(1) பக்கங்களின் எண்ணிக்கை 162

(2) புதுக்கித் திருப்பிய நாள் 9.88

(3) ஆதாரங்குறிப்பவர் சுருக்கொப்பம்

தமிழ்நாடு ஆவணக் காப்பகம்.

தமிழ்நாடு அரசு

நிதி துறை

அரசாணை எண். 2438.00 அச்சகம்
மூலகோப்புத் தாள் எண். பலவகை

நாள் : 2.10.1884 ~~198~~.

வா கண்டபடி கையாளவோ கூடாது

-1—18,006—15-6-87.

GOVERNMENT OF MADRAS.

PUBLIC WORKS DEPARTMENT.

Buildings and Roads.
Military Works.

READ—the following letter from Brigadier-General R. C. STEWART, Quartermaster-General, to the Secretary to Government, Military Department, dated Ootacamund, 18th September 1884, No. 981 C.:—

I have the honor, by order, to submit, for the consideration of Government, letter, No. 349, dated 30th August 1884, from the General Officer Commanding Bangalore division, requesting the publication of the analysis of three samples of water taken on the 24th August 1883 from the sources as per margin, and to state that His Excellency the Commander-in-Chief sees no objection to the analysis being published.

I. Direct from Ulsoor tank.
II. After passing through the filter bed.
III. Dhobys' wells.

ENCLOSURES.

From Major-General H. ROWLANDS, V.C., C.B., Commanding Bangalore Division, to the Quartermaster-General, Ootacamund, dated Bangalore, 30th August 1884, No. 349.

I have the honor to forward letter, No. 202, dated 27th August 1884, from the Engineer in charge, Ulsoor Water Works, with copies of analysis of three samples of water taken on 9th May 1883 and on 24th August 1883.

2. The analysis of the water taken on 9th May 1883 appears in the report on the water-supply of Bangalore by the Chief Engineer on special duty, dated 31st March 1884, as shown in appendix No. 26 B., page 95 of that report. The three different samples of this water are reported as "bad."

Proceedings of Government, No. 1473 W., dated 13th June 1884.

3. But the three samples of water taken on 24th August 1883 from the same sources are reported by the Chemical Examiner to be—No. I "bad," Nos. II and III "usable." This analysis does not appear in the report alluded to.

4. I have, therefore, the honor to solicit the publication of the analysis of the water taken on 24th August 1883.

From J. SMITH, Esq., Engineer in charge, Ulsoor Water Works, to the Assistant Quarter-master-General, Bangalore Division, dated Bangalore, 27th August 1884, No. 202.

I have the honor to enclose, for your information, a copy of the analysis of three samples of water taken on the 9th May 1883, and shown in appendix No. 26 B. of the report on the water-supply of Bangalore by the Chief Engineer on special duty, dated 31st March 1884.

It will be seen from this analysis that the water is stated to be bad. This was probably owing to the long drought which prevailed at that time,—only half-an-inch of water having been received into the tank for upwards of four months before these samples were taken,—as also to the water in the tank being very low, viz., 5 feet 11¼ inches below the level of the waste weir, and to the large quantity of water being used at that time, viz., 72,249 gallons per diem.

I also beg to enclose a copy of the analysis of three samples of water taken from the same places as those above alluded to on the 24th August 1883, or three and-a-half months later, and after the

tank had received 18$\frac{7}{8}$ inches of fresh water, which shows that the water taken after passing through the filter * bed and that taken from the dhoby's † wells was *usable*; the quantity of water used at this time being 52,144 gallons per diem.

* No. 3.
† No. 2.

As this analysis does not appear in the report above alluded to, I would respectfully submit that, in fairness to the general quality of this water, the analysis of the samples of water taken on the 24th August 1883 should be made as well known as the analysis of the samples of water taken on the 9th of May 1883 and published in the Chief Engineer's report of 31st March 1884.

		1 Sample of water taken direct from the Ulsoor tank.	2 Sample of water taken direct after passing through the filter bed.	3 Sample of water taken direct from the dhobys' wells.
Total solids	Grms. per litre	0·27	0·26	0·23
Volatile solids	Do. do.	0·12	0·06	0·09
Chlorine	Do. do.	0·081	0·078	0·053
Total hardness	Clark's scale	3°·5	2°·8	3°·86
Permanent hardness,	Do. do.	2°·45	1°·75	3°·15
Free ammonia	Mlgrms. per litre	0·4	0·48	0·08
Albumenoid ammonia.	Do. do.	0·56	0·48	0·8
Nitric acid	Do. do.	3·0	3·0	3·3
Remarks.				
Apparent quality of the water as inferred from the results obtained on examination		Bad.	Bad.	Bad.

Remarks.—No. 1. Deposit abundant, and composed of vegetable debris.
No. 2. Deposit scanty and composed of vegetable debris and argillaceous matter.
No. 3. Deposit scanty and composed of vegetable debris. All three samples contain a very large amount of organic impurity.

(True Copy.)

(Signed) E. H. EYRE, Lieut.-Col.,
Offg. Deputy Quartermaster-General.

Taken 9th May 1883.

	No. I.	No. II.	No. III.	Remarks.
Total solids ... Grms. per litre.	0·27	0·25	0·31	No. 1—A sample of water taken direct from the (Ulsoor) tank at 4 p.m. on the 24th August 1883.
Volatile solids... Do. do.	0·08	0·07	0·08	
Chlorine ... Do. do.	0·085	0·042	0·089	
Total hardness... Clark's scale.	2°·8	2°·45	3°·5	No. 2—A sample of water taken direct from the Dhobys' wells on the 24th August 1883.
Permanent hardness. Do. do.	1°·4	1°·75	1°·75	
Free ammonia. Mlgrms. per litre.	0·4	0·24	0·48	
Albumenoid ammonia. Do. do.	1·92	0,4	0·48	No. 3— A sample of water taken direct from the Ulsoor tank water after passing through the filter bed on the 24th August 1883.
Nitric acid ... ... Do. do. (as ammonia)	0·75	2·4	2·4	
Apparent quality of the water as inferred from the results obtained on examination.	Bad.	Usable.	Usable.	

Remarks No. I.—A very abundant deposit composed of vegetable debris.
Do. No. II.—A scanty deposit composed of vegetable debris and sand.
Do. No. III.—A very scanty deposit composed of vegetable debris and argillaceous matter.
Do. No. II.—Is the best sample.

(True Copy.)

(Signed) J. SMITH.

No. 4665, Military.

Transferred to the Public Works Department.

(By Order.)

(Signed) A. R. KENNEY-HERBERT, Lieut.-Col.,
Offg. Secretary to Government.

19th September 1884.

Order—dated 2nd October 1884, No. 2438 W., Public Works.

Recorded in continuation of G.O., No. 1473 W., dated 13th June 1884.

(True Extract.)

Major, R.E.,
Under Secy. to Govt., P.W.D.

To the Superintending Engineer, V Circle.
„ Military Department.

Exd. A. Grubert.
Spare Copies

BUILDINGS AND ROADS.
MILITARY WORKS.

Govt. of {1884} Madras.

PUBLIC WORKS.

Dated October, 2nd.

Recd.

Encl.

G.O.,2nd Oct. 1884, No. 2438 W.

OCTOBER.

Water from Ulsoor Tank and Dhobys' Wells, Bangalore

Analysis of samples of —.

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REPORT ON THE WATER-SUPPLY OF BANGALORE.

Appendix to G.O., No. 1473 W, dated 13th June 1884.

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23. Specification and approximate estimate for the supply of European Cavalry and Field Batteries from wells.
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25. Statement of results of condensers used at Aden for water-supply.
26. Analysis of water—
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PLANS.

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1. General map of Bangalore and the adjacent country in 3 sheets, scale 3 inches to a mile.
2. Drainage area and contour channels, Bangalore new water works reservoir (Ooparhalli), scale 10 chains to an inch.
3. Sheet 1—Longitudinal section of boundary catchment channels.
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4. Drainage area of Sampagi feeder and new reservoir (Ooparhalli).
5. Survey of ground the drainage of which could be diverted into Bangalore water-supply reservoir (Ooparhalli).
6. Section from Subedar's chuttrum along water-shed towards Bettahalli.
7. Survey from Subedar's chuttrum along water-shed to foot of Nundidroog and Mélékoté tank.
8. Sections do. do. in 4 sheets.
9. Survey of northern water-shed, Halsur tanks, and additional gathering ground to the eastward.
10. Levels for a channel to convey drainage of ground to eastward into Halsur lower tank.
11. Halsur lower tank, showing the alignment of proposed bund for excluding the western feeder from the tank, &c.
12. Additional catchment, Halsur lower tank, and diversion of town drainage. Details of works.
13. Survey and levels of the Agaram tank and levels of wells near thereto.
14. Relative levels of the several parts of the garrison water-supply and stand-pipe for supply from Agaram tank, &c.
15. Survey of ground to south-east of Royal Artillery Barracks, with the wells thereon, and levels to the Agaram tank.
16. Longitudinal and cross sections of the Agaram tank bund, showing the additions required in 2 sheets.
17. Section of sump well for water-supply from valley south of South Station Hospital, and approximate design for new waste weir, Agaram tank.
18. Rough plan and section of 11 vent tunnel and waste weir, Agaram tank.
19. Topographical survey, in 3 sheets.

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REPORT ON THE WATER-SUPPLY OF BANGALORE.

REFERENCES.

G.O., No. 2794 W., dated 5th October 1883.
Letter, No. 2795 W., ,, ,, ,,
G.O., No. 3101 W., ,, 1st November ,,
Memorandum, No. 2174-C., dated 10th November 1883, by the Chief Engineer, Public Works Department, with Memorandum, dated 10th December 1879, by Major C. Bowen, R.E.
Appendices Nos. 1 to 27 (*vide* list attached).
Plans ,, 1 to 19 (,, ,,).

THE investigations ordered to be made relate to the following distinct sources of water-supply :—

1*st.* The scheme for the supply of the troops, the civil and military station, and a proportion of the population of the Pettah with water from the Ooparhalli reservoir, which was constructed in 1874—78, the project having been drawn up when Major-General (then Major) Sankey was Chief Engineer of Mysore.

2*nd.* The Halsur * tank, the object being the improvement of the quality of the water of the tank by excluding from the latter altogether the drainage of the Cantonment Bazaar and other thickly-populated localities, which now enters the tank by the western feeder. The troops are at present supplied with water from this tank, the water being either naturally filtered in the case of that drawn from the Dhobies' wells, or artificially filtered by passing it through the usual media, viz., sand, charcoal, gravel, and stone.

* The spelling of the name varies in reports and plans of different dates: that here adopted is taken from the topographical survey, and is understood to be the proper transliteration of the native name.

3*rd.* Well water, the intention being, failing other means of obtaining sufficiently pure water, to construct a series of wells in the vicinity of the European barracks for the supply of the garrison.

2. These several proposals will be dealt with in the above order in this report.

3. General Sankey's scheme is much the most important project which has been taken up in connection with the water-supply of Bangalore, because it was designed to effect a radical improvement of the supply of the whole military and civil population excepting the Pettah, which has hitherto been generally fairly well supplied. More recently a partial supply of the Pettah has been proposed. It provided for—

1*st.* The construction of a reservoir in the 3rd mile of the Bellary or Tumkur road, at a level giving what was deemed to be a sufficient command of the whole station to secure water distribution by gravitation.

2*nd.* The supply of this reservoir by the formation of channels to intercept the drainage of approximately the whole area of ground available on a level higher than that of the tank itself.

