...	...	Trace.
Albumenoid ammonia	...	Do.	...	...	0.200
Nitric acid	...	Do.	...	(as ammonia)	0.300

Apparent quality of the water as inferred from the results obtained on examination Nil

Remarks.—The physical characters of the water are unfavorable; the thick reddish sediment under the microscope showed abundance of siliceous particles ("river sand"), a few infusoria and masses of disintegrating vegetable tissue. The volatile solids are suspiciously high and the albumenoid ammonia excessively so, probably due to vegetable pollution, but the

amount of nitric acid indicates the necessity for a careful sanitary survey of the catchment area, in the neighbourhood of the position at which the sample was taken, in order to make sure of the absence of any sources of animal pollution.

		No. I Hebbal tank, 5 miles north of Ban- galore.	No. II. Dhasarahalli tank, 6 miles north of Ban- galore.
Total solids ...	Grms. per litre ...	0.460	0.220
Volatile solids ...	Do. ...	0.090	0.110
Chlorine ...	Do. ...	0.014	0.025
Total hardness ...	Clark's scale ...	2° 100	2° 800
Permanent hardness ...	Do. ...	1° 750	1° 575
Free ammonia ...	Mlgrms. per litre ...	Trace.	Trace.
Albumenoid ammonia ...	Do. ...	0.240	0.200
Nitric acid ...	Do. (as ammonia) ...	0.750	0.600

Apparent quality of the water as inferred from the results obtained on examination ... Suspicious. Suspicious.

Remarks.—Large amount of vegetable matter present in water, also fine clay sand.
(Signed) J. L. VAN GEYZEL,
Chemical Examiner.

ORDER—dated 18th May 1889, No. 1326 W., Public Works.

With G.O., dated 16th July 1888, No. 2147 W., was forwarded to the Government of India a note by the late Chief Engineer Colonel Hasted, R.E., on the several schemes for supplying water to the troops in Bangalore which had been elicited by the offer of a prize of Rs. 1,000 by this Government, and in pursuance of the recommendations therein made, Mr. J. C. Larminie, Executive Engineer, was placed on special duty to work out those of the suggested schemes which appeared most promising. His reports are read above, and also those of the Surgeon-General, Her Majesty's Forces, and the Sanitary Commissioner, Madras, on the quality of this water, and of the sources in question.

2. The schemes investigated by Mr. Larminie were—

- (1) *The Mágadi Road Scheme*, which was that proposed by Mr. Standish Lee in the prize essay. Two projects for supply from the Mágadi road valley have been investigated, the one to yield sufficient for the whole civil and military station, and the other for supply for the troops alone.
- (2) *The Hebbal Valley Scheme*.—General Fischer proposed to utilize this valley as a source of supply for the troops and the civil and military station, and for the pettah or native town, or a population of 150,000 in all; but it has been shown that this is impracticable and Mr. Larminie's project for this valley contemplates supplying the civil and military station (i.e., the troops and cantonment) only.
- (3) *The Nagavaram Scheme*, which contemplates the utilisation of the Hebbal catchment area in addition to a further tract lower down, involving a higher lift.
- (4) *The Rachanhalli Scheme*, which depends upon a valley lying to the north of the last two. All these schemes are similar in character and propose the construction of storage reservoirs whence the water is to be pumped to a service reservoir on the Mantapam hill. After filtration it is to be distributed thence by gravitation to the cantonment and barracks. The quantity intended to be provided is a year's supply at $12\frac{1}{2}$ gallons per head per diem for 5,000 troops and $6\frac{1}{2}$ gallons for the remaining population of the civil and military station taken at 100,000. The garrison supply scheme provides only for the troops at $12\frac{1}{2}$ gallons per head per diem.

3. The following are particulars of the cost, &c., of the several schemes as worked out by Mr. Larminie:—

For a year's supply.	MAGADI ROAD.		Hebbal.	Nagavaram.	Rachanhalli.
	Civil and Military station.	Garrison only.			
Cost for works ...	RS. A. P. 9,02,124 0 0	RS. A. P. 2,34,130 0 0	RS. A. P. 5,98,264 0 0	RS. A. P. 6,55,054 0 0	RS. A. P. 6,76,634 0 0
Annual charges (including interest and depreciation) ...	91,000 0 0	20,000 0 0	61,000 0 0	65,500 0 0	68,000 0 0
Cost per 1,000 gallons ...	0 6 9	0 14 0	0 3 3	0 4 3	0 4 6

The Government are of opinion that any scheme to be satisfactory should provide for the storage of at least 18 months' supply; and the cost of this has been estimated for the Mágadi road and Rachanhalli projects, and also of a two years' supply in that last named. From paras. 63, 64, 70 and 71 of Mr. Larminie's report it appears questionable whether more than one year's supply could be counted on or stored at Hebbal or Nagavaram, and certain that the additional cost would be very great. The following are the results for the larger supplies in the Mágadi road and Rachanhalli projects:—

	MAGADI ROAD.		RACHANHALLI.	
	One and half years.		One and half years.	Two years.
Works ...	RS. A. P. 9,79,754 0 0	RS. A. P. 7,05,634 0 0	RS. A. P. 7,64,484 0 0	RS. A. P. 7,64,484 0 0
Annual charges ...	94,105 0 0	69,200 0 0	71,600 0 0	71,600 0 0
Cost per 1,000 gallons ...	0 5 11	0 4 5	0 4 5	0 4 7

4. From the figures above given, it appears that the garrison supply scheme may be left out of account, and that the Hebbal scheme, for one year's supply, is the cheapest. As regards quality of the water, the Mágadi road catchment gives by far the purest supply, and that of Rachanhalli is appreciably better than that of either Hebbal or Nagavaram. The Surgeon-General, Her Majesty's Forces, is of opinion that the Rachanhalli water is of good quality and fit for the use of the troops and towns-people; but the Sanitary Commissioner after an examination of the catchment areas gives unqualified preference to the Mágadi road scheme, and considers the others dangerous as the catchments contain villages and cultivated and manured lands. The Governor in Council while admitting that the objections of the Sanitary Commissioner have force, observes that they apply also in some degree to the Mágadi road basin, which itself is not quite clear of cultivation. The cost of obtaining a catchment of adequate extent and free from the dangers adverted to anywhere near Bangalore would be prohibitive, and the Governor in Council considers that the water of any of the sources examined may be regarded as practically safe, and that the opinion of the Surgeon-General may be accepted. There is no doubt that any of them will be, so far as quality is concerned, a vast improvement on the existing supply.

5. The Rachanhalli scheme presents undoubted advantages over Hebbal and Nagavaram. These as being nearer Bangalore are more exposed to contamination by manure; the basins are not so favorable either for catchment or storage; and the quantity of supply, if sufficient can be obtained at all, is much less assured. The Jakkur tank being superseded, the "free catchment," i.e., the area draining directly into the Rachanhalli reservoir, will be treble that at Hebbal and nearly double that at Nagavaram. There is no doubt at all that an ample supply can be obtained from the Rachanhalli valley, and the cost of the water is hardly in excess of that at Nagavaram. As compared with Mágadi road the water may be somewhat less

pure, but the considerably larger catchment at Rachanhalli and the great cheapness far outweigh this disadvantage in the opinion of the Governor in Council.

6. A further reason why the Rachanhalli should be preferred to the Mágadi road scheme is that the appropriation of the latter valley would interfere with the claims of the Mysore Government upon it as the most natural and attainable source of supply for the pettah or native town of Bangalore. The lift from it to supply the pettah would be much less than is necessary to gain command of the civil and military station, and it may be said roughly that $1\frac{1}{2}$ years' supply for the latter would be only a year's supply for the two together. It is, moreover, doubtful whether the catchment area as taken by Mr. Larminie would yield $1\frac{1}{2}$ years' supply for both the cantonment and native town. With the claims of the pettah, on Sankey's tank, adverted to in the papers forwarded with the Resident's letter read above, the Government of Madras has nothing to do; but the Governor in Council is strongly of opinion that, whatever be done as regards the supply of the pettah, it is very desirable that an independent source should be adopted for that of the cantonment and the troops.

7. For the foregoing reasons, His Excellency the Governor in Council resolves to recommend to the Government of India the adoption of the Rachanhalli scheme, for at least an 18 months' supply, as the most suitable. How this scheme is to be financed and how this burden should be shared between the military budget and the municipality are matters for the decision of the Governor-General in Council.

8. Ordered that the following letter be addressed to the Government of India, Military Department.

(Here enter No. 1327 W., dated 18th May 1889.)

(True Extract.)

(Signed) R. R. E. DRAKE-BROCKMAN, Lt.-Col., R.E.,
Ag. Joint Secy. to Govt., P.W.D.

To the Political Department, for communication
to the Resident in Mysore.

„ Military Department.

LETTER—to the Secretary to the Government of India, Military Department, dated
Gotacamund, 18th May 1889, No. 1327 W.

I am directed to forward, for the consideration and orders of the Government of India, copy of the Proceedings of this Government, No. 1326 W., dated 18th May 1889, containing certain papers relative to the water-supply of Bangalore and expressing the views of Government thereon. In doing so I am to commend the project called the Rachanhalli scheme to the favorable consideration of the Governor-General in Council.

(Signed) R. R. E. DRAKE-BROCKMAN, Lt.-Col., R.E.,
Ag. Joint Secy. to Govt., P.W.D.

Exd. J. Henricus.
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14

BUILDINGS AND ROADS.
MILITARY WORKS.

Govt. of {1889} Madras.

PUBLIC WORKS.

Dated May, 18th

Recd.

Encl.

G.O., 18th May 1889, Nos. 1326 W.,
1327 W.

MAY.

Water-supply of Bangalore

For forwarding copy of Proceedings on report from Mr. Larminie, Executive Engineer, on the several schemes for the —, and recommending for favorable consideration the project called the Rachanhalli scheme.

16TH JULY 1888, No. 2147 W., PUBLIC WORKS.

GOVERNMENT OF MADRAS.

PUBLIC WORKS DEPARTMENT.

Buildings and Roads.
Military Works.

READ—the following paper:—

Note by the Chief Engineer, Public Works Department, dated 7th July 1888.

ORDER—dated 16th July 1888, No. 2147 W., Public Works.

The investigations made of late years with the object of obtaining a pure water-supply for the troops stationed at Bangalore having failed to produce an efficient and economical scheme, the Government resolved to offer a reward of Rs. 1,000 for the best essay on the subject, on the conditions specified in the notification published in the *Fort St. George Gazette* of the 1st November 1887, and subsequent issues; the award being left to the Chief Engineer, Public Works Department.

2. A number of essays have been received in compliance with this invitation, and have been carefully examined by the Chief Engineer, who awards the prize to Mr. Standish Lee, Sanitary Engineer, Mysore. The sum of Rs. 1,000 will accordingly be paid to Mr. Lee by the Executive Engineer at Bangalore, and will be adjusted against Military Works under instructions from the Examiner, Public Works Accounts.

3. The essay submitted by Mr. A. H. Garratt, Executive Engineer, Bellary, is, in the opinion of the Chief Engineer, a very good one, and does him great credit. The essay of Mr. S. Tomlinson, Deputy Chief Engineer, Bombay Water Works, is also, in Colonel Hasted's opinion, a very creditable paper. Both these essays came near to winning the prize.

4. A copy of these Proceedings will be published in three successive issues of the *Fort St. George Gazette* for the information of competitors.

(Here enter No. 2148 W., dated 16th July 1888.)

(True Extract.)

(Signed) J. O. HASTED, Colonel, R.E.,
Secretary to Govt., P.W.D.

To the Superintending Engineer, V Circle.
„ Examiner, Public Works Accounts.
„ Military Department.
„ Superintendent, Gazette Press.

ENDORSEMENT—dated 16th July 1888, No. 2148 W., Public Works.

Copy of the above forwarded for the information of the Government of India, Military Department.

(Signed) J. O. HASTED, Colonel, R.E.,
Secretary to Govt., P.W.D.

Exd. F. R. Bantleman.
Spare Copies

BUILDINGS AND ROADS.
MILITARY WORKS.

Govt. of (1888) Madras.
PUBLIC WORKS.

(1)

Dated July, 16th.

Recd.

Encl.

G.O., 16th July 1888, Nos. 2147,
2148 W

JULY.

Bangalore Water-supply Scheme

Forwarding to the Government of India, for information, Proceedings of this Government awarding to Mr. Standish Lee, Sanitary Engineer, Mysore, the prize of Rs. 1,000 offered for the best essay on the —.

1326/1327
No. 19. Office of the Dewan of Mysore
Camp Mysore, 3rd December 1888.

From,

H. Hushadri Iyer Esquire, C.S.I.,
Dewan of Mysore.

To,

General Sir Harry Prendergast,
Rt. C. B., V. C.,
Resident in Mysore.

Sir,

In reply to your Office letter No. 2440 of the 10th July 1888, forwarding, for the opinion of His Highness the Maharajah's Government, copy of a note by the Chief Engineer, P.W.D., Madras, on the subject of the water-supply of Bangalore, I have the honor to forward herewith for your information copy of a note thereon by the Superintending Engineer of Mysore, which gives expression generally to the views entertained by the Durbar, regarding the merits of the various schemes proposed.