3*rd.* The distribution of the water to the several parts of the station by means of conduits, pipes, &c. The further detailed distribution was not included in the project, but was to be left to the Municipality, and, so far as the troops might be concerned, to the Government, to carry out. The instructions of the Chief Engineer, Public Works Department, in connection with this scheme are—

(1) To ascertain exactly the extent to which the original scheme sanctioned by the Government of India has been carried out;

6

(2) To definitely determine, from the experience gained since the work was discontinued, to what extent the completion of the works in their integrity, as per the sanctioned designs, would meet the requirements now considered necessary;

(3) To prepare a project for such modification or development of the existing works as will ensure the needful water-supply.

4. The first estimate of Rs. 5,69,257 for this scheme was sanctioned by the Government of India on the 23rd August 1870, and was made up of three sections:—

			Rs.
1. Reservoir			1,03,903
2. Channels of supply			
and subsidiary works (moderator tanks)	11,850		
... ...	7,112		
		18,962	
3. Distribution Works—			
Water tower or sluice	8,635		
Outlet pipe	1,605		
Filter and stone basins	72,603		
Distribution reservoir	24,123		
Delivery pipes, &c.	2,89,426		
		3,96,392	
Compensation for land		5,19,257	
		50,000	
		5,69,257	

Work was commenced on this sanction in October 1874.

5. An estimate, amounting to Rs. 5,36,363, for a revised project was sanctioned by the Government of India in July 1876, the items of the three sections being—

			Rs.
1. The reservoir			2,31,207
2. Channels of supply			
Moderator tanks	51,758		
... ...	...		
		51,758	
3. Distribution Works—			
Water tower or sluice including tunnel through the bund	11,768		
Filter and stone basins	39,123		
Distribution reservoir	...		
Delivery channels	1,15,552		
		1,66,448	
Surveys and rainfall registration	5,250		
Extra—Inspection lodge, barracks and huts ...	12,705		
		17,955	
Land compensation		4,67,363	
		69,000	
		5,36,000	

6. There was a supplemental sanction given in October 1876 for—

			Rs.
1. The reservoir			3,329
2. The delivery channels			7,632
			10,961
Compensation for land			2,000
			12,961

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7. The total outlay up to date is shown below:—

			Rs.
1. The reservoir			3,14,868
2. Channels of supply			
Moderator tanks	71,289		
... ...	...		
		71,289	
3. Distribution Works—			
Water tower or sluice	729		
Outlet pipe	...		
Filter and stone basins	...		
Distribution reservoir	...		
Delivery channels	89,454		
		90,183	
Extra—Surveys and rainfall registration	4,285		
Inspection lodge, barracks and huts	...		
		4,285	
		4,80,625	
Compensation for land		64,140	
		5,44,765	

8. The several sanctions and the outlay will be found side by side in Appendix No. 1.

9. The greatly increased cost of the reservoir was due to difficulties encountered in getting in the concrete wall which was used instead of puddle, to an augmentation of the section of the embankment, and to sundry minor causes. As the present inquiry is not concerned with the cost of the works, except in so far as this is directly connected with the efficiency of the water-supply, it need only be mentioned here that the embankment has but imperfectly answered its purpose of retaining water. The extent of the imperfection will be dealt with later on when showing what water has been received and what became of it.

Vide paragraph 27.

10. The channels of supply or catchment channels will require to be dealt with at some length, as upon their efficiency the success of the project was supposed mainly to depend. They were a special feature in the scheme, because the natural catchment basin of the reservoir is but small * or indeed insignificant, and the channels were intended to collect and bring into the tank the drainage of an area rather more than five times greater, which naturally would flow in other directions.

These channels as provided for in the estimate of 1869 (sanctioned in 1870) are described in paragraphs 16 and 17 of the report and in paragraphs 1 to 4 of the specification. They were to consist of two sets—the lower to embrace † the 105·00 contour line, and the upper set a 125·00 contour.

* 260 acres.

† Description indefinite.

These sets were practically to be divided into eight channels, having an aggregate length of about 23 miles and with normal sectional areas varying from 15 square feet near the discharge to $4\frac{1}{2}$ square feet at the upper ends. The inclination or fall of the lower series was to be made small so as to embrace the largest available area, while that of the upper series was to be made steeper so as to obtain a quick delivery of the rainfall on the contained area. In the specification for the lower series the fall prescribed is not less than 9 inches a mile at the lower ends, and not more than 18 inches a mile at the upper ends. The corresponding falls of the upper series were to be $2\frac{1}{2}$ feet a mile at the lower, and 10 feet a mile at the upper ends. In neither case are the starting levels given. The channel through the mantapam hill ridge, by which the water collected by the north-east upper and lower, and the south-west upper and lower, catchment channels was to be conveyed into the tank was to have a bottom width of 6 feet, side slopes of $1\frac{1}{2}$ to 1 and a uniform fall towards the tank.

The total cost of these channels was to be Rs. 11,850, or Rs. 515 a mile, equivalent to just under 4·7 annas the yard run. The quantity of earthwork provided for was 56,191 cubic yards, or just under 1·40 cubic yards to the yard run.

11. Of all the plans, eleven in number, enumerated in paragraph 2 of the Executive Engineer's (Mr. Henderson) report on this project, only one * is now to be found. It is not practicable therefore to give any further details of these channels as designed for the first scheme that was sanctioned. This is however of little consequence, because in the revised estimate sanctioned in July 1876 a considerable extension of the catchment channel system was provided for.

Dated 8th October 1869.
*No. 9-A—Plan of cantonment.

12. The report singularly makes no allusion to the alteration of development of these channels generally, or to their very greatly increased cost, but it does, under the head of "water-shed area," notice the intended extension of the south-east boundary or lower contour channel, whereby the drainage of Acres 170 additional was to be brought into the tank. The estimate, however, indicates a very material extension of the system, the main items being for—

Initialled W.H.—9th March 1876.

Average Section. Square feet.				
33				
16	...	...	63,000 feet, or 11·93 miles of boundary or lower main channels.	
8	...	...	49,000 " or 9·28 " of upper mains.	
2	...	...	58,000 " or 11·00 " of secondaries.	
			90,000 " or 17·04 " of catch drains.	
			49·25	

The first two in the above list correspond to the two sets of the first sanctioned scheme, but they had been found, or were supposed, to need nearly three times as much work.

159,055 cubic yards against 56,191 cubic yards.

13. The position and extent of the boundary or lower main channels have always been fairly well defined, and for this set the plan shows the location, and gives the direction that the slope or fall was to be 1 in 5,000. For the upper mains and secondaries nothing is prescribed except that the upper mains were to have a fall of 1 in 500, and the secondaries 1 in 100. These channels do not seem to have at any time been surveyed or laid down on paper, and for none of them is the intended level at the commencement shown. Regarding the catch drains there are no directions or any indications as to what was intended.

14. The extent to which the system of catchment channels has been actually carried out up to the present time is shown in the accompanying plan,† which has been prepared under Captain Kensington's instructions.

† No. 2.

The following summary compares the work executed with the scheme of 1876 :—

	Scheme of 1876.	Executed.
	MILES.	MILES.
Boundary or lower main channels	11·93	9·85
Upper mains	9·28	7·42
Secondaries	11·00	2·31
Catch drains	17·04	4·25
	49·25	23·83

15. The boundary (of gathering ground) channels have been completed as far as intended, but the extension of the south-east channel has not been carried out, because it was found that to carry it round the Gootahalli hill would involve much greater expense than had been anticipated, while the yield of the 170 acres to be drained by it would be extremely small, the ground being flat and very absorbent. There is a gunta or pond on the line which, small as it is, very seldom gets filled; consequently

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the extension for a length of 2·75 miles of the channel has been deemed undesirable. Apart from this extension the length executed is rather greater than provided for in the scheme of 1876, and this is due to an extension of the south-west channel, by which an additional area of 22·30 acres has been brought into the gathering ground. As regards the arrangement of these channels, as already stated, the intention was in general terms to give a fall of 1 in 5,000, or rather more than 1 foot a mile. In this respect a departure from the intention of 1869-70 was made, as then the fall was to be not less than 9 inches a mile at the lower ends, and not more than 18 inches a mile at the upper ends.

	11·93
	2·75
	9·18
	9·85
Difference ...	0·67

From levels recently taken, and from which the accompanying sections * have been plotted, it will be seen that the falls actually given are irregular, but that generally they are in excess of those specified at any time. With the exception of the south-east channel, the work was done in a fairly satisfactory manner, but the irregularities in the case of that channel are sufficient to affect its efficiency.

* Plan No. 3, Sheet 1, tabulated levels, Appendix No. 2.

16. In May last, with a view to improve the efficiency of these channels, orders were issued for the following arrangements to be adopted, and the work has been partially carried out.

All four channels to have bed widths as follows :—

	FEET.
Lower half mile	9
Above this	6
With gradual reduction to, at extreme upper ends	3

The average section, as provided for in the estimate of 1876, allowed a bottom width of 8 feet. These, as well as the revised dimensions, are much in excess of the quantity of water to be carried.

North-west Channel—	
Level of bed at lower end	98·00
Rise in 1st mile from lower end	3 feet.
Do. 2nd do. do.	4 "
North-east channel—	
Level of bed at lower end	98·00
Rise in each mile from lower end	3 feet.
South-west channel—	
Level of bed at the lower end	98·00
Rise in 1st mile from do.	3 feet.
Do. 2nd do. do.	4 "
South-east channel—	
Level of bed at lower end	99·00
Rise throughout per mile	4 feet.

The effect of these alterations will be to increase the velocity of the water and so lessen the loss by absorption, and, as the increased fall is obtained by deepening the lower ends without diminishing the area drained, the result is likely to be beneficial.

Level of waste weir, 104·00.

When the tank is nearly full, the surface fall will be diminished in the lower parts; but, as the depth will be increased, the rate of discharge will probably not be affected. The estimated cost of these improvements is Rs. 7,605.

The original (1876) intended average depth of cutting was to be 3 feet. The intended depth of water is not shown. The actual depth of excavation is much in excess of that proposed, which latter however does not appear to have been based on levels taken along the selected line. The accounts do not show what the quantity of work done and the cost have been.

17. *Upper Main Channels.*—The levels of these as executed are shown in Appendix 2-A, and longitudinal sections plotted therefrom will be found on Plan No. 3, Sheet 2.

The fall specified for these channels was 1 in 500, or 10·56 feet a mile.

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The total cost of these channels was to be Rs. 11,850, or Rs. 515 a mile, equivalent to just under 4·7 annas the yard run. The quantity of earthwork provided for was 56,191 cubic yards, or just under 1·40 cubic yards to the yard run.

11. Of all the plans, eleven in number, enumerated in paragraph 2 of the Executive Engineer's (Mr. Henderson) report on this project, only one * is now to be found. It is not practicable therefore to give any further details of these channels as designed for the first scheme that was sanctioned. This is however of little consequence, because in the revised estimate sanctioned in July 1876 a considerable extension of the catchment channel system was provided for.

Dated 8th October 1869.
*No. 9-A—Plan of cantonment.

12. The report singularly makes no allusion to the alteration of development of these channels generally, or to their very greatly increased cost, but it does, under the head of "water-shed area," notice the intended extension of the south-east boundary or lower contour channel, whereby the drainage of Acres 170 additional was to be brought into the tank. The estimate, however, indicates a very material extension of the system, the main items being for—

Initialled W.H.—9th March 1876.

Average Section. Square feet.				
33				
16	...	...	63,000 feet, or 11·93 miles	of boundary or lower main channels.
8	...	...	49,000 " or 9·28	" of upper mains.
2	...	...	58,000 " or 11·00	" of secondaries.
	...	...	90,000 " or 17·04	" of catch drains.
			49·25	

The first two in the above list correspond to the two sets of the first sanctioned scheme, but they had been found, or were supposed, to need nearly three times as much work.

159,055 cubic yards against 56,191 cubic yards.

13. The position and extent of the boundary or lower main channels have always been fairly well defined, and for this set the plan shows the location, and gives the direction that the slope or fall was to be 1 in 5,000. For the upper mains and secondaries nothing is prescribed except that the upper mains were to have a fall of 1 in 500, and the secondaries 1 in 100. These channels do not seem to have at any time been surveyed or laid down on paper, and for none of them is the intended level at the commencement shown. Regarding the catch drains there are no directions or any indications as to what was intended.

14. The extent to which the system of catchment channels has been actually carried out up to the present time is shown in the accompanying plan,† which has been prepared under Captain Kensington's instructions.

† No. 2.

The following summary compares the work executed with the scheme of 1876 :—

	Scheme of 1876.	Executed.
	MILES.	MILES.
Boundary or lower main channels	11·93	9·85
Upper mains	9·28	7·42
Secondaries	11·00	2·31
Catch drains	17·04	4·25
	49·25	23·83

15. The boundary (of gathering ground) channels have been completed as far as intended, but the extension of the south-east channel has not been carried out, because it was found that to carry it round the Gootahalli hill would involve much greater expense than had been anticipated, while the yield of the 170 acres to be drained by it would be extremely small, the ground being flat and very absorbent. There is a gunta or pond on the line which, small as it is, very seldom gets filled; consequently

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the extension for a length of 2·75 miles of the channel has been deemed undesirable. Apart from this extension the length executed is rather greater than provided for in the scheme of 1876, and this is due to an extension of the south-west channel, by which an additional area of 22·30 acres has been brought into the gathering ground. As regards the arrangement of these channels, as already stated, the intention was in general terms to give a fall of 1 in 5,000, or rather more than 1 foot a mile. In this respect a departure from the intention of 1869-70 was made, as then the fall was to be not less than 9 inches a mile at the lower ends, and not more than 18 inches a mile at the upper ends.

	11·93
	2·75
	9·18
	9·85
Difference ...	0·67

From levels recently taken, and from which the accompanying sections * have been plotted, it will be seen that the falls actually given are irregular, but that generally they are in excess of those specified at any time.

* Plan No. 3, Sheet 1, tabulated levels, Appendix No. 2.

With the exception of the south-east channel, the work was done in a fairly satisfactory manner, but the irregularities in the case of that channel are sufficient to affect its efficiency.

16. In May last, with a view to improve the efficiency of these channels, orders were issued for the following arrangements to be adopted, and the work has been partially carried out.

All four channels to have bed widths as follows :—

	FEET.
Lower half mile	9
Above this	6
With gradual reduction to, at extreme upper ends	3

The average section, as provided for in the estimate of 1876, allowed a bottom width of 8 feet. These, as well as the revised dimensions, are much in excess of the quantity of water to be carried.

North-west Channel—	
Level of bed at lower end	98·00
Rise in 1st mile from lower end	3 feet.
Do. 2nd do. do.	4 "
North-east channel—	
Level of bed at lower end	98·00
Rise in each mile from lower end	3 feet.
South-west channel—	
Level of bed at the lower end	98·00
Rise in 1st mile from do.	3 feet.
Do. 2nd do. do.	4 "
South-east channel—	
Level of bed at lower end	99·00
Rise throughout per mile	4 feet.

The effect of these alterations will be to increase the velocity of the water and so lessen the loss by absorption, and, as the increased fall is obtained by deepening the lower ends without diminishing the area drained, the result is likely to be beneficial.

Level of waste weir, 104·00.

When the tank is nearly full, the surface fall will be diminished in the lower parts; but, as the depth will be increased, the rate of discharge will probably not be affected. The estimated cost of these improvements is Rs. 7,605.

The original (1876) intended average depth of cutting was to be 3 feet. The intended depth of water is not shown. The actual depth of excavation is much in excess of that proposed, which latter however does not appear to have been based on levels taken along the selected line. The accounts do not show what the quantity of work done and the cost have been.

17. *Upper Main Channels.*—The levels of these as executed are shown in Appendix 2-A, and longitudinal sections plotted therefrom will be found on Plan No. 3, Sheet 2.

The fall specified for these channels was 1 in 500, or 10·56 feet a mile.

The average falls given are—

North-east channel	...	...	...	...	...	...	10·15 feet a mile.
South-west do.	...	...	...	...	...	...	14·45 do.
South-east do.	...	...	...	...	...	...	14·92 do.
North-west do.	...	...	...	...	...	...	10·58 do.

But in each case the lower part of the channel has a much steeper slope than the upper, the result apparently of having to drop the channel into the boundary channel. The smallest fall, however, is 6·13 feet a mile in the case of two miles of the north-east channel.

With regard to the difference of length, 7·42 miles against 9·28 miles, it will be readily seen from plan No. 2 that these channels could not well have been made longer, and for the reason that they were not surveyed and laid down on paper for the project it is not practicable to say how the 9·28 miles were distributed. In the estimate the entry is 49,000 feet in one item for the four channels, so probably the length was not based on measurement.

One channel, the south-east, is breached not far from its head at a deep ravine and again much lower down: the water is caught by the boundary channel which runs at a distance of from 55 to 75 yards. One or other of these channels was superfluous.

18. *Secondaries.*—Regarding these channels, there is nothing specified in the project papers as to number or position; but in one of the plans (No. 8) the average section is given, viz., 2 feet bottom width and 2 feet depth. The length excavated is less than one-fourth of that shown in the estimate, which shows a single entry for 58,000 feet. Only two channels have been cut, viz., one in the south-west and one in the north-west portions of the catchment, and it is doubtful whether they are of much use. Perhaps the catch drains, 4·25 miles, should be considered as belonging to the designation secondaries, but there is nothing to show what constituted the difference between the two classes.

19. *Catch Drains.*—For these no specification, beyond an average section 1 foot wide at bottom and 1 foot deep, was given. The estimate shows one entry for 90,000 feet of channel. About one-fourth of this length has been carried out.

20. In addition to the catchment channels, there are the road-side channels and numerous tracks and foot paths, all of which act as quick delivery channels. Altogether, even from the point of view of the rapid collection and delivery into the reservoir of the drainage, the development of the channels seems to be excessive, while, viewed economically, the cost has been out of proportion to the quantity of water to be conveyed. Had the boundary channels been laid out originally with the fall now to be given to them and been aligned so as to make the depth of cutting about 2 feet, the upper main channels might with advantage have been dispensed with altogether, and probably about half a lakh of rupees would have been saved.

21. In the revised project of 1876 the provision for moderator tanks on the line of the supply channels was omitted. Owing to the plans of the original project not being forthcoming, it is not known exactly what the arrangements were to have been, and the ground does not present any special facilities for the formation of even small tanks. Had any such been formed, they would have tended to diminish the quantity of water reaching the reservoir by increasing the loss from evaporation and absorption en route.

22. *Distribution Works.*—In the original scheme the main distribution was to have been effected by iron pipes. The great cost of the reservoir and of the supply channels led however to the substitution of concrete or masonry for iron, and the channels were in the project of 1876 designed as open ducts, but shortly afterwards supplemental sanction was obtained for covering in the ducts with slab stones. The only works done under this head are the construction of the sluice at the reservoir and the formation of a channel thence to Cathcart road, a distance of 1 mile, 5·57 furlongs, or 1·70 miles, where it ends in a square cistern on the lower side of the road. By the time the work had so far progressed, it had become evident that no such supply of water as had been supposed to be available could be relied on; and in June 1880, in applying to the Government of India to sanction the deviations and excesses which had occurred, it

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was recommended that the work should not be proceeded with further. From the delivery channel at its present terminus water can be run into the tanks* near the Cantonment Railway Station whenever the water in the reservoir may be above the level of the sluice sill, and a supply has in this way been recently passed into those tanks which are of much importance to the population of that part of the station.

*Usually called Miller's tanks.

23. *Reservoir Catchment or Gathering Ground.*—Before dealing with the water-supply, it may be convenient to explain the circumstances of the gathering ground, which form a distinctive feature of the project. Owing to the high level of the station and to the necessity therefore of placing the reservoir at a level which would command it, no site having a natural catchment basin of considerable area could be found, and that selected has an area of only 260 acres naturally draining into it. The rest of the catchment consists of ground the natural drainage of which runs in other directions and comprises an area of 1,340 acres, the drainage of which is diverted into the reservoir by the series of supply channels already described. The total area is thus 1,600 acres, or $2\frac{1}{2}$ square miles.

Of the above-mentioned 1,340 acres, the drainage from 367 acres went, prior to the construction of the reservoir-supply, channels into tanks connected with the water-supply of Bangalore, viz.:—

Vide plan No. 4.

	ACRES.
To Sampangi tank, above the sluice connected with Miller's tank ...	143
To Halsur tank, *viâ* the Bederhalli valley	53
To Dharmabudi tank between the Sampangi tank channel and the south-east supply channel of the reservoir	171
Total ...	367

The rest of the diverted drainage formerly flowed away from Bangalore.

It will be of interest to note here that the Sampangi tank has, from a period at any rate earlier than the year 1809, been supplied to a material extent from ground outside its own proper catchment basin, viz.:—

	ACRES.
Diverted from Nagavara tank	52
Do. do. Halsur tank above the sluice connected with Miller's tanks	40
Do. below do.	171 — 211
Do. Dharmabudi tank	51
Total ...	314

It has to be noticed also that recently it was decided to discontinue the diversion of the drainage of 84 acres out of the 143 acres which had belonged to the Sampangi tank feeder, but the water so relinquished has been sent into Miller's tanks.

Proceedings, Government of Mysore, 6th June 1883.

The area now draining into the reservoir is therefore 1,516 acres. The Sampangi feeder has, from a point where the extension of the Madras Railway crossed its line to the Cathcart road, been more or less filled up, and water cannot be sent that way, while the tank itself has been long considered to be of less importance than the Miller's tanks.

It is recommended that all the drainage which formerly ran into the upper portion of the Sampangi feeder, *i.e.*, of the 59 acres not yet restored, and also of the 51 acres which drained in to the southern branch of the feeder, which had its head at the Bangalore and Nundidroog road at a small gunta or pond, should be allowed to run into Miller's tanks, because it is less wasteful to allow it to flow direct into those tanks than to divert it into the reservoir and then send it back by the delivery channel, even should the water level in the reservoir admit of this being done.

24. *Water-supply.*—From the register of water at the reservoir, the actual quantity received has been calculated in the Mysore Public Works Office, and a copy has been taken; the results are shown in the subjoined statement:—

Years.	Rainfall. Inches.	Quantity of Water received. Millions of Cubic Feet.	Equivalent in Inches over Catchment.	Proportion of Rainfall draining into Reservoir.	Area of Catchment.	
					Acres.	Millions of Square Feet.
1878						
1879	41·03	42·340	7·34	0·18	...	...
1880	37·75	22·804	3·95	0·10	...	...
1881	39·56	26·478	4·59	0·11	...	...
1882	21·63	16·920	2·96	0·14	1,600	69·696
1883	36·92	23·100	3·98	0·11	...	...
	34·91	27·508	4·77	* 0·13	...	...
	211·80	159·150	27·59		...	...
	35·30	26·525	4·60	0·77	...	...
				0·13	...	...

An abstract from the rainfall register, showing the rainfall in each month from 1876 to 1883, will be found in Appendix No. 3. Up to October 1883 two of the three gauges were situated below the bund of the reservoir, and the third at the reservoir bungalow. The latter gauge has been retained, and the others removed to positions near the boundary channels north-west and north-east as shown on Plan No. 2, to obtain a better average for the gathering ground generally. It will be seen that the yield of the catchment in 1878 was in a very marked degree better than in either of the other years. This was due to exceptionally heavy rainfall in August, viz., 5·69 inches on the 20th and 3·48 inches on the 25th. The reservoir received from these two falls, nearly two-fifths of the total of the year, and the proportion of the rainfall which found its way into the tank was 0·31, or not far short of one-third.