2. I fully agree with Colonel Hasted in his opinion that Senkey's Reservoir cannot contain a pure supply, so long

as the Rifle Ranges remain in their present position at the head of the basin. Their removal, I would add, appears equally necessary, whether the Reservoir is intended to supply the Petta or Cantonment. But this Reservoir by itself is, in my opinion, quite insufficient for the supply of the Petta. Colonel Hasted (in para. 22) estimates that it will supply a population of 50,000 at $\frac{1}{4}$ fallous a day. Experience in the Mysore City where only a few fountains have yet been erected, goes to show that about $\frac{6}{11}$ fallous would be the lowest rate per head which any proper water-supply scheme should provide for. The Durbar are already carrying out some works intended for a supply to a part of the Pettah, by means of the leakage from Sankar's Reservoir. The supply thus obtained has to be considerably supplemented before a suitable scheme for the Pettah can be worked out. Both by reason of proximity and the lower lift required, the Magadi valley is more appropriate for the supply of the Pettah than that of the Civil and Military Station, but the Durbar will refrain

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refrain from any further investigation of the capabilities of this valley for the Petta supply, until some definite decision is arrived at by the British Government, as to utilizing it for the Civil and Military Station and the Troops.

3. On the subject of the use to which Sankar's Reservoir is to be put, I have nothing to add to the observations in Mysore D.P.W. Secretary's letter to Assistant Resident, No. 1540 dated 14 April 1880, nor do I consider it necessary in this place to refer to the very unreasonable views entertained by the Station Municipality on this subject. The Durbar will gladly agree to any arrangement which is convenient to the British Government. They would gladly have the full use of this Reservoir so as to be able to utilize it for the partial supply of the Pettah, and in that way, obtain some return, however small, for the large capital sunk in it. Or, if the British Government prefers to utilize it for the supply of the Troops and the Station in accordance with the original object of its construction,

them, in that case, the Durbar will be satisfied with receiving some moderate return therefrom, as contemplated in the orders of the Government of India in letter No. 304C dated 25th June 1869.

4. Under such circumstances, it appears to be somewhat premature now to discuss the question of any exchange as between this Reservoir and the Magadi valley, which is mooted by Colonel Hasted in para. 22 of his note, and I have only to add that the Durbar will offer every facility in their power for the investigation and execution of the Magadi valley or any other scheme by the British Government.

Shaw &c.

(sig) H. Phishadri Esq.
Dewan.

Copy.

Henry Alcock
Resident

No. 4366
371-8.

210

FROM

THE RESIDENT IN MYSORE.

CHIEF SECRETARY
GOVERNMENT OF MADRAS
3 DEC 83

To The Chief Secretary to the Government
of Madras.

Dated, Bangalore, 22nd December 1888.

SIR,

I have the honour, with reference to your letter No. 479, dated 14th July 1888, to forward copies of a letter from the Dewan, and of a Memo by the Secretary to Government, Public Works Department, Mysore, on the subject of Colonel Hasted's note on the Bangalore Water supply.

2. I am of opinion that Sankey's Reservoir is capable of improvement

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No. 19 dated 3rd December 1888

so that it might be far more useful than at present, and there is no doubt that water from the Hebbal Tank can be raised to supplement the supply for the Civil and Military Station and the Garrison, or that a supply for the Civil and Military Station and Troops can be pumped from one of the Tanks near the head of the Pennakini River, or that a good supply, far more to be relied on than any of the above, can be stored in the Hassargutta Tank in the Arkavathy Valley, but the object of the Madras Government seems to be to obtain the purest water available for the Troops at a moderate cost, and I think that the clearest source of supply within ten miles of the

Barracks

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Barracks is the streamlet, an affluent of the Arkavathy River, that might conveniently be impounded near the 5th mile stone on the Magadi Road.

3. Mr. Laminie has been deputed to examine the projects for obtaining water from the Arkavathy and Pennakini Valleys, when his reports give the means for ascertaining which project is capable of giving the needful supply at the cheapest rate, it will be possible to determine whether one reservoir should supply the Troops and the Civil and Military Station, or the Troops and the Pettah, or the Troops and both Station and Pettah.

When

When a project has been selected for
execution it will be a fit time to settle
the respective rights of the Government
of India and of the Government of Mysore
to the water in Sankey's Reservoir.

I have the honor to be,

Sir,

Your most obedient servant,

Wm. Lindsay

Officiating Resident.

Wm.

Vote. 1326/327 6 gr

The Chief Engineer's note on the
Bangalore Water Supply deals with
the several essays submitted in re-
ponse to the Notification of the
Madras Government, offering a
premium for the best solution of
the water difficulty. In so far as
Col. Hasted's recommendations -
affect Mysore, I have to offer the
following remarks.

2. The first point requiring
consideration and settlement, is the
right to Sankey's Land, the subject
of paras 2, 3, 4 and 5 of Col. Hasted's
Memorandum. In my
note of 14th April 1888, I endeavoured
to explain so far as I could, the
position of the Mysore Govt. in
regard of this land, my remarks
concerning which appear to me still
to hold good. Col. Hasted observes

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However, that whilst the expenditure by the Mysore Govt. of nearly $5\frac{1}{2}$ Lakhs as the works constitutes a decided claim as their part to the tanks supply, the contention of the Municipality that the surplus Revenues of Bangalore may be assumed to have met the expenditure should not be lost sight of. In disparaging of this argument, it must not be thought, be forgotten that prior to the revision the surplus revenues of the Province, as a whole, were given to the Public Works generally, according to the necessities of the various claims and in the order of their relative importance, and the net result of this expenditure of the surplus Revenue was, in consequence of the famine, a State debt of 80 Lakhs at the revision. It is not unreasonable for me

* This should be so.

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to infer that, had the Opporhully water Supply Scheme never been attempted, either this debt would have stood at $74\frac{1}{2}$ Lakhs, instead of 90, or that the $5\frac{1}{2}$ Lakhs spent therein would have gone to other Works from which the Mysore State would have been deriving a direct benefit; or, had the Scheme proved a success the Municipality and the Military Dept. would have been paying to the Mysore Government a moderate percentage on the outlay incurred. As it is, not only does the burden of the outlay rest on Mysore, but the Municipality claims sole right and title to the results of that outlay and declines to meet any charges whatever therefor. However, an early settlement of this question is most desirable. As matters now stand

the Public Works Department of Mysore are hampered by the rival claims of St. John and Pettah, and have to incur an annual outlay on the maintenance of its feeders, without being able, at same time, to improve them in any way.

3. I may note here an error in para 14 of the Memorandum, into which Col. Hasked has apparently inadvertently fallen, as regards the possible reduction of loss by leakage. It was as to 16 Million cubic feet, not to a mean between $12\frac{1}{2}$ and 15 Million, that Major Kensington thought, might be reduced, the loss from evaporation and leakage combined, which General Mullins computed to be $20\frac{1}{2}$ Million cubic feet.

4. As regards the merits & demerits of General Fischer's Hebbal

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Scheme, and Mr. 1327 ¹³²⁷ Hasked Lee's Nagard Road Valley Scheme, I have already submitted brief notes - embodying my views. Both these involve the cession of land appertaining to Mysore, but until it is decided finally whether one or other of them is to be taken up, the question of Compensation need not be worked out.

5. As regards the Second Pennathur drainage Scheme - Major Kensington's. I have not had the opportunity of going into it carefully, but, I have personally expressed to Col. Hasked what I thought about it. I agree in his remarks thereon, paras 13, 14 & 15. I doubt whether as this Scheme being thoroughly worked out, it will have any special advantages over a modified project for the Hebbal Tank. Here again Compensation

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would be a serious element, and the interference with the supply of other tanks will have to be considered. The only other point in the papers in which Mysore is directly interested is, the decision of Colonel Hackett recorded in his para 22, that the troops and the Civil and Military Station should receive their supply from the Magadi Road Valley, Laukey's tank being left for the supply of the Pettah. The Magadi Road Valley, it is clear is the most suitable place for the supply of the Pettah, and this being the case and Laukey's tank not affording an ample supply, however much we may improve it, it is not obvious why the Pettah should relinquish its claims to this valley in favour of the Civil and Military Station. The troops only might certainly

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draw their supply from this Valley without detriment to the Pettah, and if the Magadi Road Reservoir is to be constructed, it might be utilized for the troops and the Pettah, not for the troops and the Civil and Military Station, the cost being borne by the Military Deptt. and the Pettah Municipality, in the proportion of the quantity of water drawn off by each. I presume the Pettah Corporation will not object to such an arrangement, and will be prepared to meet their share of the outlay necessary.

7. The proposal that the rights to Laukey's tank should be a set off against the grant of the Magadi Road Valley by Mysore for less than the actual value of the land is

hardly as fair as, as the title
to Laukey's Tank stand as
grants altogether apart from
the question now raised. This
would be equivalent to making
Mysore pay more for Laukey's
tank than they have paid
already without obtaining there-
from any adequate return.

D. If what I have advanced
above meet with approval, the
project to be worked out would
be the construction of a service
reservoir near the Pettah to be
supplied from the Magadi
Road Valley with water sufficient
for 50,000 people, minus what
can be sent down from Laukey's
Tank, plus 60000 gallons for
the troops. The cost of this to
be borne by the Military de-
partment and the  Pettah.

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Municipality in the proportion
of the water given to each. The
Military department would
then set up their Ulloor Engines,
pumps, and mains to send up
the water from the above service
Cistern to the service cisterns in
the Barracks.

Sd/- C. Bowen R.E.
Sup. Engineer
Mysore P.W.D.

Bangalore
27 July 1888 }

Copy.

M. Narain Rao.

Arch Form

Copy

Gen Clarke
Reyher

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27 January 1889

Transferred to
the Public Works De-
partment

Redmire

Chief Secretary

Thru,

The Resident in Mysore

No 4366
371-8

Dated 22/12/88

Reg 157/1/89

Encls. 2.
with 5 plans

7. 1. 89.

Forwarding
copies of a letter from the
Demand of a Memo by the
Secy to Govt. P.W. Dept on the
subject of Coll. Huated's note
on the Bangalore waterworks

Transferred

Report by J. C. ... 1210
29.12.88

Report to accompany the Estimate for Water-Supply
to the Cantonment and Garrison of Bangalore
and to the Estimate for supply
to the Garrison alone.

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In accordance with No. 3 reference, instructions were given for the investigation of two schemes for the supply of water to Bangalore.

REFERENCES.

- (1) Letter from the Government of India No. 1182 M. W. of 14th June 1887 recorded in G.O. No. 1924 W. of 18th July 1887.
- (2) G. O. No. 2310 W. of 20th October 1887.
- (3) Chief Engineer's Note printed with G. O. No. 2480 W—A of 14th August 1888.
- (4) Chief Engineer's Note printed with G. O. No. 25 W of 8th January 1889.

1st.—That proposed by Mr. Lee, to whose essay was awarded the reward of Rs. 1,000 (reference No. 2), and 2nd, that proposed by Major Kensington.

2. The instructions given were general, and were to the effect that, every item composing the estimates was to be gone into in minute detail and most carefully estimated for.

3. Accordingly, some time was devoted to consideration, from every point of view, of each detail. Mr. Lee's, commonly called the Magadi Road scheme, being the most promising, was first taken in hand.

4. The country was carefully examined to secure the best site for the dam, as also for the best and most economical line for the Supply Main to Bangalore, and endeavours were made to obtain further data regarding rain-fall and run-off.

5. Some time was also devoted to the preparation of a fairly accurate survey with levels and contours of the proposed Magadi Road Reservoir, site and the design of the masonry dam was made out in detail.

6. According to somewhat modified instructions received in December, approximate estimates, to admit of a comparison of the various schemes, were considered in the first instance sufficient. Had it been understood that sketch plans and estimates were only required, the work could have been done much sooner; as it is, the projects are now submitted well within the two months mentioned, (Reference No. 4.) However it is hoped that the time which has been devoted to minor detail will be of value hereafter. For, of the estimates herewith submitted, that for the Magadi Road scheme has been prepared in considerable detail, and is believed to be a very close approximation of what the work may be expected to cost.

7. To the Nagavara scheme, that for the Hebbal tank, and for the smaller scheme for the Garrison supply (instructions regarding the two latter received in December last) it has not been possible to devote so much attention. The surveys and estimates are however believed to be close approximations.

8. The accompanying comparative statement gives the leading features of the several schemes and their estimated cost. Each scheme will now be reviewed in detail. They have all been based on the same general data as laid down in the Chief Engineer's Note, and regarding which a few observations may, it is hoped, be permitted. (Vide paras 12 to 18.)

9. The more correct name for this scheme would be Maligal, near which Magadi Road or Maligal Scheme. *village it is proposed to construct the reservoir. The catchment area of 9 square miles (as measured on the Topographical Survey vide sheets 42 and 63) extends 3 miles to the north and 1 mile to the south of, 2 miles of the road from Bangalore to Magadi (4½ to 6½ miles).

*Situatd about one mile below the bridge over the stream at furlong stone 5 on the Magadi Road.