16·541 millions out of 42·340 millions of cubic feet.

It was anticipated, when the project for this reservoir was first brought forward, that the yield from a part of the catchment would be one-third of the rainfall, and from the remainder two-fifths. So far the actual yield has been on the average just over one-eighth (0·13), and, even from the very exceptionally heavy rainfall of August 1878, the yield was less than the smallest proportion estimated as receivable on the whole annual rainfall. From the records it appears that the directly effective rainfall was in each year as below shown, the balance not producing any rise of water in the reservoir, though of course it contributed to increase the effect of that which did cause a rise:—

Vide paragraph 62 of Major Sankey's Memorandum, dated 9th September 1868. Proceedings of Madras Government, No. 2794 W., 5th October 1833, Public Works, page 23.

Years.	Total Rainfall. Inches.	Effective.	Non-effective.
1878			
1879	41·03	33·41	7·62
1880	37·75	26·85	10·90
1881	39·56	28·28	16·71
1882	21·63	17·91	3·72
1883	36·92	29·06	7·86
... ...	34·91	27·27	7·64
Total ...	211·80	162·78	54·45
Average ...	35·30	27·13	9·07

N.B.—The effective rainfall yielded nearly 1 million of cubic feet for each inch.

The anticipated yield of the catchment was estimated at 62·125 millions of cubic feet from a rainfall of 28·2 inches, the average of the two years of lowest consecutive rainfall out of 20. How greatly the yield was over-estimated is now sufficiently evident, for even the best year, with a rainfall more than 45 per cent. in excess of that taken as the basis of the calculation, yielded but little more than two-thirds of

* In the latter part of this year the area was reduced to 1,516 acres.

the quantity, and the result of an average rainfall, during the six years, of 25 per cent. in excess, shows a shortcoming of nearly 58 per cent.

On what data the estimated yield was based is not stated. It will be seen, on referring to the appendices * containing particulars of the water-supply of the Halsur tank, that the water received by the new reservoir, so far from being exceptionally small, is considerably greater, in proportion to the area drained and the rainfall, than that obtained by the Halsur tank.

* Nos. 11 to 14.

25. This great difference between the estimated and actual yield of the catchment has been attributed chiefly to the following causes:—

Major-General Sankey's Memorandum of 23rd September 1883, paras. 16 and 17. Proceedings of Madras Government, No. 2794 W., 5th October 1883, Public Works, page 25.

(1) The presence of a tufted grass (*andropogon*) over very nearly the whole area of the catchment.

(2) The absence of certain quick delivery channels which were intended to expedite the off-flow.

With regard to the first of these causes, the grass referred to is very thick and luxuriant in the catchment basin proper of the reservoir, but it is by no means general elsewhere. There is much of the area covered with short grass, than which nothing better could be desired, and it will be advantageous if the long, can be generally superseded by the short, grass. Possibly burning the grass annually, or as frequently as it may be dry enough, will tend to the production of a better kind. To get rid of it by weeding would be expensive, even if it were likely to be effectual; and it may well be doubted whether it would be successful, for this particular grass propagates itself rapidly wherever certain kinds of soil are thrown out of cultivation, and it will continue to grow on the reservoir catchment unless it can be ousted by some other form of vegetation. As the quick delivery channels—if by these were meant the catch-drains—were never planned in detail, or any specification as to the way in which they were to be laid out given, it is not clear what the intention was.

Above the lower part of the south-east channels there are some cuts which may have been formed as catch-drains.† The general tendency of all such drains with steep falls is to cause rapid erosion of the soil, and, were the complete scheme of catch-drains, viz., 17·04 miles, or 6·81 miles of drain to the square mile of catchment, carried out in this manner, the effect would be a rapid silting up of the larger channels or of the bed of the reservoir. To a certain extent this latter might be beneficial as tending to reduce subsoil leakage, but the process once started could not be stopped at will, and it might end in the destruction of the greater part of the storage capacity, and consequently of the utility, of the reservoir.

† Exclusive of these, 4½ miles of regular catch-drains have been formed.

26. *Capacity of the Reservoir.*—A condensed table of capacity and water-spread of the reservoir is given in Appendix No. 4. Below 75·00 the contents are estimated to be 6·273 millions of cubic feet. Between that level and that of the sluice sill, which is at 90·00, the contents are 16·330 millions, so that below the level at which water can be drawn off the capacity is or was 22·603 millions of cubic feet. Certainly a good deal of silt has been carried into the tank, and probably the quantity of water below 75·00 is not considerable.

The waste weirs crests are at 104·00, and the contents to that level, above the sluice sill, are 28·617 millions of cubic feet. The full tank level was originally intended to be at 105·00 and water was to be retained above the crests of the waste weirs by small bunds thereon: at the higher level 31·351 millions of cubic feet would be retained above the sill of the sluice. The sluice sill was placed at the lowest level which would command the higher parts of Bangalore which it was intended to supply, and, as regards the troops, the highest point is the cistern of the European Infantry Barracks, the floor of which is 16·35, and the necessary level of delivery about 9·35 feet below the reservoir sluice sill, which leaves not more than sufficient head, and, indeed, less than conveniently sufficient were filtration provided for. It would not be practicable, therefore, to lower the sluice even if it would be worth while to incur the expense of cutting another channel through the Gootahalli ridge.

27. The reservoir has not once filled even to the 104·00 level. The highest and lowest gauge readings in the several years have been as shown below :—

Years.	Dates.	Highest Gauge Readings.	Contents. Millions of Cubic Feet.	Dates.	Lowest Gauge Readings	Contents. Millions of Cubic Feet.
1878	21st October ...	100·25	19·299	15th April ...	81·42	..
1879	5th November ...	96·75	11·782	17th May ...	90·33	0·504
1880	28th October ...	97·85	14·045	12th April ...	88·62	..
1881	13th November.	93·12	5·000	8th June ...	87·67	...
1882	20th May ...	92·87	4·571	13th May ...	84·69	...
1883	17th October ...	98·00	14·355	10th August ...	84·53	...

The contents shown are above sluice sill level.

From these figures it will be seen that in the best year the reservoir contained, when at its highest level, but little more than one-third of the supposed quantity * annually required apart from wastage by evaporation and other causes, while in other years the proportion was very much less.

The wastage or loss by evaporation, &c., was estimated at 9·125 millions of cubic feet. What it has been is as follows :—

—	Millions of Cubic Feet.	Difference to be accounted for.	Quantity Drawn off.	Balance. Loss.	—
1878 Contents 1st January ...	0·000				
Receipts during year ...	42·340				The small loss in this year is partly due to there having been but little water in the reservoir prior to April, from the first of which month the register commences.
	42·340				
Contents end of year ...	33·055	9·285	...	9·285	
1879 Contents 1st January ...	33·055				
Receipts during year ...	24·568				
	57·623				
Contents end of year ..	27·532	30·091	...	30·091	
1880 Contents 1st January ...	27·532				
Receipts during year ...	22·738				
	50·270				
Contents end of year ...	29·698	20·572	...	20·572	
1881 Contents 1st January ...	29·698				
Receipts during year ...	16·920				
	46·618				
Contents end of year ...	24·306	22·312	*	22·312	
1882 Contents 1st January ...	24·306				* A small quantity is believed to have been pumped out in March and April, but there is no record of the quantity, and the gauge register indicates no abnormal fall.
Receipts during year ...	23·100				
	47·406				
Contents end of year ...	23·303	24·103	2·890	21·213	
1883 Contents 1st January ...	23·303				
Receipts during year ...	27·507				
	50·810				
Contents end of year ...	25·554	25·256	5·905	19·351	
	...	131·619	8·795	122·824	
Average ...	...	...	...	20·471	

The contents here shown are total contents.

The evaporation is probably greater at this reservoir, the situation of which is high, than at the Halsur tank ; but the leakage under the bund is accountable to a very material extent for the rate at which the water surface falls. In November 1883 when the gauge reading was 97·44, that part of the leakage which came to the surface was gauged to be about 0·683 cubic feet a second, or 1·77 millions of cubic feet a month. This would account for 0·355 of a foot of fall in the water surface in a month, or just over one-third of an inch a day, between the levels 98·00 and 97·00. The actual total fall was three-quarters of an inch a day, and this leaves 0·41 of an inch to be accounted for by evaporation and leakage not coming to the surface. At Halsur tank the fall in the surface, including the water drawn off, was 0·208 of an inch a day. The net result is that these water works have in the six years, in addition to about 9 millions drawn off, been able to reserve 25·554 millions of cubic feet for the supply of Bangalore, but of this quantity only 2·951 millions were at the end of December above the level of the sluice sill, and they would not suffice, were the distribution works in operation, for more than about three weeks. Again the reservoir contained no water above the level of the sluice sill for the following periods. The details will be found in Appendix No. 5 :—

	No. of Days.
1878	198
1879	...
1880	77
1881	167
1882	184
1883	268
Total ...	894
Average ...	149

Had the supply of Bangalore been attempted, the above periods would of course have been largely increased, and the days on which anything like a full supply could have been afforded would have been extremely few. No doubt it was foreseen that it might be necessary to pump water occasionally into the distributing mains, but the project was essentially a gravitation scheme, and it was not contemplated that pumping would have been needed otherwise than as an exceptional arrangement. It may be added that even with pumping the circumstances are altogether hopeless. In 1883 there would have been no water above the 75·00 level between the middle of May and the middle of October had the supply of the place been started at the beginning of that year. With an earlier start the balance of water at the beginning of the year would have been still less. On the 3rd October moreover there would have been a deficit of upwards of 11 millions of cubic feet. Not until the 13th October would the supply have balanced the expenditure, and at the best time of the year, viz., in November, when at least six months' consumption should have been stored, there would have been less than one month's supply.

The reservoir may occasionally be able to supplement to a moderate extent the supply to Miller's tanks ; and with a sluice at a lower level it will be capable of improving the supply of that part of the Pettah which is said to be indifferently provided with water. It is clearly out of the question to think of supplying the station generally, or the troops, from so precarious and inadequate a source as the reservoir now is.

28. With regard to the possibility of adding to the catchment or gathering ground of the reservoir, it may be desirable first to consider what area might reasonably be expected to supply the reservoir adequately and prevent risk of failure of supply in, at any rate, all but remarkably and exceptionally dry years, such as, for instance, 1876. The data now available show first that the water losses have amounted to about $20\frac{1}{2}$ millions of cubic feet per annum, but the quantity lost would have been very much greater if the water level had been such as would have admitted of the adequate supply of Bangalore ; secondly, that the receipts cannot safely be taken at more than one-eighth of the rainfall at most, while one-tenth would be a safer assumption ; thirdly, that no material accession to the water stored can be depended on between November and May, or say for $5\frac{1}{2}$ months, so that the reservoir should, at

the end of November, contain enough water to meet the losses and provide the supply of $5\frac{1}{2}$ or 6 months. Now the losses by evaporation, &c., in these $5\frac{1}{2}$ months have amounted on the average to a depth of 6·55 feet.

Vide Appendix No. 6.

Further the minimum level to which it would be prudent to allow the water in the reservoir to fall may be taken to be 95·00, at which level the contents above sluice sill are 8·380 millions of cubic feet.

It follows then that the reservoir on the 30th November should, to be efficient for its intended duty, contain 26·25 * millions of cubic feet above the level 95·00 *plus* 6·55, or 101·55. Now at 101·55 the present weir crest level they are 28·617 millions; consequently the reservoir would have to be enlarged to hold 26·25 *minus* 6·243, or 20·007 millions of cubic feet more than at present. To effect this the weir and the bund in proportion would have to be raised about 6·62 feet, and the contents at this higher level would be 48·711 millions of cubic feet. On the average the reservoir has held on the 30th November only 7·997 millions, and the additional supply required is 40·714 millions, to obtain which an increase to the area of the gathering ground of at least 3·78 square miles would be necessary; while, taking into account the great distance from which water would have to be brought, probably 5 square miles would be none too much, or, in other words, the present area would need to be trebled.

* Half of 52·50 millions (*vide* preceding paragraph).

contents are 22·374 millions, and at the

28·617
22·374
6·243

29. In the above calculation the scope of the original project has been adhered to, but in his memorandum of the 23rd September 1883, paragraphs 40 and 41, General Sankey proposes to reduce the unit of supply from 10 to $6\frac{1}{4}$ gallons a head per diem, and on the other hand estimates that the number to be supplied may be taken not to exceed 130,000 instead of the 90,000 previously to be provided for. The quantity required at $6\frac{1}{4}$ gallons a head for the larger population would be 47·45 millions of cubic feet yearly, which does not differ very greatly from the supply originally intended to be distributed. With regard to the unit of supply, it may be assumed that the quantity of water consumed will, under similarly more or less complete arrangements for the prevention of waste, depend chiefly upon the facilities afforded to the population for getting at the water. If the people can get the good water with as much facility as that of more or less indifferent quality heretofore used, they will use it freely and exclusively so far as it may be available, but, unless the old sources of supply be very bad, they will not go to a much greater distance to get the better water. Of course it would be an advantage to the people to be able to get even a gallon or two of really good water daily, but, were the supply small and at the same time accessible, the inevitable result would be that some would have to go without any. When the circumstances are such as to make it desirable in the interests of the public health to introduce a purer supply of water, it is obviously also desirable to make that supply ample and to place it within easy reach of the people, so that it may be freely and universally used. Statistics of actual consumption by native populations are not to any great extent available.

At Madras it is believed that 300 out of 400 thousand of the population are now supplied, and the consumption is stated to be 11 gallons per head per diem.

President's letter, P. W. and C. No. 203, dated 25th February 1884.

In Appendix No. 7 will be found some particulars of most of the water works schemes which have been carried out in India, and it will be seen that the unit of supply varies greatly, and in some cases it was based rather on the quantity of water to be had than on what would have been desirable.

In support of his proposal to reduce the unit of supply from 10 gallons to 5 gallons, or, "to err on the side of liberality," to $6\frac{1}{4}$ gallons, or 1 cubic foot per head per diem, General Sankey mentions † that "investigations of a very painstaking character in the town of Mysore brought out the fact

† Memorandum, dated 23rd September 1883, paragraphs 41-42.

that for these (drinking and culinary) purposes the average amount actually used by natives only amounted to $1\frac{1}{4}$ gallons per head per diem, or just one-fifth of the quantity proposed to be given" at Bangalore.

The paper evidence this information was obtained is a letter from the Commissioner of the Ashtagram Division; and of the investigations, Colonel Hay remarks that "accuracy is unattainable," and the object of the inquiry was to give a "general view of existing circumstances." The general result arrived at was that 25,000 to 30,700 pots of water, estimated to contain $2\frac{1}{2}$ gallons each, were used daily, the population being 57,765. The larger quantity, 76,750 gallons, makes the average just under $1\frac{1}{3}$ gallons a head, but (paragraph 68) 20,000 people are supposed to have used 45,730 gallons; so 37,765 people were left with 31,020 gallons only. Even were the data reliable, they would merely show that in an extremely badly-supplied locality the people took so much water to their homes. The population of Mysore obtain water for domestic purposes with very great difficulty, and a more abundant and accessible supply has been deemed to be of so much importance that a water-supply scheme calculated to afford $6\frac{1}{4}$ gallons per head per diem has been drawn up and will, it is hoped, be carried out at an early date. The unit adopted is no doubt based on General Sankey's revised estimate of requirements, but on the other hand a wide margin has been left to prevent disappointment, for the main distributing channel is capable of discharging the above supply in six hours, and the reservoir is to hold 100 millions of cubic feet, or nearly five times as much as the estimated yearly consumption. Consequently, should the quantity used be double that of the assumed unit, the water will, should the tank fill, be available, as also the means of distributing it.

General No. 57-73, dated 25th August 1874 (*vide* Appendix No. 9).

Vide Appendix No. 7.

Under any circumstances the European troops could not be supplied from the tail end of a system based on a unit of $6\frac{1}{4}$ gallons a day per head. The Ooparhalli reservoir is at, or rather beyond, the extreme western limits of Bangalore, and the troops are at the eastern end and some at the extreme eastern limits. As it is, there are sometimes complaints of want of water though their supply is specially provided on a sufficiently liberal scale. What would be the result of attempting to supply them from the tail end of a system based on a low unit may easily be imagined.

30. Result of examination of the country to the north of Bangalore. The country to the north has been examined, and the additional catchment area a little to the south of Yellahanka, which was supposed * to be available, has been contoured. There is first a hill to the west of the 7th milestone of the road, and this would afford an area of about 0·43 of a square mile: then proceeding westward, there is the Bettahalli hill, of which the part sufficiently high measures 0·70 of a square mile. A mile south of the western side of the above hill there is a small hill with an available area of 0·04 of a square mile, or altogether 1·17 square miles could be obtained in this locality. The distance the water would have to be brought would be between 9 and 10 miles, and the section shows what the circumstances would be. The most favorable line, viz., the water-shed between the Pennakini and Arkavatti rivers has been selected, but this at Subedar's chuttrum is about 40 feet below the necessary level; at 1 mile and 50 yards therefrom is the lowest point, which is $23\frac{1}{2}$ feet lower, for nearly $4\frac{1}{2}$ miles a continuous and for the most part lofty aqueduct would be needed, and in the 8th mile and again to the east of the Bettahalli hill aqueducts would be required. The expense of aqueducts for so small a catchment would be prohibitive, and it is certain therefore that no addition to the gathering ground of the reservoir in this neighbourhood is feasible. In order moreover to ascertain the circumstances of the country conclusively, another set of levels has been run from Subedar's chuttrum along the water-shed to the southern spur of Nundidroog, and thence to the Mélékoté tank, which was, in the earlier discussions, supposed to be a possible source of supply, but which is not on a sufficiently high level, its waste weir being at 3046·49, or only

* Memorandum of 23rd September 1883, paragraph 34

Plan No. 5.

Plan No. 6.

Plans Nos. 7 and 8.

12·52 feet above the weir of the Ooparhalli reservoir. From these levels it will be seen that there is no considerable extent of ground, which is on a level high enough to supply the reservoir, nearer than the sloping ground at the foot of Nundidroog itself, or at 27 miles from Subedar's chuttrum. Also that to bring in water by a channel would involve some 21 miles altogether of aqueducts owing to the low level of the water-shed. It is, therefore, economically impracticable to bring in water to the reservoir from gathering ground to the north by means of a channel. If water is to be brought from the neighbourhood of Nundidroog, a reservoir must be made there, the water stored therein, and the supply taken to Bangalore in a cast-iron pipe. In that case it would be doubtful whether it would be wise to make any connection with the Ooparhalli reservoir, seeing how much water would in consequence be wasted by evaporation and leakage, &c., and it would probably be deemed better to construct a comparatively small masonry-lined reservoir to hold only about a week's supply. On this supposition, the conclusion would be that nothing can be done to improve the circumstances of the Ooparhalli reservoir, the utility of which would then necessarily be limited to occasionally supplementing the supply of Miller's tanks and improving the water resources of the Pettah, as mentioned in the latter part of paragraph 27 above.

31. The feasibility of supplying Bangalore from Nundidroog has not been fully investigated, as it has not been ascertained whether a good site for a reservoir at a suitable level can be found, but the general circumstances of such a scheme in other respects can be indicated.

(1) The extent of gathering ground available would probably be about 9 square miles, but whether any reservoir site could be found into which the whole of this drainage could be conveniently conducted is problematical. The above area is on the west of Nundidroog, on which side, judging by the topographical survey, a site is the more likely to be found. On the eastern slopes there is an area of about 3 square miles, which is probably high enough to allow of the drainage being diverted into a reservoir on the west side. Altogether it is certainly disappointing to find that, even at this distance from Bangalore, no large area is to be met with at a sufficiently high level.

(2) The supply required for a population of 135,000 at 10 gallons a head per diem being 216,000 cubic feet a day, and as it would be desirable in a project of this kind to allow for an increase of the population to say 150,000, 240,000 cubic feet a day may be taken as the quantity needed.

(3) The head available would probably be about 60 feet, and the length of main not less than 150,000 feet. As the water would be delivered into a service reservoir, it could run continuously, and the diameter of the main would be 2 feet.

(4) The proper capacity of the storage reservoir would be not less than 60 millions of cubic feet.

(5) The capacity of the service reservoir near Bangalore would be five days' supply, or 1·20 millions of cubic feet. The desirable level for its floor would be 100 feet above the Halsur tank datum, equal to 10 feet above the sill of the Ooparhalli reservoir sluice, or reduced level 3029·97. With a depth of water of 10 feet it would have an interior superficial area of 120,000 square feet. The form would be influenced by the site chosen, which would be somewhere between Subedar's chuttrum and the Ooparhalli reservoir, but probably a rectangle, affording clear room, 600 by 200 feet, would be found convenient, and to make it fully satisfactory as a pure water reservoir it would have to be covered in by arches over which some 3 feet of soil would be laid.

(6) The water would in all probability have to be filtered either near the storage reservoir or before entering the service reservoir.

The following summary gives an approximate estimate of the cost of the project. For mains of 24 inches in diameter a thickness of 1 inch of metal is usual, but, so far as head is concerned, ¾ of an inch would be ample; so estimates are given for each thickness, and in Appendix No. 8 further details will be found:—

	Rs.	Rs.
Storage reservoir	45,000	45,000
Filters	75,000	75,000
Main between storage and service reservoirs, 24-inch	17,70,000	13,77,000
Service reservoir	2,40,000	2,40,000
Distribution mains, &c., at 5 rupees a head	7,50,000	7,50,000
	28,80,000	24,87,000

Assuming that 10 per cent. on these sums would be required to cover interest, maintenance, and deterioration, and that establishment for regulating the supply and looking after the works would cost Rs. 6,000 a year, the annual cost of the water-supply would be either Rs. 2,94,000, or Rs. 2,54,700, equivalent to Rs. 1·960, or Rs. 1·698 per head of a population of 150,000, or Rs. 2·262, or Rs. 1·96 a head of the present population of 130,000.

This would not, under the circumstances, be at all an extravagant charge, and at Lahore, with an abundant supply of water at a distance of half a mile from the service reservoir, the charges based on the same percentage, but with pumping, amount to Rs. 1·258 per head of the population of 130,000.

Capital outlay, a little over 15 lakhs.

Were 25 to 30 square miles of gathering ground available, as also a good site for a reservoir, it might be well worth while to incur the considerable outlay indicated for the purpose of supplying the whole of Bangalore with good water. As it is, in years of scanty rainfall there would be a risk of partial failure of supply, though it is probable that even in a year like 1876 a sufficient quantity for essential requirements would be forthcoming.

32. *Halsur Tank.*—This tank, the present source of water-supply for the European troops, had naturally a catchment basin of about square miles ... ... 5·50
A small portion of the western part of this area was diverted prior to the early part of the century into the Sampangi tank ... ... 0·33
5·17

And between the years 1854 and 1867 the construction of the four tanks known by the name of Miller's tanks, near the Madras Railway (cantonment) station, further curtailed the area by ... ... 0·53
Present effective area ... 4·64

In 1877 an upper Halsur tank was formed by throwing a bund across the northern margin of the old tank, and the catchment is now divided therefore into two sections of 2·54 and 2·10 square miles, respectively, for the supply of the upper and lower tanks. The upper tank discharges its surplus into the lower, and its contents are also from time to time turned into the lower tank to supplement the supply of the latter when required.