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10. In every particular except cost, it is by far the most promising of the three schemes investigated for the supply of the Cantonment and Garrison. But, provided a scheme is admitted to be promising in other particulars, the mere question of even a few additional lakhs to the cost should not, it is thought, weigh much against it. The comparative statement shows the small additional quantity of *water (some 20 M. C. feet extra for a year's supply) which has to be stored to provide for loss from evaporation, leakage, etc., owing to the favorable conformation of the reservoir site, a narrow deep valley, the area of waterspread at F. S. L. being 85 acres.

11. The other advantages are:—

Advantages of Maligal Scheme.

- (1) The whole of the catchment may be considered free.
- (2) Probably not more than one-sixth of the area is at present under cultivation; there is however a growing tendency to extend it, chiefly casuarina plantations; so the Mysore authorities have been requested to check its further extension for the present.
- (3) The catchment area chiefly consists of steep, bare lateritic Hills, from which personal observation showed that even moderate showers are very quickly run off (vide also para 18 of Chief Engineer's Note, reference No. 3.) In this connection also vide paras 17 to 19 regarding percentage of run-off.
- (4) Analysis of the water taken from the stream under unfavorable circumstances—shortly after a flood—shows it to be remarkably pure, and the accompanying table compares it with water from the other sources, as also with that now pumped up for the use of the Bangalore Garrison. Even in the driest season there is, it is stated, a small stream of pure water always flowing.
- (5) A supply for more than one year can be more advantageously stored here than elsewhere.

12. Regarding the quantity of water to be stored, i. e. 40 M. C. feet or only one year's supply. As a comparison between the various schemes, it may suffice to estimate for storing this quantity; but it is considered that with only one year's supply in store a bad season or two cannot possibly be tided over.

13. The minimum supply, 7 M. C. feet per square mile of catchment, which according to the accepted Mysore data might always, it was thought, be expected to flow off, cannot, it is now found, be counted on as a certainty.

14. Seven M. C. feet means 3.01 inches of rain, run off each square mile. Taking 17" as the lowest rain-fall 3.01" would be almost 18% of that total fall, while there is abundant evidence to show that, to obtain so high a percentage the fall must be in sharp heavy showers. Everything depends on the character of the rain fall. In the course of only an average year's fall (36 inches) provided that some of the falls come down in quick heavy bursts, the 18% might safely be counted on, while light continuous rain, although the 24 hours' fall might be high, would yield a much smaller percentage.

15. The lighter the annual rain-fall the smaller and fewer are the chances of obtaining heavy showers of short duration, so that in a season of minimum fall, it may happen and very probably will, that the run off, instead of being 7 M. C. feet per square mile, will be almost nil. (This, it is known, on the best authority, has already been experienced at the Mysore water works). Consequently, how essential would it not seem to store as large a supply as can consistently be done?

16. Two and even three years' supply have been advocated. The reports that have during these investigations from time to time been submitted regarding the Magadi Road scheme, advocated the storing of 1½ years' supply (60 M. C. feet), which requires, allowing for waste, evaporation, &c., as near as can be 100 M. C. feet in the reservoir. (Vide table of consumption and waste).

* 40 M. C. F. required for supply of the Cantonment and Garrison, so 60 M. C. F. must be stored for a year's supply.

17. That this quantity can be impounded in an average year is hardly open to question. The Mysore data gives 11 M. C. feet per square mile as the average, as deduced from Sankey's Tank, a most unfavorable catchment. As noted in para 18 of Chief Engineer's *Note, the run off of the Magadi Road catchment must be higher, and observations made during the course of these investigations give the following approximate results.

18. During the period 11th September to 2nd October last, the total fall from certain selected showers was 5.4 inches. This fall over the catchment (taken as only 8½ square miles) means 106.63 M. C. feet.

The quantity that passed down the stream was approximately computed to be 42.71 M. C. feet. $\frac{42.71}{106.63} = 0.4$ or 40 per cent average. Individual falls gave for ½ an inch in 1½ hours, (after a long period of draught) 3 per cent. Even on this occasion the stream began to increase half an hour after the rain commenced.

For a 2 inch fall	..	..	58 per cent.
" 1.3 "	..	..	29 "
" 1.1 "	..	..	40 "
" 0.5 "	..	..	30 "

Catchment by this time well wet.

All these were falls of short duration from 1½ to 3 hours.

19. But although the data is admittedly very approximate, still it suffices to show what may be expected in an average year. The year under reference was however under the average, as the total fall was only 34 inches.

20. To impound 1½ year's supply, 100 M. C. feet, 4.78 inches of rain must run off the 9 square miles of Magadi Road catchment, or only 13.3 per cent of an average year's fall.

21. The dam, to impound this quantity, should be 9½ feet higher than that for one year's supply now estimated for (see section), and the additional cost, as per detailed estimate, for a masonry and concrete dam for the full width of this section would be Rs. 177,630.

22. The advantages of the scheme are detailed in paragraph 11. The chief disadvantage will now be alluded to: it is that the run off being so very quick the water, even in small freshes, comes down highly charged with silt. It is consequently proposed not to draw off water below 13 feet above bed of stream at site of dam (level 33.48 on survey), thus utilizing a length of the river bed as a silt trap; with a view to keep this clear it is proposed to place two or more 3 foot iron pipe scouring sluices, worked by equilibrium valves in the foot of the dam, and a special design for these valves has been partly worked out. But even with all possible precautions it is feared that silting up will go on.

23. Messrs. Richardson and Cruddas, the well-known Engineering Firm of Bombay, have taken considerable trouble in furnishing particulars and cost of the best description of pumps and engines to work against the Heavy Heads involved in the three schemes, that of Magadi Road being greatest. The Heads in each case have been deduced as follows, Magadi Road being taken as an example.

Top water level in settling ponds	..	..	3090.0 M. S. L.
Lowest off take at Reservoir	..	..	2741.71
Actual lift...			348.29 feet
Pumps can be placed 25' above draw off	..	..	25
			323
Head allowed to overcome friction in supply main to Bangalore at 6' per mile	..	..	33

Total Head to pump against... 356 feet

181
24. It was specified that the pumps should be able to throw up a week's supply in six days of twelve hours, or at the rate of 66,540 gallons per hour.

25. For this work Messrs. Richardson and Cruddas recommend three sets of engines, pumps and boilers, any two of which working together shall work up to the required quantity, leaving a third (engine, pumps and boiler) in reserve.

26. They recommend, direct acting, compound condensing engines and pumps.

High pressure steam cylinder .. 21 inches diameter

Low pressure 36 inches.

Pumps 48 inches stroke .. 12 " diameter, and

Lancashire boilers each of 35 H.P. nominal.

Their estimate for three sets of the above delivered in Bangalore is Rs. 53,000.

27. An idea of the combined pump and engine can be obtained from the wood cut at page 35 of Messrs. Richardson and Cruddas' catalogue. The wood cut, however, does not represent a compound engine. It is extremely compact, each pump and engine only occupying a space of 28' x 31', so the three pumps can be arranged alongside in a room measuring about 48' x 35'. These pumps are made for lifts from 250 to 1,500 feet, for quantities of water from 3,000 to 50,000 gallons per hour.

28. A provision of Rs. 12,000 has been made for engine and boiler houses. A detailed estimate has not been made out, as one amounting to Rs. 9,260, based on very liberal rates, was framed in connection with the Agram Tank scheme; rather more accommodation will be required in this instance, for which the extra Rs. 2,940 will be sufficient provision.

29. The Agram Tank scheme estimate for quarters, Rs. 14,000, has also been adopted; provision is made therein for quarters for one European Engineer and two European or Eurasian drivers, for native stokers, and for a store room and office, the whole surrounded by a wall, &c. At Magadi Road (Maligal) a good site for the quarters will be on the Hill top above the right end of the dam.

30. As in Maligal Reservoir with one year's supply stored, there will be 31½ feet difference of level between highest and lowest water levels, and as pumps cannot be placed more than about 25 feet above the lowest level to be pumped from, to avoid the necessity of placing the pumps below engine level, it has been decided to place the pumps in rear of the dam, the site marked on the survey will be a suitable one. Although perhaps not so safe, as if placed above the dam and above M.W.L., the arrangement admits of the cheaper and more compact form of engine described.

31. To store one year's supply a dam 45 feet above present bed of stream at the proposed site will be required. At the centre section a height of 50½ feet has been allowed for; the cross section of the valley at site shows the various levels of foundations proposed; they are probably lower than will be found necessary.

32. The site selected is a little higher up the stream than that intended by Mr. Lee. At the latter, the line of strike of the rocks, with all the joints and fissures, are parallel to the axis of the stream, while higher up the line of strike is perpendicular to the river, and the bed of rock is much harder and sounder as far as can be judged by gullies, trial pits and other indications. This bed of rock extends all over the valley at no great depth.

33. Taking the Bhim Tal dam near Naini Tal as a precedent, it is proposed to form this dam of two outer skins or walls of coursed rubble in cement mortar, thus obviating the necessity for supporting planking when carrying up the concrete hearting of the dam. It was intended to use Portland cement for the entire mass of concrete, but the Chief Engineer being of opinion that an outer casing of cement concrete would be sufficient, the estimate has been framed accordingly, allowing for the rubble casing in front and rear, and a thickness of 2 feet of the concrete in rear of the front rubble face to be in cement mortar. The remainder of

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the concrete to be of ordinary lime mortar. The additional cost of the dam, laying all the concrete in cement, would be Rs. 77,353. 3,223 at Rs. 24, the difference of rates for cement and lime concrete. Probably a lighter section than has been estimated for near the flanks would suffice.

34. A diagram showing the section of the dam with the curves of pressure, and a table of weights and pressures and also the required dimensions if calculated by Molesworth's formula, accompanies the estimates.

35. After some consideration the right end of the dam was fixed on as the best site for a surplus weir; there is evidently a bed of rock at no great depth below the surface, a trial pit shows rock at level 55.0. The weir has been designed for a drop, still 5 feet lower, of a type which has been found to answer well and is much less expensive than a clear drop.

36. As designed the 150 feet of weir with a depth of 3 feet passing over, will discharge ½ an inch of rain per hour from the catchment of 9 square miles.

37. According to Mysore Public Works Department experience, as much as 1 inch per hour from a catchment of this area and description may occasionally be expected; but to provide a weir for so exceptional occasions seems unnecessary, as an arrangement might be made to pass such excessive rain-fall over the dam. The staff in charge of the pumping machinery could easily look after and work any simple arrangement decided on. Water so surplussing will fall on the rear slope of the dam, up to depth over crest of 3 feet.

38. As shown on the reservoir survey, the weir bye wash bed, is placed at +50 and carried along till this level runs out of cutting, where the surplus can be passed over the rock into an existing ravine. It is believed however that a rocky bed will be met with above this level (i. e. +50).

39. The left embankment of the bye wash can be formed from the cutting, provision is made for a substantial, grouted and pointed revetment to it, for a length of 400 feet below the weir rear wings.

40. The pump valves will be placed at level 53.48 or 25 feet above the lowest take-off level in the reservoir, from the pumps the supply main to Bangalore will be carried round the left side of the reservoir for a short distance and thence strike away in a north easterly direction, crossing the road from Bangalore to Magadi near furlong stone 5; thence the line will run, with three slight bends, to the Mantapam Hill, where it is proposed to place settling ponds, filters and service reservoir.

41. The line will not pass near the Pettah, and in selecting it (the line) the objects kept in view were to secure the shortest route, subject to facilities of laying and the avoidance of sudden rises and dips, two or three small ravines will have to be crossed, for which a lump sum provision has been made in the estimate, the cheapest arrangement will be to support the pipes on the rough stone posts so universally used, or on light bridges formed of old rails. The line crosses the Mysore State Railway to Tumkur about a mile north of the Pettah terminus.

42. As the pipes nearest to the reservoir have the heaviest Head to withstand, a heavier section of metal has been allowed, 1" in thickness for the first mile, 1½" for the next, and ¾" for all the rest. For practical reasons the pipes cannot well be of less thickness than ¾". A sufficient number of scour cocks, air and back or reflux pressure valves have been allowed for. All the items and rates have been carefully considered.

43. As noted in para 23, the size of the main has been calculated (as also for the other schemes) taking a head of 6 feet per mile, the week's supply being pumped up in 6 days of 12 hours 7,70,000 cubic feet = 2.96, say 3 cubic feet, required discharge per second. An 18" pipe by Kutler's formula will at 6' per mile, discharge rather more, or 3.4 C. per 1". However a 17" pipe would be too small, discharge 2.86 feet per 1"; so the larger size has been adopted.

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Messrs. Richardson and Cruddas, in connection with the engines, considered the size 18" as specified suitable.

44. It is proposed to construct these on the Mantapam Hill. The only disadvantage of this site is that it necessitates about a mile extra of supply pipe to the Cantonment, but there are several counterbalancing advantages.

Settling pond, filters and service reservoir.

- (a) The site is at the highest available level.
- (b) It is well away from all dwellings and their accompanying sources of contamination.
- (c) The land can easily be made available and no existing rights of any consequence will be interfered with.
- (d) The only other suitable sites are either the golf ground or the high ground; for the former floor of service reservoir should be placed at level 3030, for the latter 3040, thus reducing the head for distribution, and neither site affords the same facilities for construction, and they are besides much used as recreation grounds by the officers of the Garrison and other European residents. The constructions in question would completely spoil either.
- (e) The site selected on the slope of the Hill admits of the settling ponds, filters and service reservoir being arranged at suitable levels with reference to one another (vide Plan No. 14).
- (f) For either Hebbal or Nagavara schemes the one disadvantage noted disappears.

(g) Borings to a depth, lower than necessary for excavation, shew the soil to be pretty similar to that visible on the surface, i.e., hard compact lateritic soil; mixed with water the clay from the borings seemed almost fit for puddle, so that there can be no objection to constructing ponds, filters and service reservoir as proposed, i.e., in cutting, with a good facing of cement concrete laid on the slopes, cut into steps, if constructed with masonry sides, the works would be considerably more expensive.

45. The question of placing these works near the supply reservoir has been considered and the idea abandoned as it would involve additional pumping, as there is no suitable site below the reservoir where they could economically be constructed. The pumps proposed are specially adopted to the pumping of muddy water.

The plan shows the general arrangements.

46. The settling ponds have been designed for a depth of 8 feet of water, of which 7 feet can be drawn off leaving 1 foot of depth for silt accumulation, each pond to hold one day's supply.

Details. It will be a question for future consideration if a greater number of ponds should not be provided. With a view, to deliver the water into the ponds as quietly as possible, the supply main from the pumps will deliver into a large circular well, whence the water will be conveyed by iron pipes, regulated by valves, to masonry chambers, and thence by over falls which can be regulated by shutters, into the ponds.

47. From the ponds the water will be drawn off by means of adjustable (or floating) suction pipes, which the drawings will fully explain, into the filters.

48. Two have been provided for, each capable of filtering a day's supply in 24 hours, at the rate of 50 gallons per square foot per 24 hours. A liberal allowance as, 75 gallons is commonly taken as the duty of a filter. The draw off sluices from the filters to the service reservoir are arranged so that the necessary head on the filters can be arranged to any required extent, from 1 inch up to 3 feet, probably 18" will be found sufficient; the arrangements for turning the water from either settling pond to either filter are shown on the plan.

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49. Designed to contain rather more than three days' supply—with a view to keeping the water as cool as possible a roof formed by a series of flat brick arches has been provided. It is now

Service Reservoir.

generally admitted that service reservoirs should be so covered in. The rough stone pillars allowed for are universally used in Mysore and they are cheaper, cleaner and occupy less space than brick arches would. Rolled iron beams have been allowed for, but old railway rails would do equally well and would probably be cheaper.

50. Town distribution will now be described when the Magadi Road scheme will as a whole have been considered.

The remarks regarding the settling ponds, filters, service reservoir and distribution will be common to the other two schemes for the supply to Cantonment and Garrison, so there will be no need to recapitulate them.

51. The distance fixed, 600 feet, in a straight line, nearer than which water need not be brought to any house, greatly simplifies the system.

The proposed lines of piping are shown on the accompanying two sheets of the Topographical Survey of the Cantonment, and the statement of distribution details gives particulars of the various lines proposed.

52. The original intention was to have worked out the system in greater detail, by taking careful measurements and levels for each line, as also by the preparation of detailed drawings and estimates for each special curve and connection required (as was done for the Ootacamund distribution). But under recent instructions it was not possible to do all this, so the estimate is based on the survey, some of the lines have been levelled and many of the survey B. Ms. checked, and with one exception, the latter have been found to agree well with recently taken levels; some differences have also been found between the levels of the Troop supply cisterns.

53. All the levels connected with the various schemes are taken from B. M. No. 2 at the N. E. corner of the Golf ground opposite this office (No. 6 Bellary Road) gateway; this B. M. was recently moved, but has been again put in at the same level as that given for it on the Topographical Survey 3057.48 M. S. L. A connecting level to the S. W. corner of the office plinth gives a value to the latter of 3056.83. A list of the levels of various other points which have been levelled to accompanies.

54. For purposes of calculation the population has been taken:—Europeans 5,000, Natives 100,000; this latter figure is probably 6,000 over the actual at present, but the allowance of 6,000 for increase is not excessive. It has been decided to

*Reference No 3. allow 2 cubic feet per day for Europeans and one cubic foot for natives. To properly proportion the pipes statements of the population, street by street, would be required, but no such information is available in the Municipal Office; all that could be obtained was a statement of areas and population, and even this is very incomplete and does not include the whole of the population; however it has been used to some extent and partly by guess, the population has been divided amongst the various lines as shown in the distribution statement, and the sizes of the pipes thus deduced, seem reasonable enough, and are capable of distributing the required quantities in eight hours.

55. The statement of distribution fittings gives the particulars of the various fittings allowed for each line. The European Infantry Barrack cistern will be supplied by No. 2 branch of main line No. 4. This latter line will at its termination near Trinity Church join the existing supply pipes to the Cavalry and Artillery Barracks.

56. Probably here and there, short lengths of extra piping will be required to bring certain localities within the limit of distance, but there is ample provision in the estimate for such contingencies.

57. The rates allowed for actual pipe laying are much lower than were allowed at Ootacamund, but they are believed to be sufficient, each item, lead, yarn and excavation have been separately allowed for.

58. Of the two lines for the main from the reservoir to the bifurcation of the distribution mains, the alternative line to the west is some 700 feet shorter and will probably be preferable, the estimate has been made out for the other, but no great

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26/1 difference would result, as though the grade would be increased from $\frac{1}{253}$ to $\frac{1}{250}$, the discharge of the pipe would not be materially increased, and so its size $15\frac{1}{2}$ " could not well be reduced.

59. From the comparative statement of cost and other particulars, this scheme would at first sight seem most promising. The tank also is well calculated to attract popular attention, situated as it is on the high road to Bellary at no great distance from the station and at a higher level than any of the other sources of supply, a fine looking sheet of water, of 204 acres in extent, at present weir level.

60. The total catchment area is 13 square miles, of which only 5 square miles are free, as marked by a dark green line on the map, and in considering these schemes it has been decided that only free catchment can safely be counted on, and in connection with the run off, even from free catchment, the remarks in paragraph 15 should not be lost sight of.

61. The catchment can hardly be considered a steep one and in the middle it is very flat.

62. The tables of capacity and areas and the table of consumption and waste show that, to store one year's supply (40 M. C. feet) it is necessary to impound 123 M. C. feet, so that 83 M. C. feet would be wasted and lost in evaporation owing to the great water-spread of the tank, which at the level, ($7\frac{1}{2}$ feet above weir), required to store 123 M. C. feet is some 361 acres in extent.

63. It only remains to apply the data of run-off, per square mile, of free catchment.

Miles.

$5 \times 7 = 35$ M. C. feet available in a bad season.

$5 \times 11 = 55$ M. C. in an average season.

$5 \times 17 = 85$ Maximum supply.

64. In a year however, of average fall, with the character of the rainfall at all favorable, there can be little doubt that the required quantity could be impounded, as then the run off from the entire catchment of 13 square miles could be counted on. During the progress of these investigations the tank has surplussed several times, but if it be decided, as is believed, to be absolutely necessary, that at least 18 months' supply should be stored, over 200 M. C. feet would be required, involving the raising of the tank about 20 feet and the *submerging of a large area of valuable land.

*Vide contour survey of tank.

65. These do not seem to call for particular notice, the tank bund carries the Bellary Road, hence the necessity for the top width allowed. The present weir is crossed by a bridge of 7 vents of 9 feet each. Provision is made for removing two of the piers and raising the remainder, replacing the arches with rolled iron beams and buckled plates, and raising the weir body wall in rear of the bridge, as shown on the sections.

66. The nature of soil in rear of bund is shown on the bore hole diagram.

67. The distance of the tank from the filters and service reservoir being so much less than Magadi Road, reduces the cost of the supply main and this shorter distance and smaller lift materially reduces the first cost of the engines and the working expenses. The same establishment would, however, it is considered, be necessary, as for the more powerful engines required at Magadi Road.

68. This tank is in the same valley as the Hebbal about $1\frac{1}{2}$ miles lower down to the east. The weir is 23 feet lower than that of Hebbal. Correctly speaking its free catchment is only 3.6 square miles, its total catchment being Hebbal catchment of 13 square miles

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+3.6=16.6 square miles to obtain the $8\frac{1}{2}$ miles, of free catchment alluded to in G. O. 25 W. of 8th January 1889; the 5 square miles of Hebbal free catchment must be reckoned on.

Major Kensington proposed to increase the catchment and take up the surplus of Jukkur Tank by a catch channel, but the unfavorable opinion reported regarding a work of the kind has been endorsed by the Chief Engineer, so the proposal has not been carried further, indeed the Mysore experience of catch channels is not encouraging, and in this instance, as the tank should be raised $11\frac{1}{2}$ feet, the fall available from the Jukkur tank would not then be sufficient.

69. The tables of capacity and consumption show that, for a year's supply (40 M. C. feet) 106 M. C. feet must be impounded, and to do this weir level must be raised $11\frac{1}{2}$ feet, the water-spread being increased from 86 to 334 acres, the land which would be submerged is valuable, being under wet and garden cultivation. The comparative statement gives (as also for the other schemes) the approximate cost of compensation, and if for this scheme, the Hebbal tank were deprived of the water from the five square miles of its free catchment, it would happen that in bad years the Hebbal tank could not supply the land irrigated by it, hence in both estimates appears the same sum Rs. 10,770, compensation for land deprived of water.

70. Applying the data as in para 63

Supply available.

Miles.

$8.5 \times 7 = 59.5$ M. C. feet minimum.

$8.5 \times 11 = 93.5$ M. C. F. in an average season.

$8.5 \times 17 = 144.5$ M. C. F. maximum, against 106 M. C. F. required.

As in the case of Hebbal tank, (para 64) in an average year, a supply from the total catchment might be counted on.

71. To impound $1\frac{1}{2}$ year's supply, though the area submerged, while it would not be so great as at Hebbal, would involve the acquisition of much valuable land.

72. The estimates seem to call for no remark, as they have been prepared on the same lines as the others. The bore hole diagram gives the results of two borings made below the bund.

73. The catchment areas of both Hebbal and Nagavara tanks cannot by any means be considered clean; they are both highly cultivated and being close to Bangalore receive a considerable amount of night soil manure, parts the Nagavara catchment are most offensive. Neither catchment can be nearly as clean as that of the Hessargatta tank, which has been condemned as a source of supply partly for this reason.

* Reference No. 4.

74. As shown, both Hebbal and Nagavara tanks fail, when reviewed in the light of the data available. So, as has been reported, the only cheap alternative to the Magadi road scheme would be the Rachenhalli (or Dhasarhalli) tank; this is at the same level as the Nagavara tank and only $\frac{1}{4}$ mile further out to the north. It is in a narrower and deeper valley than the Nagavara and so the water-spread would be smaller, and to store a year's supply it need only be raised about 8 feet. Its total catchment is 36 square miles, of which 15 square miles may be considered free, as the tanks in this area are shallow and unimportant; and the chief one, the Jukkur, irrigates but a small area. A more detailed report and approximate estimate for a supply from this source will shortly follow.

75. To briefly summarize for the three schemes which have been worked out for the supply of the Cantonment and Garrison :—
Summary.

MAGADI ROAD.

Pros.

Most advantageous catchment basin, valley steep and narrow, insuring a rapid and high percentage of run off, the whole catchment being free.

2. Catchment now only cultivated to a small extent, and that with crops but slightly manured.

3. Advantageous site for the formation of the supply reservoir, a deep narrow valley, height of dam to store one year's supply 45 feet above river-bed, area of waterspread at that level 85 acres. Height of dam to store 18 months' supply 54½ feet, area of water-spread at that level 124 acres. A still larger supply could be stored if necessary.

4. Analysis shows the quality of the water from this source to be much purer than any of the others.

5. Constantly flowing stream of limpid water flow, said to continue even in the driest weather to a small extent.

Cons.

1. Cost of the project and annual working charges.

2. Possible difficulties with the reservoir owing to the amount of silt brought down by floods.

3. Possible difficulties in obtaining permission from the Mysore Government to carry out the works as the supply of the Pettah from this source has been talked of; however there should not be great difficulty from this cause as Sankey's tank has been handed over to Mysore.

76. HEBBAL AND NAGAVARA SCHEMES.

Pros.

Smaller initial cost with lower annual cost for working. Distance to sources of supply being less as also heads to be pumped against. These advantages are also in favor of the Hebbal scheme as compared with Nagavara, while there is but little counterbalancing advantage in favor of the latter, as here the compensation for land submerged would be much more costly. The latter tank is now rapidly drying up. Rather than reserve the 5 square miles of free catchment belonging to Hebbal, to supply the Nagavara tank for supply of the town, it would be better to adopt the Hebbal tank as a source of supply and increase its free catchment by taking up some of the tanks above it.

Cons.

1. Water not so pure as that of Magadi Road.

2. Shallow tanks of great water-spread involving the storage of a large volume of water to meet loss by evaporation and leakage.

3. Catchment basins not large enough to furnish required supplies in any but favorable seasons of rain-fall.

4. Catchment basins highly cultivated and manured and generally not favorable to a rapid run off.

5. Cost of compensation for land submerged and deprived of water would be expensive, as land in both localities is valuable.