33. The greater part of the catchment or gathering ground of the lower tank, with the exception of less than one-fifth of a square mile to the eastward, is occupied by the large population of the cantonment bazaar, and, until the completion of the main sewer in 1864, most of the filth from a population of about 75,000 was washed down into the tank whenever a heavy fall of rain occurred. The sewer has much improved matters, as it is capable of carrying off all the bazaar drainage, provided the rainfall does not exceed about one-tenth of an inch an hour. There is no doubt, however, that the water flowing into the tank after a considerable period of dry weather followed by heavy rainfall is decidedly foul and unsuitable for drinking and culinary purposes.

The whole of the drainage of the 1·68 square miles which reaches the tank by the western feeder, which runs from just below the lowest of Miller's tanks through the bazaar, might without difficulty be diverted from the tank by running a bund across from the culvert by which it passes into the tank to the main bund a little to the north of the present surplus weir, which latter would be lowered and a new weir built in the

new bund; this tank receives drainage from foul ground at its north-west corner, and this also would need to be diverted into the western feeder above the culvert just referred to.

Moreover, the water-supply of the upper tank is far from pure. There is a large population on this part of the gathering ground, and there are tanneries and a large native cemetery, which are quite sufficient to account for the quality of the supply.

34. It has been ascertained that a considerable area of fresh ground could be drained into the lower tank by running a supply channel at a gradient of 2 feet per mile to the eastward.

The position and general circumstances of this area are shown on the general plan,* and on a larger scale and in more detail on plan No. 9. This ground measures 3·10 square miles, and the soil is generally of the light sandy character which is common to the neighbourhood. The water-supply from it would be of a better character than that now received by the tank, but it certainly would not be even approximately pure, for, though the land is for the most part under dry cultivation, it is extensively manured with all the various more or less filthy material which is conveyed from the barracks, the station, and the bazaar by the conservancy carts. There is further the additional objection that the construction of such a channel would interfere with, and diminish the supply of, a great many small tanks, some of which belong to the Mysore Government, while others are privately owned.

* No. 1.

The settlement of compensation would be difficult and troublesome, because there are not only the tanks of which the supply would be directly diminished to a demonstrable extent, but many others which get water from the surplus of the former, and no reliable estimate could be formed of the extent to which the supply of these lower tanks would be affected. On the whole then, promising though the plan of bringing in a supply from the open country to the eastward appeared in the first instance, it is considered that the circumstances are too unfavorable as regards quality of the supply to warrant relief being sought in this direction.

To secure the drainage from the 3·10 square miles above mentioned, a channel $9\frac{1}{2}$ miles in length would be needed, but a fresh area of 2·174 square miles could be secured by stopping the channel at 5 miles, and, as this would more than compensate for the 1·68 *plus* 0·22, equal to 1·90 square miles of the present catchment, which would be diverted from the tank, and as the shorter channel would interfere with but few existing tanks, it would be the better arrangement.

	Rs.
The cost of diverting the western and north-west feeders of the tank would be about	18,850
The supply channel $9\frac{1}{2}$ miles in length for the catchment of 3·10 square miles would cost about	11,120
The channel 5 miles long for the catchment of 2·174 square miles would cost about	6,460

So that the larger scheme would require an expenditure of Rs. 29,970 and the smaller of Rs. 25,310 exclusive of compensation for water diversion. Approximate abstract estimates and specifications are given in Appendices Nos. 16 to 17-C. In either case it is proposed to raise the full tank level 1 foot, and so increase the storage by 5·113 millions of cubic feet.

35. The Halsur tank, prior to the formation of the upper tank, held, when full ... ... millions of cub. ft. 38·293

At present the capacities of the two tanks are—

Upper tank	millions of cub. ft.	11·240
Lower do.	do.	37·633
		48·873
Increase ...		10·580

A table of capacities has been drawn up and will be found in Appendix No. 10. Statements of particulars of water-supply have been worked out from the registers for the years 1880 to 1883 inclusive, Appendices Nos. 11 to 14, and a summary is given in Appendix No. 15. From the latter it will be seen that the year 1880 was one of exceptionally heavy rainfall, and the tanks received no less than 165·372

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millions of cubic feet, but in neither of the other years was the yield of the basin equal to the capacity of the tanks. The average receipts of these three years were indeed only just one half of that capacity.

36. It has been alleged that the falling off in the supply of the Halsur tank has resulted from the diversion of part of the drainage by the catchment channels of the new (Ooparhalli) Reservoir, but the area of drainage so diverted is only one-twelfth* of a square mile, and would account for only 1·32 millions of cubic feet in the last three years or on the average 0·44 millions per annum, or 1·8 per cent.

* 53 acres (*vide* paragraph 23).

Compared with the period prior to 1864 the supply has no doubt suffered material reduction by the construction of the main sewer, but the idea of the prejudicial effect of the Bangalore water-supply project works doubtless originated in the contrast between the abundant supply of 1880, when the waste weir discharged surplus on no less than 88 days between the 14th August and the 7th December, and the short supply of subsequent years. The real cause is explained by the rainfall register, and a reference to the statistics of the Halsur water works, Appendix No. 20, will show that the water level in the tank on the 31st December was much the same in 1878, the first year in which the new reservoir held water, as in 1877, and that in 1879 and 1880 it was at a higher level than in any year after 1872.

37. It will be noticed that the rainfall registered at the Halsur rock is about $18\frac{1}{4}$ per cent. less than that registered at the Bowring Civil Hospital, which is distant 1,900 yards. but little more than a mile. This is due chiefly to the gauge at the rock being on the top of the rock, or indeed some feet higher than the latter.

An examination of the monthly abstract of the registers shows that, on the other hand, in February the rainfall gauged at the rock has always been higher than that at the hospital, but for the other 44 months this was the case in only 6 months.

Appendix No. 19.

It is further noticeable that the rainfall register at the Bowring Hospital is not always a guide to the rainfall over the catchment of the Ooparhalli reservoir, distant about three miles, for 1880 was only an average year in the latter locality, the rainfall being 39·56 inches against 51·69 at the hospital, and again in 1881 the figures are 21·63 and 27·44 respectively. In 1882 and 1883 the two sets of registers agree very nearly.

38. The yield of the Halsur catchment basin for the four years averaged 0·174 and 0·146 of the rainfall registered at the rock and hospital respectively. The proportion at the Ooparhalli reservoir averaged 0·12 for the same period. Omitting 1880, the proportions for the Halsur catchment are 0·085 and 0·071, and for the Ooparhalli reservoir 0·127.

39. *Wells.*—These, as a means of procuring water, are in very general use, and, seeing how small a proportion of the rainfall runs off the ground, it might be expected that a fairly abundant supply would be met with below the surface. The ordinary surface soil is very sandy, and below this, at varying depths, a subsoil composed of gneissic rock in a more or less advanced state of disintegration and decomposition is met with; this overlies gneiss in either the massive or detached state. In many places the rock comes to the surface, but more generally it is at a considerable, and sometimes at a very considerable, depth therefrom. Many houses possess wells which are said to yield water of excellent quality, but there is no certainty that two wells, though only a short distance apart, will contain water of at all similar character. The water of the wells in that part of the station which has for a long time been thickly populated is generally confessedly bad, as is to be expected, but besides these there are many wells the water of which is unfit for domestic use because it is impregnated with salts, which render it brackish or bitter.

There is at Bangalore ample space on fairly clean ground for a sufficient number of wells to produce collectively a much greater quantity of water than is required, but, while it is certain that a very considerable proportion of such wells would contain brackish water, there would be no means of determining beforehand where wells of

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good water would be obtainable. Borings would afford *primâ facie* evidence of the character of the soil at the spot, and the water drawn therefrom could be tested, but even then it would not be demonstrable that the water taken from a large well on the same spot would be of the same quality, for directly the quantity taken out become considerable, the area drawn from would be extended proportionately, and new conditions would be met with.

There is no generally-distributed water-bearing stratum, containing good and pure water, into which wells can be sunk, and a supply of this character obtained with certainty.

40. To the south of the South Station Hospital there is a small water course on the banks of which some wells were sunk in the famine years 1876—77. One of these wells, No. 2, at 760 yards from the hospital and conveniently situated as regards the Field Artillery and European Cavalry Barracks has been tested, and the partial (qualitative) analysis made under the direction of the Deputy Surgeon General is fairly favorable.

Plan 15.

Vide first entry in Appendix No. 26-F.

If an abundant supply of such water could be obtained, this source might be considered satisfactory, but the experiment made in March with an engine and pump lent for the purpose by the Secretary to the Mysore Government, Public Works Department, shows that at a time when the yield of a well is certainly not at its minimum, the inflow averaged during 138½ hours only 5·37 cubic feet, or 33·56 gallons an hour. On the average of four years the hourly consumption of water by the troops has been 2,349 gallons.

Appendix No. 21.

It would therefore require 70 such wells to supply the total quantity required, and probably not less than 40 larger wells, distributed so as to drain the greater part of the basin of the water-course, which has an area of 258 acres, would suffice, while there would be always the possibility of the failure of the supply towards the end of the dry season. With a bund across the valley above the road, it is probable that sufficient water would be obtainable for cooking and drinking purposes for the Cavalry Regiment, the two Field Batteries, and the Hospitals, as this part of the supply might be taken to be one-sixth of the whole, or say 400 gallons an hour, which quantity might be obtained from say six connected wells of 20 feet diameter each, and the supply could be lifted by a pump worked by coolies or bullocks, which would be less expensive than a steam engine, as the cost would not exceed Rs. 1,000 per annum.

41. Similar arrangements might be made for the supply of the Horse Artillery and the European Infantry at a cost of about Rs. 1,500 per annum, but for other purposes two-thirds of the present supply would still have to be pumped up from the Halsur water works, and the cost of these two-thirds would be but little less than the Rs. 10,400 expended at present on the whole supply of the troops.

The register of the pumping operations at No. 2 well will be found in Appendix No. 22.

42. Some of the data—*e.g.*, the number and length of the connections with the several buildings—for an approximate estimate of the cost of the arrangements above indicated would require more time for their collection than is now available, but the following summary will give a tolerably good idea of the probable outlay required. The way in which the calculation has been made will be found in Appendix No. 23.

	Rs.
Seven wells	
Pump with gear	4,550
Pipes and laying	1,200
Trench for connecting pipes	8,354
Unwatering during construction	3,000
Taps and fittings	3,000
Contingencies	2,000
	1,896
	24,000

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About an equal amount would be required to supply the Horse Artillery and the European Infantry Regiment with water from wells, or say Rs. 50,000 altogether. The current charges being estimated at Rs. 1,000 *plus* 1,500 annually, this, capitalized at twenty-five years' purchase, would represent Rs. 62,500 ; so the entire cost of supplying well water for drinking and cooking purposes only to the European troops would be about Rs. 1,12,500.

43. None of the heretofore considered sources of supply being likely to be acceptable and also adequate, attention has been given to others which it seemed possible might be better suited to meet the requirements. Necessarily there could be no adequate supply obtainable without pumping, and all that could be hoped for was sufficient water at a level not very much below that of the station and at a moderate distance. The Hoskote tank, which is much the largest in the neighbourhood, was visited. It has a catchment basin of 540 square miles, and is the terminal of a very large group of tanks, of which at present only one sub-series has been surveyed, so the statistical information is incomplete. Notwithstanding the large number of tanks above it, the supply is said to be good. In 1876 there was some water, but not enough for cultivation ; in 1877 the tank got a good supply. About twenty years ago (probably 1866) the tank was entirely without water. In 1875 the supply was so great that it was feared the tank would breach.