77. GENERAL SUMMARY.—All in favor of Magadi Road. To reserve the free catchment areas would be very expensive. The cost has not been brought into the estimate for each scheme, but has been added, at foot, in the general abstract. The amount for Magadi Road has been made out in detail by the Mysore Revenue Department, for the other schemes approximate values deduced from total areas and average value of the land have been entered.

78. A statement accompanies, showing how the annual working charges have been arrived at. As in previous estimates 15 per cent interest and depreciation has been allowed on the machinery, but only 7 per cent on all aer iron work, pipes and fittings etc., and 4 per cent on the balances of the estimate. The entries for establishment should suffice, and in making them out the cost of working the elaborate engines which drive the cotton spinning mills at this place has been looked into. These are worked very inexpensively by a far smaller establishment than had now been allowed for, but even this latter is only about ¼ of the present Ulsur establishment where also the cost of firewood is greater than at the cotton mills, the reason assigned being that the mills are at liberty to make advances to contractors which a Government Department cannot do. At Ulsur works wood has been costing from 217 lbs to 270 lbs per Re. 1. At the cotton Mills, Re. 1 or 316 lbs. 300 lbs per rupee has been taken as the cost, for these calculations, the consumption of wood per hour has been taken as quoted by Messrs Richardson and Buddas for each engine. Of course, the comparatively antiquated engines and pumps of the Ulsur works could not be as economically managed as the more perfect machines now in the market.

And in considering the cost of working the schemes under reference, the cost of the present Ulsur supply for the Troops alone (Rs. 16,565 for establishment and working + allowance for interest on first cost, this latter has been calculated to amount to Rs. 31,839, total Rs. 48,404) should be deducted, it represents almost an annual dead loss to Government. If a combined supply to Garrison and Cantonment were carried out, the annual total cost could easily be met by a very low water rate, about Rs. 1 per head of the population who already probably pay as much or more for their present unsatisfactory supply. As far as has been ascertained a water rate would be cheerfully paid.

SUPPLY SCHEME FOR THE GARRISON ALONE.

The importance and urgency of obtaining a pure and unfailing supply of

Reference No. 4.

water for the Garrison, in the event of its not being found possible to carry out a supply scheme for the Garrison and Cantonment combined being recognized, the estimates amounting to Rs. 2,34,130 have been prepared, the comparative statement gives the cost and other particulars side by side with the large schemes. The annual working expenses are estimated at Rs. 20,000, cost per 1,000 gallons being Rs. 0—14—0 against Rs. 2½ per 1000 gallons, cost of the existing Ulsur supply.

2. It is proposed to draw the supply from the same source, as for the combined supply from Magadi road, only in this case a smaller catchment area being required, a point has been selected ¼ of a mile above the bridge over the stream at 5½ miles of the road from Bangalore to Magadi. Above this point the catchment area is 5 square miles, as colored by a pink line of deeper tint, on the Topographical Survey.

3. Taking as laid down, the required supply at 10,000 C. feet per day the tables of capacity and consumption show (evaporation and waste as before, 0.7 feet per month) that for the year's supply of 3.65 M. C. feet 8 M. C. feet must be stored in the reservoir, the height of dam required being 28 feet feet above river bed.

Reference No. 4.

4. The dam is colored pink on the cross section of the valley, the section of the dam for so much of the height from the top to be the same as designed for the large reservoir. The estimate provides for cement right through as it is proposed to surplus over the dam, provision being made for a mass of rough stone in rear.

5. For the reasons set forth in paras 12 to 18 of the report on the combined supply, it is thought that 18 months' supply should here also be stored, also that a supply for the native troops in Garrison should be included. The supply of 10,000 C. feet per day is based on the requirements of the European troops; only a slight addition to the height of the dam would be needed, the engine power and main provided for is capable of pumping up a larger supply.

6. Provision is made for two sets of direct acting compound engines, pumps and boilers, either of them capable of pumping up a week's supply in three days of ten hours, through a 10 inch main.

7. The size of the main has been calculated as before, a head of 6 feet per mile being allowed, seven days supply pumped up in three days of 10 hours i. e., $\frac{70,000}{3 \times 10 \times 24 \times 10} = 0.648$ C. feet per second, a quantity the 10" pipe will discharge.

8. The same arrangement of settling ponds, filters and service reservoir as for the larger schemes has been estimated for, the service reservoir to hold ten days supply and to be roofed in with brick arches supported by stone pillars and rolled iron beams similar to the one proposed for the larger schemes.

A suitable site will be on the South Parade as shown on the Topographical Survey of the Cantonment. Borings show the soil to be a firm red clay with some sand. From the service reservoir the supply can be conveyed to the Infantry Barracks cistern and on by the existing lines of pipe to the Cavalry and Artillery cisterns.

Over 11,000 Cubic feet per diem have been pumped up from Ulsur in the dry season.

- (a) In drawing up this report, endeavours have been made to make it as concise as possible, consequently nothing has been noted regarding topographical peculiarities of the country, climate, rainfall, &c. &c.; quite enough has already been written on these subjects.

Chapter II of Mr. Lee's essay contains a general description of Bangalore, and in the same pamphlet is a diagram showing the rainfall for a series of years. The levels given in the pamphlet are incorrect and the estimates extremely sketchy, and with reference to the notification published with G. O. No. 2810 W. of 20th October 1887 (page iii of Mr. Lee's essay) it may be noted that the essay has not in any way been adopted as the foundation of the Magadi Road scheme as now prepared except so far as indicating the locality and source of supply.

- (b). All the estimates which have hitherto been prepared for the water supply of Bangalore, made provision for stand pipes, an obsolete expedient, now hardly ever adopted, the necessary pressure to force the water through the mains is now-a-days always communicated by the engine through the medium of an air vessel.

- (c). For the sake of comparison a table is appended, giving the estimated amounts of the Garrison supply estimate as now prepared and that drawn up by the late Captain Romilly for a Garrison supply from the Agram tank.

- (d). The projects as now submitted are by no means as complete, particularly as regards plans as the undersigned could have wished; but as time was an object most of the plans are sent just as they have been roughly drawn out in pencil.

- (e). The Hessargutta tank on the Arkavati river has been brought forward as a source of supply by Colonel Vibart and has been briefly alluded to in paragraph 73. It is thought that the objection to the impurity of the catchment is not a very serious one; the table of analysis shows the water to be good. There can be no question that a very large volume of water could be impounded in an ordinary year, as per figures given in this office report No. 74 of 26th November 1888. Notwithstanding the greater distance—11 miles from service reservoir site—the level of the tank being higher, the head to be pumped against would be 18 feet less than at Magadi Road. To impound a two years' supply the cost would not probably be much more than at Magadi Road and at the latter locality would be the risk and chances of leakage, attending the construction of a high dam. At Hessargutta the existing tank of a capacity of 91 M. C. feet with its massive old bund would be, as it were, a reliable foundation to start from.

2nd February 1889.

J. C. LARMINIE

Executive Engineer.

Bangalore Water Supply.

Comparative statement showing cost and other particulars &c. of the various schemes proposed.

	Magadi Road-Maligal.	Hebbal Tank.	Nagavara.	Garrison Supply.	
Distance from source of supply to service reservoir.	5 miles.	2½	3	5½ mcs.	Net distances.
Head to be pumped against	356	162	186	232 ft.	Includes head allowed to overcome friction in supply main at 6' per mile. Head calculated from level of pumps to delivery level in the settling Ponds. Pumps placed 25' above lowest take-off.
Lowest take-off level	2741.71	2918.0	2897.0	2792.27	
Delivery level in settling ponds	3090.0	3090.0	3090.0	3014.62	
Areas of Reservoirs at F. S. L.	84.78 acres.	361	334.6 acres.	1522	
Capacities of do at do	60.54	123.4	106 M. C. feet.	8324	Required supply 40 M. C. F.+waste from all sources. For 1, 2 and 3 required supply 40 M. C. F. for Garrison 4 M. C. F.
Total catchment area	9	13	13.6	5	
Free do do	9	5.0	3.6	5	
ABSTRACT OF ESTIMATES.					
Dam	1,02,740	25,650	30,500	50,000	To store 18 months' supply at Magadi Road add Rs. 77,030.
Engines, Pumps and Boilers	53,000	40,000	44,000	13,000	
Connection with Reservoir	1,000	—	—	—	
Pump Well	1,500	1,500	1,500	1,000	
Engine and Boiler House	12,000	12,000	12,000	6,000	
Chimney	5,000	3,000	3,000	2,000	
Quarters for Establishment	14,000	14,000	14,000	8,000	
Supply Main	2,57,000	1,15,400	1,51,900	1,12,000	18 inch main for 1, 2 & 3; 10 inch main for Garrison supply.
Settling Ponds	37,350	37,350	37,350	14,110	
Filters	36,860	36,860	36,860	7,110	
Service Reservoir	53,430	53,430	53,430	21,110	
Town distribution	2,29,744	2,29,744	2,29,744	—	
	85 acres at Rs. 100.	100 acres at Rs. 100	200 acres at Rs. 100	18 acres at Rs. 50	
Compensation for land submerged by Reservoir...	8,500	18,550	30,000	100	
Do for land deprived of water	—	Assessment x 10 10,770	10,770	—	
Total...	9,02,124	5,98,254	6,55,054	2,44,300	Major Kensington states that the land now under Nagavara tank could be supplied by Rachenhalli tank, so no allowance is made. As all the water from Hebbal free catchment would be required for Nagavara Tank, none could be spared for irrigation, so the amount for land deprived of water is also entered against the latter estimate.
Annual cost of working	* 91,000	* 61,000	* 65,500	* 20,000	
Cost of water per 1,000 gallons	Rs. 0 5 9	Rs. 0 3 3	Rs. 0 4 3	Rs. 0 14 0	

* Including interest on cost of construction.

J. C. LARMINIE,

Executive Engineer.

Supplemental Report by J. E. Lammie, Esq., dated 18th January 1869.

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BANGALORE WATER SUPPLY.

Supplemental Report on the proposal to supply the Garrison and Cantonment from the Rachenhalli (or Dasaralli Tank.)

The report which has been already submitted treats of the question of obtaining a supply from three sources,

REFERENCE.

Para 74 of report which accompanies the estimates which have been already submitted.

1st—Magadi Road

2nd—Hebbal Tank

3rd—Nagavara Tank.

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The first named is likely to prove an expensive scheme, both for first construction and subsequent working, and is not besides without its draw-backs, the chief being the uncertainty attendant on the construction of a new masonry dam.

2. The two latter schemes completely fail when considered in the light of the data decided on, chiefly owing to the small areas of free catchments available; consequently a source of supply which, while combining the advantages of the two latter schemes, i. e., comparatively high level and proximity to Bangalore, with a larger catchment area, would comply with the necessary requirements. The Rachenhalli Tank fulfils these conditions fairly well.

3. It is just $\frac{1}{2}$ of a mile further out, to the north, than the Nagavara Tank and almost at the same level; the accompanying comparative statement compares its particulars with those of the three schemes for the combined supply as already submitted.

4. The conditions of the catchment basin are more favorable than those of either Hebbal or Nagavara Tanks.

(a) As to the total area, i. e. 36 square miles, and here it may be remarked that under the conditions of rain-fall prevailing in Mysore a large catchment, though even not free, is of value, as the chances then of catching local showers are so much better. Major Kensington, R. E., who has had considerable experience of Mysore, considers that, by far the best tank filling rains, are not those of the monsoons, but the local showers that fall before and after each monsoon; this quite agrees with the experience (limited of course) gained during these investigations, and it is from these very local showers, which usually come down in sudden heavy bursts of short duration, that the greatest percentage of run-off is obtained.

(b) The catchment is not so highly cultivated and being further from Bangalore and more out of the way, receives but little, (if any) of the clearances from the dust bins. The good quality of the water is shown by the table of analysis.

(c) The catchment is steeper and narrower, and observation after heavy rain showed a rapid and copious run-off.

(d) The catchment of 15 square miles, which may be considered free, is colored burnt sienna, on the 1 inch Topographical sheets which accompany the first report.

5. It is true that several tanks appear in this area, but the principal one, the Jukkur, would disappear, as its ayacut would be submerged by the raising of water level in the Rachenhalli Tank, so under the head land compensation, provision is made for taking up this area (only 87 acres). All the other tanks are shallow ponds of no importance.

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6. The remaining 21 square miles of the total catchment extend away to the north of Yelahanka as marked by a blue pencil dotted line on the map. The Yelahanka is a considerable tank, which at times passes off much surplus.

7. The table of consumption shows that to store a year's supply, present full tank level must be raised 7½ feet, when the three tanks will compare as under:—

	Hebbal.	Nagavara.	Rachenhalli.
Extra depth required to store one year's supply	feet 7½	11½	7½
Area of water-spread when so raised	acres 361	334	338
Corresponding capacity	123.4	106	118

8. It has been already shown that of the two tanks, Hebbal and Nagavara, the balance of advantages is rather in favor of Hebbal, so only with this latter tank need further comparison be drawn.

9. For one year's supply, the area of water-spread and required capacity are smaller at Rachenhalli, as shown by the statement (of particulars and cost), the amount of compensation for land submerged by the Reservoir is Rs. 1,300 more at Rachenhalli, but it is believed that the former (Hebbal) is underestimated and that more ~~not~~ land would be submerged than is allowed for. There was no time to obtain exact particulars like those now given for Rachenhalli Tank, while as a set-off against the land submerged in this case, would be the land obtainable around the margin of the Jukkur Tank, the weir of which might be lowered 6 feet, and as the tank would be no longer required for irrigation (vide para 5) the stone now forming its revetment could be utilized for the Rachenhalli Tank, and accordingly a lower rate for revetment has been allowed in the estimate for the latter.

10. But it is in the comparison of the run-off on the catchment area of Rachenhalli with that from Hebbal and Nagavara areas as compared with the required amount of water, that the advantages of the former scheme become most apparent.

	Hebbal.	Nagavara.	Rachenhalli.
	M. C. F.	M. C. F.	M. C. F.
Required for one year's supply	123	106	118
Available i. e. free	5×7	3.6×7	15×7
Catchment × 7 M. C. F.	35	25.2	105
Deficiency.....	88	80.8	13

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55 m. c. ft. between weirs and 6' below that level
11. But if it be admitted that it will not do to trust to obtaining invariably a minimum of 7 M. C. F. run-off, and that at least 18 months' must be stored, which in an ordinary year can easily be done, then the Rachenhalli Tank has still further advantages over Hebbal for storing the greater supply, for as the contoured survey of the Tank shows, a further rise of level of the water would only submerge an inconsiderable area along the right and left margins; 18 months' supply could not be stored at Hebbal without submerging a large area of valuable land, raised 7½ feet as shown, for one year's supply, the water-spread (of Rachenhalli) would then be 6 feet below the weirs of the Jukkur Tank, so that this latter might be used as a supplemental reservoir to the other. It is a deep compact little tank, containing about 30 M. C. F. and is now only a few inches below F. S. L., notwithstanding a considerable draw off through the sluices, pointing to the existence of copious springs in the valley, as no rain worth noting has fallen since early in November.

12. If the Jukkur Tank be utilized as a supplemental reservoir, the Rachenhalli Tank need not be raised, for any given supply, to so great an extent, but the time available now will not admit of this question being worked out.

13. The quantity of water required, if stored in the Rachenhalli Tank, for 18 months' supply, has however been computed and is shown in the consumption table, in one period of six months 210 M. C. F. would be required. Present tank level should be raised 13 feet (against 7½ feet for a twelve months' supply) or to level 63 on the tank survey, colored green, and area of waterspread at that level would be 461 acres.

14. To obtain 210 M. C. F. 6 inches of rain should run off the free catchment of 15 square miles. Much more than this would be available in ordinary years.

15. The water in the tanks in this valley is remarkably pure and clear looking (for quality see table of analysis), so the difficulties on account of silt, likely to be met with at Magadi Road, would here be avoided.

16. The tank has two weirs of 80 and 90 feet in length; these could inexpensively be raised, for which a lump sum of Rs. 5,000 is allowed in the estimate for raising the bund.

17. The item of estimate, raising the bund (i. e. dam), is less costly than either Hebbal or Nagavara, the bund being much shorter.

J. C. LARMINIE,
Executive Engineer.

18th February 1889.

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SUPPLEMENTAL.

BANGALORE WATER-SUPPLY.

*Comparative Statement showing cost and other particulars
of the various schemes proposed for a combined supply to
Garrison and Cantonment.*

	Magadi Road Mahgal.	Hebbal Tank.	Nagavara.	Rachenhalli.	
Distance from source of supply to Service Reservoir.	5 miles.	2½	3	4	
Head to be pumped against ...	356	162	186	194	
Lowest take off level ...	2741·71	2918·0	2897·0	2895·0	2 lower than Nagavara, Tank being deeper.
Delivery level in settling ponds ...	3090·0	3090·0	3090·0	3090·0	
Areas of Reservoirs at F. S. L. ...	84·76 acres.	361·0	334·6 acres.	338 acres.	
Capacities of do at do ...	60·54	123·4	106 M. C. feet	118 M. C. F.	For one year's supply.
Total catchment area ...	9	13	16·6	36 Sq. miles.	
Free do do ...	9	5·0	3·6	15	
ABSTRACT OF ESTIMATES.					
Dam ...	1,92,740	25,650	30,500	16,000	
Engines, Pumps and Boilers ...	53,000	40,000	44,000	45,000	
Connection with Reservoir ...	1,000	...	...	...	
Pump well ...	1,500	1,500	1,500	1,500	
Engine and boiler house ...	12,000	12,000	12,000	12,000	
Chimney ...	5,000	3,000	3,000	3,000	
Quarters for establishment ...	14,000	14,000	14,000	14,000	
Supply Main ...	2,57,000	1,15,400	1,51,900	1,94,400	
Settling Ponds ...	37,350	37,350	37,350	37,350	
Filters ...	36,860	36,860	36,860	36,860	
Service Reservoir ...	53,430	53,430	53,430	53,430	
Town distribution ...	2,29,744	2,29,744	2,29,744	2,29,744	
Compensation for land submerged by Reservoir {	85 acres at Rs. 100. 8,500	100 acres at Rs. 100 18,550	200 acres at Rs. 100 30,000	68 acres dry at Rs. 100 19,550	87 acres wet ayacut of Jakkur Tank sub- merged by raising of Rachenhalli Tank.
Do for land deprived of water ...	...	Assessment × 10 10,770	10,770	Assessment × 10 13,500	
Total.....	9,02,124	5,98,254	6,55,054	6,76,634	
Annual cost of working.....	91,000	61,000	65,500	63,000	
Cost of water per 1,000 gallons.....	Rs. 0—5—9	Rs. 0—3—3	Rs. 0—4—3	Rs. 0—4—6	

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Supplemental

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Bangalore Water Supply
Comparative statement showing cost and other particulars of the various schemes
proposed for a combined supply to Garrison and Cantonment

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Rachanahalli Scheme.									
	Magadi Road Maligal.	Heddal Tank.	Nagarwa.	Supply for 12 Months		Supply for 18 Months	Supply for 24 Months		
				For 12 Months Supply					
Distance from Source of supply to Service Reservoir	5 miles	2 1/4	3	4	4	4	4	14	
Head to be pumped against	256	162	186	194	194	194	194	194	
Lowest take off level	2741.71	2918.0	2897.0	2895.0	2895.0	2895.0	2895.0	2895.0	
Delivery level in Settling Ponds	3090.0	3090.0	3090.0	3090.0	3090.0	3090.0	3090.0	3090.0	
Area of Reservoir at H.S.L.	84.76 acres	361.0	334.6 acres	338 acres	446 acres	985 acres	389.44	36	
Capacity of do do	60.54	123.44	106 m.c.ft.	113 m.c.ft.	210 MCF	36	15	15	
Total catchment area	9	13	16.6	36 sq. m.	36	36	36	36	
Area do do	9	5.0	3.6	15	15	15	15	15	
Height of Pond above present Fair level				14 3/4 ft.	20 ft.	25 1/2 ft.	25 1/2 ft.	25 1/2 ft.	
Dam	1,92,740	25,650	30,500	16,000	30,500	52,000	45,000	45,000	
Engines, Pumps & Boilers	30,000	40,000	44,000	45,000	45,000	45,000	45,000	45,000	
Pump well	1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,500	
Engines & Boiler house	12,000	12,000	12,000	12,000	12,000	12,000	12,000	12,000	
Chimney	5,000	3,000	3,000	3,000	3,000	3,000	3,000	3,000	
Quarters for Establishment	14,000	14,000	14,000	14,000	14,000	14,000	14,000	14,000	
Supply Main	2,57,000	1,15,400	1,51,900	1,94,400	1,94,400	1,94,400	1,94,400	1,94,400	
Settling Ponds	37,350	37,350	37,350	37,350	37,350	37,350	37,350	37,350	
Filter	36,860	36,860	36,860	36,860	36,860	36,860	36,860	36,860	
Service Reservoir	53,430	53,430	53,430	53,430	53,430	53,430	53,430	53,430	
Town Distribution	2,29,744	2,29,744	2,29,744	2,29,744	2,29,744	2,29,744	2,29,744	2,29,744	
Compensation for land submerged by Reservoir	85 acres @ 1200	100 acres @ 1200	200 acres @ 1200	194 acres @ 1200	315 Pachanahalli	315 Pachanahalli	315 Pachanahalli	315 Pachanahalli	
do for land deprived of water	8,500	18,550	30,000	32,150	32,150	32,150	32,150	32,150	
Total	9,02,124	5,98,254	6,55,054	6,76,634	7,64,484	7,64,484	7,64,484	7,64,484	
Annual cost of working	91,000	61,000	65,000	68,000	71,600	71,600	71,600	71,600	
Cost of water per 1000 gallons	Rs 0-5-9	Rs 0-3-3	Rs 0-4-3	Rs 0-4-4	0-4-5	0-4-5	0-4-5	0-4-5	

of this 585 Acres belong to Pachanahalli
400 do do. do

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of this 585 acres belong to Rachanahalli, 400 do do. Noir Sye, 400 do do.

Top of Bund 7 ft above F.S.L.

30.500 N. Nagarwa Supply & Nagarwa Road add 197,630

→ Limit the allotment of land to 1/4 of the total area of the project. x With 1/4 of the total area to be the limit of the project. The limit of the project is 1/4 of the total area of the project. The limit of the project is 1/4 of the total area of the project.

J. Lawrence
Per-
1/3/89

Bengaluru Water Supply.
Comparative Statement of Annual Working Expenses
for the Rachenhalli Tank Project, Estimated to show a Supply for three different periods.

4/4

	Estimate percentages & Working Expenses.					
	For 12 Months Supply		For 18 Months Supply		For 24 Months Supply	
	Item of Estimate	Per Cent Charge	Item of Estimate	Per Cent Charge	Item of Estimate	Per Annual Charge
Machinery	45,000	15%	45,000	15%	45,000	15%
	194,140	7%	194,140	7%	194,140	7%
	2,29,744	7%	2,29,744	7%	2,29,744	7%
Balance of Estimate on which ordinary interest is charged.	2,07,750	4%	2,36,750	4%	2,95,600	4%
Total of Estimates	6,76,634		7,05,634		7,64,484	
Establishment						
One Head Engineer on Rs 2,00					2,400	2,400
Two Engine Drivers on Rs 20					480	480
Four Stokers on Rs 3					384	384
One Superintendent of						
Waterworks on Rs 7					100	100
Cleaning of the Rachenhalli Tank					336	336
Fuel	900 kerosene				5,000	5,000
Small Stores	3744 keros				11,482	11,482
Total Annual cost of 2,50 million Gallons					1,900	1,900
Contingencies Repairs &c					68,893	70,407
Total cost for 2,50 million Gallons					1,117	1,193
Rate per 1000 Gallons Delivered					69,200	71,600
					0-4-5	0-4-7

J. C. Srinivasan
Secy
4/3/89

No. 822

Heading.

Quintment.

Water-Supply

From

Sir J. A. Hanbury, M.B., K.C.B.,
SURGEON-GENERAL,

H. M.'s FORCES,

To

THE Secretary to Government,
Public Works Department,
Madras.

SIR,

In reply to your letter No. 1223C
dated 9th instanc, I have the honor to inform
you that, basing my opinion on the statement
of analysis received from you, I consider the
water of good quality and fit for the use
of the Troops and Towns people.

I have the honor to be

Sir

Your most Obedt. Servant.

J. A. Hanbury

M.B.,

Surgeon General

H. M.'s Forces.

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Megadi Road

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	Grams. per litre	Clark's scale	Mr. M. per litre	Trace	(as Ammonia)
Total solids	0.250				
Volatile solids	0.070				
Chlorine	0.011				
Total hardness	2.450				
Permanent hardness	0.875				
Free ammonia					
Albumenoid ammonia	0.200				
Nitric acid	0.300				

Apparent quality of the water as inferred from the results obtained on examination.

Remarks. The physical character of the water is unfavourable. The thick sedimentary sediment under the microscope showed abundance of silicious particles ("rust sand") a few infusoria and masses of disintegrating vegetable tissue. The volatile solids are suspiciously high and the albumenoid ammonia excessively so. Probably due to vegetable pollution, but the amount of nitric acid indicates the necessity for a care. - Just sanitary survey of the Catchment area, in the neighbourhood of the position at which the sample was taken, in order to make sure of the absence of any source of animal pollution.

W. M. M. M.



From
THE SURGEON-GENERAL,
H. M.'s FORCES,

To
THE Secretary to Government
Public Works Department,
Madras.

No. 822
Cotacamund.
25 March 1889.

States that the water supply from Rachenhalli Tank at Bangalore is of good quality and fit for use of the Troops and Townspeople.

3/4. P. 5/9.

Recd no 1620 C of 27.3.89

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7684 1889.
From
THE CHEMICAL EXAMINER,
Madras.

No. 832

Dated 4th April 1889
Received

ENCLOSURES.

To
THE Garrison Surgeon
Bangalore

REFERENCE.
Your letter No. 256 dated
31st October 1888

SUBJECT.