The extent of irrigation is about 2,000 acres and the revenue about Rs. 5,000 ; the assessment has been reduced since 1877. The season of cultivation is from December to August or September. Only one crop is cultivated, and this is commenced from December to April, the harvest being from June to September. The tank is from 12 to 13 miles from the barracks, and it is about 104 feet lower than the Halsur tank. There is a small hill, 2 miles west of the 14th mile-stone, which would be a convenient site for a stand pipe as it is 190 feet above the tank level. The appearance of the water in January, when the tank was nearly if not quite full, was not prepossessing, and the native opinion of it is unfavorable, the expression used being that they would not give it to a horse to drink, and they say that to bathe in it is apt to produce fever. The inhabitants of the town use the water of a small tank which lies immediately east of the large tank and north of the town, and its water is altogether different in appearance. Under these circumstances it seemed unnecessary to carry the investigations further. The information above given was obtained from the native accountant of the amani tanks.

44. About three miles south-east of the Race Course, or Cavalry and Field Artillery Barracks, there is the Agaram tank, which on the whole affords the best prospect of being a suitable source for the supply of the troops. It has a catchment basin of 32·10 square miles, of which however a considerable part is rendered non-effective or only partially effective, by the upper tanks in the same basin. It receives no drainage from the pettah or cantonment. It is said to be generally well supplied, though in 1876 it was, in common with nearly every tank in the country, for a time dry. This season, though the rainfall was below the average, the tank was full up to the 19th January, or 4½ weeks after the last considerable rainfall. On the 6th March the water had fallen 0·96 of a foot, so that, inclusive of the water drawn off for cultivation, the water surface had fallen less than one quarter of an inch a-day.

The position of the tank with regard to the barracks and that of its catchment basin will be seen on referring to plan 1, sheets 1 and 2, and the survey of the tank is given in plan 13.

The area of the water-spread at full tank level is 131 acres, or 5·706 millions of square feet. The sill of the lowest sluice is at 7·16 feet below full tank level, and the area of water-spread at this sill level is computed to be about 1·017 millions of square feet. The capacity between sluice sill and full tank level is about 24·068 millions of cubic feet, and it has been ascertained that, were the full tank level raised three feet, 20·601 millions of cubic feet would be added to the contents. There are 280·17 acres of land classed as wet under the tank, and of these 129·10 acres are usually cultivated and yield a revenue of Rs. 617-8-0.

The full tank level is 58·25 feet below that of the Halsur tank, and the water would have to be pumped at least so much higher in order to secure as much command as at present.

45. Samples of the water have been analysed by the Chemical Examiner with the result shown in Appendix No. 26. It will be seen that the water has obtained only the qualified character "usable," but that is the highest character given in any of the analyses of Bangalore water, and it seems to be more than doubtful whether anything more favorable is likely to be found.

The Agaram water is slightly clouded, but it is good wholesome looking water and very different indeed from that which even at the best of times is to be found in the Halsur tank. It will be noticed that the analysis differs somewhat in the case of the two samples, though the water was all taken from the tank at one time and at one place.

46. It was at first intended to get rid of all matter capable of removal by filtration from the water by sinking a large well in a convenient spot near the north-west corner of the tank, and allowing no water to enter the well except through several feet of soil. The analysis by the Chemical Examiner however of the water of one well to the north-west of the tank, and the partial analysis at Bangalore of the water of four wells but a short distance from its water-spread on the west side, which, and more especially Nos. 3 and 4, were chosen to serve as an index to the probable quality of the soil through which a supply well would be sunk, render it more than probable that such an arrangement might materially injure the quality of the water. The fixed hardness, for instance, is 6·2 degrees in the best, No. 4, of these four wells against 1·4 to 1·75 degrees for the tank water, while in other respects the well water is considerably less pure than that in the tank, though the former looks clearer.

Appendix No. 26-E.
Do. No. 26-F.

It would be desirable, if possible, to avoid the expense and complication of artificial filtration, and so in any case it would be desirable to have an experimental well sunk in the bed of the tank to test, through the water therefrom drawn, the character of the soil through which the water has filtered, and its effect upon the potable qualities of the supply. Samples of water have been taken from two wells or pools in rear of the western end of the bund, and their analyses will be found in Appendix No. 26-G. The results are satisfactory as the turbidity of the water is no doubt due to the wash of the water on the soil, the pools or wells being used for irrigation.

47. On plan 14 are shown the relative levels of the tank and the several service cisterns attached to the barracks, hospitals, &c. Also the proposed height of the standpipe, which is intended to be rather more than 15 feet above the water surface, when full, of the highest cistern to be filled.

48. Appendix No. 24 contains specifications and approximate estimates for the work to be done, and a short summary of the latter is subjoined. It appears to be essential to increase the capacity of the tank if the water be drawn direct fr[om] the latter, and in the estimate for this arrangement such increase has, it will be see[n] provided for. The average consumption of water by the troops has been 3·092 [mil]lions of cubic feet per annum, or less than one-seventh of the contents [of the] tank and probably not more than one-twentieth of the quantity received: the [estimate] maximum consumption also has been taken as 5·256 millions of cubic feet in the [year] perhaps one-twelfth of the supply coming into the tank. Were however a [re]sponding extent of land, viz., about 25 acres, thrown out of cultivation and compt[ro]tion on that account paid, there would still be much risk of the storage proving in[ef]cient at times. With an addition to the storage capacity of nearly four time[s] maximum off-take, there is every probability of there being always in the ta[nk] ample reserve to meet the contingency of an unusual interval between s[uc]receipts from rainfall. It is indeed worth consideration whether it would [be] better plan, even if water be drawn from a well within or below the tank, [to] the tank, as by so doing all question of injury to land-holders under the ta[nk] be avoided, and that is a matter of importance.

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Particulars.	With: Water drawn direct from tank.	With: Water drawn from supply well in or below tank.
	Rs.	Rs.
Engines and pumps	36,500	36,500
Stand-pipes including masonry	3,930	3,500
Delivery mains	1,18,000	1,18,000
Suction pipe from supply well	...	2,570
Supply well	...	900
Suction pipe from tank	4,600	...
Do. from pure water well	560	...
Two filters	15,000	...
Enlarging tank	13,000	...
Ground for pumping station	250	250
Engine-house and chimney	12,500	12,500
Quarters for Engineer, &c.	3,000	3,000
Enclosure walls	4,000	4,000
	2,11,340	1,81,220
Contingencies	8,660	6,780
	2,20,000	1,88,000

49. Inquiry has been made as to whether any of the pumping plant at the present water works would be suitable and available for transfer to the Agaram water works. The engine at the rock is an old one, but with new boilers it would be serviceable for some years to come. The engine at the Dhobies' wells is comparatively new, and it ought to be capable of a much higher duty than has so far been obtained from it. At present it is costly as regards fuel consumed as compared with work done, but it seems probable that this is in a considerable measure due to the use of a small delivery pipe.

However the chief difficulty would lie in the necessity for continuing the present water-supply arrangements until other and better arrangements have been carried out and are perfectly ready to be substituted. The troops cannot be left without water for two or three weeks or perhaps longer, and so the engines and pumps must be kept where they are and others be provided for the new works. It may be taken as certain however that it will in the long run be the more economical and satisfactory plan to get complete machinery, suited in all respects to the work to be done, from a firm which understands the special requirements of such works. Water works need to be well carried out in all respects, and all the parts should be in harmony. The old plant will fetch something considerable when done with though much less than its value. The pipes now in use ought to fetch their full value, or some of them might with advantage be used for extending the distribution arrangements to the lines occupied by the officers of the regiments supplied.

50. It is nearly certain that water of perfectly satisfactory quality could be obtained at Bangalore only by distillation, and it seemed desirable therefore to complete the water-supply investigations by ascertaining the cost of the necessary apparatus and the expense of producing potable water in this way. General Hyde of the India Office has obligingly furnished the requisite information. In Appendix No. 25 will be found a statement giving the results of the working of the new and old Government condensers at Aden, as well as those of two private owners. The new condensers were made by the Normandy Company and are considered to be the best and most economical known. Also two letters from the Normandy Company to General Hyde and estimates for three sets of apparatus. It will be seen that the cost of two sets of apparatus to produce together 12,000 gallons in 24 hours would be ... £ 4,362
One set to produce 9,000 gallons ... ... „ 3,052
One set to produce 12,000 „ ... ... „ 4,046
These prices are free on board in London, and the corresponding prices at Bangalore would probably be Rs. 65,430, 45,780, and 60,690.

GALLONS.

The smaller or 6,000-gallon size has, in an experimental trial at Aden, produced in 24 hours 7,082

The larger, or 9,000-gallon size has, in an experimental trial at Aden, produced in 24 hours 12,110

But the average yield is shown by the statement to be about four-fifths of the above. Coal is the fuel used at Aden, and one pound of coal is equivalent to four pounds of wood, the fuel available at Bangalore.

The yield is 16 lb. of condensed water for 1 lb. of coal, and therefore 4 lb. of water would be obtained for 1 lb. of wood fuel.

The Company's estimate of outturn is higher than the above and varies slightly according to the size of the apparatus, the yield being 18·0, 18·8, and 19·8 lb. of water to 1 lb. of coal for the three sizes respectively.

The Aden experience may, it is considered, be accepted as a safe guide.

No better water than that of the Dhobies' wells could be obtained for distillation. Assuming that 9,000 gallons a day would meet the requirements of the troops if the use of the condensed water were restricted to drinking and cooking purposes, one set of apparatus at a cost of Rs. 45,780 would suffice if kept constantly at work, but as at any rate it would be advisable to stop the machinery on Sundays, it would be desirable to have a 12,000 gallons set which would produce in six days enough water for eight days' consumption, and its cost would be Rs. 60,690. The weight of 12,000 gallons is 120,000 lb., and the wood fuel required would be 30,000 lb. The present price of wood is 1 rupee for $268\frac{1}{2}$ lb., therefore the daily cost of fuel would be Rs. 112 nearly, and the annual cost $52 \times 6 \times 112 =$ ... ... Rs. 34,344

Small stores, &c. 256

Working expenses 34,600

The apparatus includes pumps capable of delivering the water where required. It is stated that the attendance of one man will suffice to work the apparatus, and therefore the existing establishment at the Dhobies' wells would suffice; and, as the engine and pumps there would not be required, the buildings would be available for the condensers.

The only other outlay would be for pipes, cisterns at the barracks, &c., say 25,000, and the total annual outlay may be thus estimated :

	RS.
15 per cent. interest and depreciation on the cost of the condensers ...	9,104
10 per cent. do. on rest of outlay	2,500
Working expenses	34,600
	46,204

or about 15·40 rupees annually per head. The present cost, about Rs. 10,400 a year, for the working expenses of the Halsur water works would remain unaffected, as water for other purposes would have to be pumped up by the Halsur rock water works.

51. The results of the investigations that have been made are briefly these :

(1) The Bangalore water-supply project was designed and has been, with the exception of the greater part of the distribution works, carried out to supply the population generally with good water.

Paragraph 27.

The (Ooparhalli) reservoir is inadequately supplied. It has never been full or nearly so for nearly five months in the year; on the average of six years the water level therein has been below the sill of the off-take sluice. The cause of this failure is the very small extent of the gathering ground, $2\frac{1}{2}$ square miles, which is not more than about one-third of the area necessary to enable the reservoir to perform the duty for which the works were constructed.

Paragraph 28.

There is but an insignificant extent * of additional ground the drainage of which could be brought into the tank within a distance of eight or nine miles, and, owing to the low level of the intervening country, the cost of bringing in the water therefrom would be out of all proportion to its quantity and value.

* A little over one square mile.

Paragraph 30.