Has the honor to
supply analyses of two
samples of water as re-
quested.

No. 246
4th April 1889

Sur copy.

M. B. C. & S.
M.D.,
Chemical Examiner.

10-4-89

Office of Sanitary Commr. 468
Camp Colacannund 16th April 1889
From
Surgeon Major J. A. Loring
Sanitary Commissioner
Madras

The Secretary to Government
P. W. Department.

Sir,
With reference to your letters Nos 122 c
and 1620 c received 11th March and 1st April
I have the honor to state that I have
visited Bangalore and inspected the
catchment basins mentioned in Mr.
Larminie's reports and submit the follow-
ing remarks as regards the quality of
the waters.

* herewith returned
as requested with
map.

2. In deciding upon a water supply the
value of the supply must be determined
by a local examination of such proximate
and remote conditions as may affect
its purity. The cleanliness and nature
of the gathering grounds, extent of
cultivation, the amount of manuring &c &c
and points of a similar kind have to be
considered

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considered and supplemented by a Chemical examination. In the schemes mentioned in Mr. Lammie's report the tanks or reservoirs are to be filled with the rain water that runs over the surface so the cleaner that surface is the purer will be the water collected. In none of the schemes however, will the water be entirely free from the risk of contamination from surface drainage, as in each catchment area there are villages and manured cultivated lands. The gathering ground of the Magadi Road Scheme is one which is least objectionable and which is most promising as regards the purity of the water. In this catchment area there are very few villages (and those are small ones), very little cultivation and that with crops but slightly manured. The catchment area of the Hebbal, Rachenhalli and Nagaravara schemes cannot be considered at all clean and as they at present stand could not be expected to give a wholesome supply of water. Cultivation is carried on ^{in places} to a considerable extent and in places with

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with crops which are highly manured and in the Hebbal and Rachenhalli catchment areas there are also many villages. The waters of the Hebbal, Rachenhalli and Nagaravara tanks or reservoirs would therefore be liable to dangerous contamination as they would not only flow over highly manured cultivated lands, but the tanks would also receive the surface filth of the villages situated in their catchment areas.

3. While at Bangalore I requested the Deputy Commissioners to favor me with the number of villages, population of each, extent and kind of cultivation in each catchment area, but this information has not yet been received. I will forward it immediately I receive it.

4. From an examination of the catchment areas the Magadi Road Scheme, as mentioned above, is the one which will give, as regards quality, the best water, and this is also borne out by the Chemical Analyses copies of which I have received this morning from the Chemical Examiner and herewith enclose. It is not stated at

which part of the stream (Magadi Road) The
sample was taken, but if this was known
in the amount of Nitric Acid &c to find in
re Analysis might be explained. According
to Mr. Lammie's report dated 2nd February 1889
vide para 11(4) the water of the Magadi
Road Scheme, which was analysed, was
taken from the stream under unfavorable
circumstances yet the results show it to
be a much better water than either that
of the Hebbal or Dhasarahalli (Rachinalli)
tanks. The remarks made regarding the
Magadi Road water apply also to the
Hebbal and Dhasarahalli tank waters
but to a much greater extent. From an
examination of the catchment areas
and from the Chemical Analyses
the Hebbal and Dhasarahalli water supplies
are shown to be subjected to animal
pollution and as there is always danger
of drinking in a water which is known to be
contaminated with animal matter they
are not in my opinion advisable sources
of drinking water supplies. The scheme
therefore which I would recommend
is the Magadi Road one as from a
Sanitary

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Sanitary point of view it undoubtedly
would give purer water than either the
Hebbal or Dhasarahalli.

I have the honor to be
Sir

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Your most Obedt Servant
Jas. Anderson Esq.
Surgeon Major
Sanitary Commissioner
Madras

H4

1450 C. 20. 3. 87.
 1650 C. 27. - -
 988 W. 3. 4. -
 19 B. 8. 4. 11
 2292-3 W. 10. 9. 86.
 1924 W. 18. 7. 87.
 2870 W. 20. 10. 87.
 2940-11 W. 5. 11. 87.
 1107 W. 13. 4. 88.
 409 Q. 13. 7. 88.
 566 R. 22. 8. 88.
 479 - 14. 7. 88. Pub.
 2147-8 W. 16. 7. 88.
 1222-3 C. 7. 3. 87.

P. W. Department

From

4552

Surgeon Major J. A. Laing
 Sanitary Commissioner
 Madras

The Secretary
 to Government
 P. W. Department

Dated 10 }
 Dispt 10 } April 1889.
 Recd 10 }
 No 9/

Encls/5/2

Subject

Remarkings on the quality
 of the water supply schemes
 proposed for Bangalore
 and recommending
 the Magadi Road Scheme

Oct. 31/4.

P. W. D.

Note.

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With endorsement No.
 2148 W Public Works dated 16th
 July 1888, the order of the
 Government in the P. W. Dept
 dated 16th July 1888. No. 2147 W
 Public Works were communicated
 to the Government of India
 informing them that the
 prize of 1000 Rs had been
 awarded to Mr. Standish
 Lee for the best essay on
 the mode of obtaining and
 improved water supply for
 the cantonment and garrison
 of Bangalore.

In accordance with
 para 23 of the late Chief
 Engineer. Colonel Hasted's
 Lt

Notes upon the schemes
brought forward for consideration
it was resolved to depute
an experienced officer
for the purpose of preparing
in detail the estimates of
the three schemes that
were judged worthy of
adoption with the view
of considering their respective
merits both from an
engineering as well as
financial point of view,
and making a selection
of the scheme best suited
to all requirements.

The three schemes above
referred to were those of the
Hibbal, Nagawaram,
and Magadi Road
catchment basins. Although
in the opinion of this

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Government the Hibbal
scheme was "open to such
serious objection" that it
could not be accepted, yet
inasmuch as the Bangalore
Municipality thought favorably
of it and had at one time,
vide letter from the Govt
of India No 615 MW dated
19th March 1888, some idea
of taking it up themselves,
it was considered advisable
that that scheme also
should be investigated in
detail.

Mr. Lammie, Executive
Engineer, was therefore deputed
to this duty under G.O. dated
14th August 1888 No 2480 W
with instructions to place
himself in communication
with Colonel Bowen R.E.

Deputy Engineer of Mysore.

In the course of his investigations, Mr Larmine brought into the field of observation another proposal for supplying the garrison and cantonment from the Rachenhalli Tank situated some $\frac{3}{4}$ mile North of the Nagavaram Tank, and under further instructions communicated to him, he submitted the required report and estimates upon this scheme as well. The report upon the first three schemes is dated 2^d Feby 1889 and that upon the Rachenhalli project the 18th idem.

This Government

13th Feby 1889
lost no time in taking all these papers under their consideration, and at a meeting of H.E. the Governor and the Hon^{ble} M^{rs} Stokes and Garstin held at Government House Madras on the 22^d Feby 1889, the Chief Secretary, the Secretary to Gov. P.W.D. and Mr Larmine being present, it was, after full discussion and consulting Mr Larmine "decided that of the four schemes put forward, the Rachenhalli one was the best as regards cost, quantity of water available and quality of water.

Orders were at the

time issued that the opinion of the Sanitary Authorities should be taken as to the quality of the water proposed to be taken from this source.

The Surgeon General, H.M.'s Forces, and the Sanitary Commissioner, Madras, were accordingly asked for their opinion, & copies of analysis of the waters were duly furnished to them. The former of these officers in his letter dated 25th March 1889 No. 822 says "basing my opinion on the statement of analysis received from you, I consider the water

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if good quality and fit for the use of the Europeans and Natives." This decision of the Surgeon General it will be noted is a qualified one based as it is only upon the analytical statement and not upon personal inspection of the sites. A copy of the survey showing the inspection sites was forwarded to that officer but judging from the fact that his letter was dated from Ootacamund it is assumed that he did not inspect the localities, and which in fact he was not asked to do in the letter sent

to him from the Chief Engineer.

In the letter to the Sanitary Commissioner on the other hand that officer was requested to proceed to Bangalore as soon as practicable, inspect the catchment basins and give his opinion regarding the quality of the water.

Mr. Spring has now informed me that he went to Bangalore on the 19th March and remained there until the 29th during which period he inspected all the catchment basins referred to. His opinion is given in the letter received from him ~~collected~~ and which

~~shows~~ appears to be unfavorable to the Nachenahalli project and in favor of the

Bangalore to also Supply Project

No. 14. 16th April/89

13th . Madras one -

[327] Setting aside the sanitary aspect of the case, the points that remain to be professionally considered are, 1st the initial cost of the project, 2nd the ^{annual expenses} ~~annual~~ ^{incurred} in raising the water for distribution, & 3rd the quantity of water available for this purpose -

These particulars are furnished in the Comparative statement furnished by Mr. Lammie and dated 13 Feb/89, where a 12 months supply was entered to the stores, but as it was considered by Govt. that the approximate cost of storage for 18 and 24 mos. with respect to the Nachenahalli project should be ascertained as well, this was done, and is shown in the comparative statement subsequently furnished by Mr. Lammie on the 4th Mar/89 and which is attached to this note -

It is considered that an 18 months supply will meet all the requirements of the Garrison and Cantonment, and the cost of this it will be seen will be Rs 705634.

as against Rs. 6,76,634
for a 12 months supply, whilst
the working expenses are only
increased by Rs. 1200 per
annum. The F.T.L.
Contours of the reservoir in
this case lies $1\frac{1}{2}$ feet below
the crest of the upper Tank
(Jukkur) ~~with~~ lying
immediately above it, in
the same valley, and was
much as the land hitherto
cultivated by that Tank
lies within this contour
and has been taken up
in this item for land com-
pensation; the water ^{provided}
available in this Jukkur
Tank, which amounts to
55 M. Cft. between its
 weir crest and 6' below that
level will be available for
supplementing the supply
in the Nachemballi Tank
and provide itself also
for a combined supply
for 22 months at least.

The advantages ~~clearly~~
~~associated with~~ ~~possessed~~
possessed by

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The Nachemballi scheme as
a source of supply for Banga-
lore are so obvious when com-
pared ^{with} the initial cost,
against annual working
expenses and quantity of water
stored in the three other
projects, that I have no
hesitation in recommending
it for adoption.

The project has been
prepared by Mr. Laramini
in sufficient detail to
enable it to be
taken up at once, ^{and the}
subsidiary details of
distributing piping, being
filtration ~~transmission~~
will be taken up and
^{elaborated} ~~worked out~~ during the pro-
gress of the work. It is
considered that the amount
provided for each ~~main~~
and sub-head of the S.P.
is ^{so far} ~~an~~ sufficient liberal, ~~as~~
as toward the necessary
hereafter of a revised estimate or
subsequent enhanced expenditure
on the work.

One X

22.4.89

PROCEEDINGS OF THE MADRAS GOVERNMENT.

Under date the

Read the following

Bangalore Water Supply

Report by J. C. Lammie Esq. (H.E. No. — of February 2. 1889)
 Supplemental
 do — by — do — (— — of — 18. —)
 From the Sanitary Commr. Madras (— 450 of March 26. —)
 " Surgeon Genl. Hill Forces (— 822 of — 25. —)
 " Sanitary Commr. Madras (— of — of April 10. —)
 Note by the Chief Engineer S.W.D. (— 3 of — 24. —)

Ordered that the Gvt.
 of India be addressed.

I have written revised draft.

(H.E. No. W of)

to the papers received by
 Madras Proj. & the letter from
 the Secy. 22 Dec. 88 & also
 4.2. July 88. should be
 Print the whole.

The Secretary to the
 Government of India,
 Military Dept.

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May

Sir

With Public Works Encl.
 No. 2148W dated 16th July 1888
 was forwarded to the Gvt.
 of India a copy of the
 Proceedings of the Gvt.

The Military Dept.

N^o 2147 W dated 16th July 1888
showing the progress then made
in the investigation of a
water supply scheme for
the troops stationed in
Bangalore. A special officer
was subsequently placed on
the work, and the result of
his investigations is contained
in his reports dated 2^d Feb'y
and 18th February 1889, which,
together with the opinions
of the Sanitary Authorities,
and of the Chief Engineer.

P.W. Dept, are herewith forwarded
for the information of the
Government of India.

2. Of the projects
investigated H^e the Gov^r
in Council approves of
that known as the Saachan-
hulli Project, which provides
for the supply of the garrison
and cantonment from the
Saachanhulli tank situated

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some $\frac{3}{4}$ mile, north of the
Naganerani Tank.
3. This project appears,
as pointed out in the Notes
by the Chief Engineer, to
afford advantages both as
regards cost and the quantity
of the water which none of
the other projects possess
in an equal degree. I am
accordingly to request the
sanction of the Govt of India
to the project being elaborated
and subsequently carried
out. —

P. W. D.
24.4.89

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Sup. Ant. Card

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Remo again

Co. O. 16 July 1888 no 2147.

News. Remo Riv. in Mysore. 22 Dec 1888.

Report by J. C. Lammie Esq. 2 Feb 89.

Tripple do. 18 Feb 89

Do st. do. 4 Mar 89.

From Aug. Gen. H. W. Jones 25 Mar 89.

Samuel Law? 10 April 89

Link in full.

With the Co. 16 July 1888, no 2147 W.

was forwarded to the Govt. of India as
note by the Anti Chief Engineer

Mr. Herbert R. on the various
scheme for water supply, with

to the Govt. in Bangalore which
had been visited by the Govt. of

Mysore & also by the Govt. of
the Government of the Government

then made, Mr. J. C. Lammie
Chief Engineer was

placed on leave duty to work
out those of the suggested scheme

which appeared most promising

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tion. Investigator by examining

2. The schemes appeared were

(2) The ^{valley} of the Great Salt Lake.

starting, the Villaherms natives
on with a population of 15,000 in all
to there; but it has been & some

(3) The Nagawana Scheme, which contemplates the utilization of the 'Orbhal catchment area' in addition to a further tract lower down, involving a higher lift.

all these schemes are similar
in character, ~~and propose~~ ^{and propose} in con-
struction of storage reservoirs where
the water is to be pumped to
a lower reservoir on the Mantua
plain. ~~Where~~ ^{Where} after filtration it
is to be distributed ^{thence} by gravitation
to the cotton mill & branches.

3. The following are the particulars of the cost &c. of the several Whimies as worked out by Mr.

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For a year's study.

The Gov^t are of opinion that any scheme to be satisfactory should provide for the storage of oil for eighteen months supply; and the cost of this has been estimated for the Muzaffar Road & Ruckmahal's projects, and also for two years supply in that last named. From paras 63, 64, 70 & 71 of Mr. Lammie's report, it appears questionable whether more than one years supply could be carried on or stored at Wethal or Nagurana, & certain that the additional cost would be very great. The following are the remarks from the Engrs Supply in this Muzaffar Road & Ruckmahal's projects.

Washburn	Rushamulla	
Shyams	1 1/2 yrs.	7-8 years
Round. 12 1/2"		
Washburn. No. 977754	705634	764484
American Shyama No. 94125	69200	71600
Cat. Washburn's. No. O.S.H.	O-S.B.	O-S-B

9. From the figures above given, it appears that the Garrison Society scheme supplies less relief amounts and that the Bible

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scheme, for our joint supply, is the
cheapest. As regards quality of the
water, the Muguir Road catchment
gives by far the purest supply,
better and than that of Ruckenhall's is far
superiorly appreciable better than that
^{taken} at Hobbs & Wapora. The Surgeon
General H. J. Jones ^{is of opinion}
that the Ruckenhall water
is of good quality & fit for ^{the} use of
the troops & towns people; but the
Sanitary Commission after an
examination of the catchment
area gives unqualified preference
to the Muguir Road scheme, & con-
sider the other dangerous as ^{the catchment} ex-
tensive cultivated ^{village or} improved land
surrounding it. The Co. in C. while ad-
mitting that the objections of the
Sanitary Comⁿ. have force, shows
that they apply also in some degree
to the Muguir road basin, ^{which} said
itself is not quite cleared cult.
The work of obtaining ^{a catchment} supplies
of adequate extent and free from
the dangers adverted to anywhere.

near Bangalore would be, no-
hibition, and the Govt. considers
that the water of any of these
sources examined may be required
in practically open, and that the
opinion of the Engineer General may
be accepted. There is no doubt that
any of them ^{to some extent} will be a vast improve-
ment on the existing supply.

5. The Runkhali scheme presents
undoubted advantages over Hebbal
& Nagawara. There as being nearer
Bangalore are more exposed to conta-
mination by manure; the basin
are not so favourable either for
catchment or storage; and the
quantity of supply, if sufficient could
be obtained, at all is much less
assured. There is no doubt that
all that we require supply can be
obtained from the Runkhali
Valley, and the cost is hardly
less in excess of that at Nagawara
as compared with Masab's road
the water is less pure, but this
considerably larger catchment
at Runkhali, and the greater

The public tank being superseded, the
"per catchment" i.e. the area drain-
directly into the Runkhali reservoir
will be twice that at Hebbal, and
nearly double that at Nagawara

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champion pre-empted this dis-
advantage in the opinion of the
Govt.

6. It is further shown why Ra-
chankalli should be preferred to the
Mysore road scheme, is that the
appropriation of the ^{valley} water would
interfere with the claims of the
Mysore Govt. and spirit in the
most natural and attainable source
of supply for the petty or native
town of Bangalore. The lift from
it ^{to supply} the petty would
be much less than is necessary
to gain command of the civil &
military station; and it may be
said roughly that the years supply
for the petty would be only ^{as} ~~one~~
year supply for the two together,
while it is doubtful whether the
catchment area ^{as taken by Mr. Leaning} would give 12
years supply for both the
cantonment & the native town
with Masab's road with the claim
of the petty on Masab's tank
advocated in the papers forwarded
with the Resident's letter dated
read above, the Govt. of Mysore

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Rough copy of
draft

has nothing to do; but the Govt
C. is strongly of opinion that what-
ever be done as regards the supply of
the water, it is very desirable that
an independent source should be
adopted for that of the Cantonment
& the troops.

7. For the foregoing reasons, viz. the
Govt. C. makes no recommendation to
the Govt. of India the adoption of
the Ruckmulla scheme for-
wards an eighteen months supply
as the most suitable. Now this
scheme is to be financed & how this
burden should be shared between the
military budget & the municipality
an matter for the decision of the
Govt. C. in C.

8. Ordered that the following letter
be addressed to the Govt. of India
this 1st inst.

(M.C.)

To the Political Secy. for Govt. of India
in the Secy. Dept.

I am directed to forward for the consideration of the Govt. of India
copy of the Report of the Committee of the Govt. of India
to the water supply of Bangalore & the views of Govt. of India
to amend the project called the Ruckmulla scheme to the Government
of the Govt. in C. M.C. Secy.

X/

B. & Co.
Public Works Department.
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PROCEEDINGS OF THE MADRAS GOVERNMENT.

Under date the
again
Read the following

132/43
G.O. 16th July 1888 No 2147 W.

Read also:-
From the Resident in Mysore (H.E. No 4366/371 of Dec 22 1888)
Report by J. C. Lammie Esq (" of July 2 1889)
Supplemental report by do (" of 18th "
do Statement by do (" of March 4 "
From Surgeon Genl. H. S. Dore (" 822 of March 25 "
Sanitary Commissioner, Madras (" of April 10 "

With G.O. 16th July 1888 No 2147

It was forwarded to the Govt
of India a note by the late
Chief Engineer Colonel Bartle R.E.
on the several schemes for
supplying water to the troops
in Bangalore which had
been elicited by the offer of
a prize of Rs 1000/- by the

J.H.S.
11/6/89

Note. This draft has not been
copied quite as well as it
might have been

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this Government, and in pursuance of the recommendations therein made, Mr. J. Larmine Executive Engineer was placed on special duty to work out those of the suggested schemes which appeared most promising. His reports are read above, and also those of the Surgeon General — H. M. Forces and the Sanitary Commissioner Madras on the quality of this water, and of the sources in question.

2. The schemes investigated by Mr. Larmine were:—

(1) The Magadi Road Scheme, which was that proposed by

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by Mr. Standish Lee in the prize essay. Two projects for supply from the Magadi Road Valley have been investigated, the one to yield sufficient for the whole Civil and Military Station, and the other for supply for the troops alone.

(2) The Hebbal Valley Scheme—

General Fischer proposed to utilize this Valley as a source of supply for the troops and the Civil & Military Station, and for the Pettah^{or} native town, or a population of 150,000 in all; ^{but} it has been shown that this is impracticable and Mr. Larmine's project for this Valley contemplates supplying the Civil & Military Station (i.e. the troops and Cantonment) only.

(3) The Nagaravaram Scheme, which contemplates the utilization of the

Kebbal catchment area in addition to a further tract lower down, involving a higher lift.

(4) The Raichanhalli scheme

which depends upon a valley lying to the north of the last two. All these schemes are similar in character, and propose the construction of storage reservoirs — ~~thence~~ the water is to be pumped to a service reservoir on the Mantapam Hill. After filtration it is to be distributed thence by gravitation to the cantonment and barracks. The quantity intended to be provided is a year's supply at $12\frac{1}{2}$ gals ^{per head} per diem for 5000 troops and $6\frac{1}{4}$ gal. for the remaining population of the Civil and Military station taken at 100,000. The

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Garrison supply scheme provides only for the troops at $12\frac{1}{2}$ gallons per head per diem.

3. The following are particulars of the cost of the several schemes as worked out by Mr. Harminie:—

<u>7 years supply.</u>		<u>Magadi Road.</u>		<u>Kebbal. - Nagaravani - Raichanhalli</u>	
Cost for works.		Civil & Military Station - Garrison only			
		Rs 902,124 — 234,130		598,254 — 653,054 — 676,634	
Annual charges					
(including interest & depreciation)		— 91,000 —		20,000 — 61,000 — 65,500 — 68,000	
Cost per ¹⁰⁰⁰ 100,000 gallons.		— " 0-5-9 —		0-14-0 — 0-3-3 — 0-4-3 — 0-4-6	

The Government are of opinion that any scheme to be — satisfactory should provide for the storage of at least eighteen months supply; and the cost of this has been estimated for the Magadi Road and Raichanhalli projects, and

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and also of a two years supply in that last named. From paras 63. 64. 70 and 71 of McHarmine's report, it appears questionable whether more than one year's supply could be counted on or stored at Hebbal or Nagaravara, and certain that the additional cost would be very great. The following are the results for the larger supplies in the —
 Magadi Road & Raichanhalli projects:—

	Magadi	Raichanhalli
	Road $1\frac{1}{2}$ yrs	$1\frac{1}{2}$ yrs - 2 yrs

Works. Rs 979,754 - 705,634 - 764,484.

Annual Charges } 94,105 - 69,200. 71,600

Cost per 1000 Gallons } - 0.5-11 - 0.4-5. 0.4-7

4. From the figures above given, it appears that the Garrison supply scheme may

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 be left out of account, and that the Hebbal scheme, for one year's supply, is the cheapest. As regards quality of ^{the} water, the Magadi Road catchment gives by far the purest supply, and that of Raichanhalli is — appreciably better than that of either Hebbal or Nagaravara. The Surgeon General H.M.'s Forces is of opinion that the — Raichanhalli water is of good quality and fit for the use of the troops and townspeople; but the Sanitary Commissioner after an examination of the Catchment areas gives unqualified preference to the Magadi Road scheme, and considers the

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others dangerous as the catchments
contain villages & cultivated &
manured lands. The Governor
in Council while admitting
that the objections of the
Sanitary Commissioner have
force, observes that they
apply also in some degree to the
Magadi tank basin, which itself
is not quite clear of cultivation.

The act of obtaining a catchment
of adequate extent and
free from the dangers
attached to anywhere near
Bangalore would be prohibitive,
and the Gov. in Council
considers that the water of
any of the sources examined
may be regarded as practically
safe, and that the opinion

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of the Surgeon General may
be accepted. There is no doubt
that any of them will be, so far
as quality is concerned, a
vast improvement on the existing
supply.

5. The Raichanalli scheme
presents undoubted advantages
over Hebbal and Nagavaran.
These, as being nearer Bangalore
are more exposed to contamination by
manure, the basins are not so
favorable either for catchment or
storage; and the quantity of
supply, if sufficient can be
obtained at all, is much less
assured. The Jakkur tank being
superceded, the 'free catchment', i.e.
the area draining directly into
the Raichanalli reservoir, will
be treble that at Hebbal, and

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nearly double that at Naguraram. There is no doubt at all that an ample supply can be obtained from the Rachankalli Valley, and the cost of the water is hardly in excess of that at Naguraram. As compared with Magadi road the water ^{is of a much} ~~is~~ less pure, but the considerably larger catchment at Rachankalli, and the great cheapness for out-weigh this disadvantage in the opinion of the Governor in Council.

$$\begin{array}{r} 13 \text{ 26} \\ \hline 13 \text{ 27} \end{array}$$

President's letter read above,
the Government of Madras
has nothing to do: but the
Governor in Council is strongly of
opinion that whatever be
done as regards the supply
of the peltah, it is very desirable
that an independent source should
be adopted for that of the
Cantonment and the troops.

7. For the foregoing reasons,
His Excellency the Governor in
Council resolves to recommend
to the Govt of India the
adoption of the Rachanahalli
scheme, for at least an
eighteen months supply,
as the most suitable. How
this scheme is to be financed
and how this burden

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should be shared between the
Military Budget and the
Municipality are matters for the
decision of the Governor General
in Council.

8. Ordered that the
following letter be addressed
to the Govt of India Military
Dept.

(H. B. N. of)

To

The Secretary to the
Government of India
Military Dept.

To
The Political Dept for Comd.
to the Resident in Mysore.
- milly. Dept. ✓

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Sir,
I am directed to forward
for the consideration and orders
of

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Govt. of India
PUBLIC WORKS.

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CO. 10 May 1891 1226
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Bengal Water Supply
of Bangalore
Orders an report from
Mr. Lammie, Esq. Eng.
the General Scheme
in the —

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Bengal Water Supply
Bangalore
From copy of the
report from Mr. Lammie
Eng., on the General
Scheme for the —, &
summing for four
consideration the project

18/5/89