The Bangalore water-supply project is therefore incapable of supplying the station or the troops, and its utility will necessarily be confined to the improvement of the supply of a part of the Pettah or native town and to occasionally supplementing the supply of Miller's tanks, which are of much importance to the inhabitants of the cantonment bazaar. The high ground at Nundidroog is the nearest and indeed only locality in which there is any considerable extent of ground on a sufficiently high level to command Bangalore, and even there the area between 9 and 12 square miles is much less than would be desirable. It is not yet certain that a suitable site for a reservoir in that neighbourhood can be found, but, if there be such a site, the cost of supplying Bangalore generally including the garrison would be between Rs. 24,87,000 and Rs. 28,80,000, depending upon the thickness of the cast-iron mains. These amounts represent, together with an allowance for working expenses, annual charges of from Rs. 1·698 to 1·960 per head of a population of 150,000 and of from Rs. 1·960 to 2·262 per head of the present population of 130,000.

Paragraph 31.

(2) The Halsur tanks, the present source of supply for the troops, are supplied from, for the most part, a densely-populated gathering ground, and the quality of the water is therefore unsuitable for drinking and cooking purposes. It would be possible to exclude the whole of the foul drainage from the lower and larger of the tanks, and to compensate for this exclusion by bringing in the drainage of open cultivated country to the eastward. This new gathering ground, however, though comparatively clean, is manured with the dirt and refuse of the cantonment bazaar, barracks, &c., and is therefore not capable of yielding anything like pure water. It is moreover not practicable to get rid of the foul supply of the upper tank, which receives drainage not only from ground carrying a considerable population, but from that occupied by tanneries, a large native cemetery, &c.

The Halsur tanks therefore are not capable of being made a really satisfactory source of water-supply for the troops.

The cost of such improvements as are feasible would be from Rs. 25,310 to Rs. 29,970, the former for a new catchment of 2·174, and the latter for one of 3·10 square miles.

(3) The proportion of the annual rainfall which does not run off the surface of the ground, but which is absorbed thereby, is in favor of wells as a source of water-supply, and there is still a large extent of open and fairly clean ground in the neighbourhood of the barracks occupied by the troops, in which wells could be sunk to obtain the water-supply required for drinking and cooking purposes.

Paragraph 39.

The nature of the sub-soil composed of gneissic rock in a more or less advanced state of decomposition makes it difficult to find subsoil water of suitable quality, and there is great uncertainty as to the quality of the water which wells sunk in any given locality would yield.

Separate sets of wells would moreover be needed to supply—

1*st*—The European Cavalry.
The two Field Batteries.
The South Station Hospital.
2*nd*—The Horse Artillery.
3*rd*—The European Infantry Regiment.
The North Station Hospital.

The water-supply of one well, No. 2, about 760 yards south of the South Station Hospital has been tested as regards both quantity and quality. The latter is satisfactory, and the former indicates that, for drinking and cooking purposes only, six supply wells, each 20 feet in diameter, would be required for the first section above mentioned of the garrison.

Paragraph 42. The total cost of supplying the troops from wells is estimated at Rs. 1,12,500, representing the following annual expenditure :—

	Rs.
Interest and depreciation on cost of works at 10 per cent. ...	5,000
Working expenses	2,500
Total ...	7,500

which would be in addition to present charges on this account.

The difficulty of forecasting the quality of the water and the uncertainty as to the maintenance of that quality if found suitable in the first instance render it unadvisable to resort to wells as a source of supply if any better arrangement can be made.

(4) A new source of supply for the troops has been found in the Agaram tank, a reservoir situated about three miles to the south of the SouthStation Hospital, and having a catchment basin of 32·10 square miles, of which however a considerable part is rendered non-effective by a number of tanks in the upper part of the valley. The tank is well supplied; it receives none of the drainage of Bangalore, and the quality of the water, which has been analysed by the Chemical Examiner, is described as "usable," the highest character given to any water, from the neighbourhood of Bangalore, which has been examined. The surplus weir is 56·62 feet below that of the Halsur (lower) tank, and water would have to be pumped up to a level sufficiently higher than at present to cover this difference and the head due to the greater distance. The water could either be drawn direct from the tank, filtered, and then pumped into the existing service cisterns, or it could be drawn from a supply well in or below the tank, in which case artificial filtration might not be needed. The tank at present has a capacity of 24·068 millions of cubic feet, and by raising the weir 3 feet an additional storage capacity of 20·601 millions would be secured, making the total 44·669 millions of cubic feet. The estimated outlay required is Rs. 2,20,000 if water be taken direct from the tank, and Rs. 1,88,000 if it be drawn from a supply well within the influence of the tank. These amounts would represent an annual expenditure as follows :—

Paragraph 44.

	No. 1. Rs.	No. 2. Rs.
Interest and depreciation on cost of engines, pumps and boilers, &c., at 15 per cent. ...	5,475	5,475
Interest and depreciation on other outlay at 10 per cent.	18,350	15,150
Total ...	23,825	20,925

or from Rs. 7·94 to 6·87 per head.

The present working expenses for pumping, &c., amounting to about Rs. 10,400 per annum, would suffice for the new pumping station ; and the engines and pumps at the Halsur rock and Dhobies' wells could, after the new arrangements had been completed, be disposed of.

Troops and families, 3,000.

(5) Water of unexceptionable quality is probably obtainable at Bangalore only by distillation.

Paragraph 50. It has been ascertained that the best known apparatus for this purpose is the Normandy Company's condenser, which is that recently introduced for the Government water-supply at Aden.

Taking 9,000 gallons, or 3 gallons a head, as the quantity essential for the use of the troops for drinking and cooking purposes, the annual expenditure on this account would be about Rs. 46,204, or Rs. 15·40 per head.

The working expenses of the present water works would be unaffected, as all the rest of the supply would have to be obtained from the Halsur tanks.

The Dhobies' well water would be the best for distillation, and the buildings there would be suitable for the condensing apparatus.

The Normandy condenser produces pure, cold, palatable, and well ærated water.

52. The thanks of the undersigned are due to Captain Kensington, R.E., the Secretary to the Mysore Government, Public Works Department; to Lieutenant-Colonel Burton, R.E., Executive Engineer, Presidency Division, and to Mr. J. Smith, the Engineer of the Halsur Water Works, for much valuable assistance given in carrying out the investigations referred to in this report; as also to Dr. T. Tarrant, Deputy Surgeon-General, Bangalore Division, for the very useful information afforded, at short notice, as to the quality of samples of water taken from several wells, and to the President of the Madras Municipal Commission, for particulars of the consumption of water, cost of distribution and maintenance, and of pipes and fittings, &c.

BANGALORE,
31st March 1884.

(Signed) J. MULLINS, Col., R.E.,
Chief Engineer, on special duty.

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APPENDIX No. 1.

COMPARATIVE Statement of Sanctions and Outlay, Bangalore Water Supply Project.

Heads.	Original Estimate sanctioned by the Government of India on the 23rd August 1870.	REVISED ESTIMATE, SANCTIONED BY THE GOVERNMENT OF INDIA.		Total Revised Estimate.	Total Outlay.	—
		July 1876 Revised Estimate.	October 1876 Supplemental Estimate sanctioned by Chief Commissioner.			
	Rs.	Rs.	Rs.	Rs.	Rs.	
Embankment and weir	1,03,903	2,31,207	3,329	2,34,536	3,14,868	
Catchment channels	11,850	51,758	..	51,758	71,289	
Moderator tanks	7,112	..	..	..	..	
Water tower	8,635	11,768	..	11,768	729	
Filter and store basins *	72,603	39,123	..	39,123	..	
Distribution reservoir †	24,123	..	..	..	..	
Delivery channels	2,91,031	‡ 1,15,552	§ 7,632	1,23,184	‖ 89,454	
Compensation for land, &c. ..	50,000	69,000	2,000	71,000	64,140	
Surveys and rainfall registration ..	..	5,250	..	5,250	4,285	
Inspection lodge, barracks and huts.	..	12,705	..	12,705		
Total ..	569,257	5,36,363	12,961	5,49,324	5,44,765	

* Design modified and then given up.
† This part of scheme abandoned.
‡ Open masonry channels instead of iron pipes.
§ Covering the channels.
‖ Nothing done beyond Cathcart road.

		Millions of Cubic Feet.	Cost per Millions of Cubic Feet.
			Rs.
Reservoir.	Total capacity ..	51	10,681.
	Available do. ..	29	18,785.

APPENDIX No. 2.

LEVELS of the Boundary Catchment Channels, Ooparhalli Reservoir, Bangalore Water Supply Project, taken in April and May 1883.

Mileage.	Bed-levels, &c.	Remarks.	Revised bed-levels May 1883.
MS. F.		*North-east Channel.*	
0 0	99·87	Newly excavated bed at zero stone	98·00
0 1	101·42	On grade stone	..
0 2	101·43	Do. do.	98·75
0 3	101·33	Do. do.	..
0 4	101·57	On bed	99·50
0 5	102·08	Do.	..
0 6	102·44	Do.	100·25
0 7	103·23	Do.	..
1 0	102·50	Do. Rise 1·23 per mile ..	101·00
1 1	102·18	Do.	..
1 2	102·42	Do.	101·75
1 3	102·80	Do.	..
1 4	103·07	Do.	102·50
1 5	103·21	Do.	..
1 6	103·26	Do.	103·25
1 7	104·02	Do.	..
2 0	103·70	Do. Rise 1·20 in mile ..	104·00
2 1	104·21	Do.	..
2 2	104·35	Do.	104·75
2 3	104·00	Do.	..
2 4	104·44	Do.	105·50
2 5	104·60	Do.	..
2 6	105·01	Do.	106·25
2 7	105·42	Do.	..
3 0	107·84	Do. Rise 4·14 in mile ..	107·00
3 1	120·11	Do.	..
		North-west Channel.	
0 0	99·38	Newly excavated bed ..	98·00
0 1	101·49	On grade stone ..	..
..	100·98	On bed newly excavated. ..	..

Mileage.	Bed-levels, &c.	Remarks.	Revised bed-levels May 1883.
MS. F.		*North-west Channel*—cont.	
0 2	101·65	On grade stone	98·75
0 3	101·80	Do. do.	..
0 4	101·82	Do. do.	99·50
0 5	102·17	Do. do.	..
0 6	102·29	Do. do.	100·25
0 7	102·51	Do. do.	..
1 0	102·72	Do. do.	101·00
1 1	102·91	On bed of channel ..	..
1 2	103·25	On grade stone ..	102·00
1 3	103·33	On bed of channel ..	..
1 4	103·46	Do. do.	103·00
1 5	103·74	On grade stone ..	..
1 6	104·06	On bed of channel ..	104·00
1 7	104·49	On grade stone ..	..
2 0	104·76	On bed of channel ..	105·00
2 1	106·08	Do. do.	..
2 2	108·19		..
		South-west Channel.	
0 0	100·26	Bed of channel and floor of culvert	98·00
		N. B. Waste weir 104·11.	
0 1	101·04	On grade stone ..	..
..	99·34	Bed newly excavated ..	..
0 2	101·48	On grade stone ..	98·75
..	99·88	Bed newly excavated ..	..
0 3	101·64	On grade stone ..	..
..	100·44	Bed newly excavated ..	..
0 4	101·89	On grade stone ..	99·50
..	101·26	Bed newly excavated ..	..
0 5	101·97	On grade stone ..	..
0 6	101·55	Bed newly excavated ..	100·25
0 7	102·38	On grade stone ..	..

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Levels of the Boundary Catchment Channels, Ooparhalli Reservoir, Bangalore Water Supply Project, taken in April and May 1883—(*Continued*).

Mileage.		Bed-levels, &c.	Remarks.	Revised bed-levels May 1883.
MS.	F.		*South-west Channel*—cont.	
1	0	102·67	On bed	101·00
1	1	103·18	Do.	..
1	2	103·11	Do.	102·00
1	3	103·41	On grade stone ..	..
1	4	103 29	On bed	103·00
1	5	103·61	On grade stone ..	..
1	6	103·95	Do. do.	104·00
1	7	104·36	Do. do.	..
2	0	104·57	Do. do.	105·00
2	1	105·48	Do. do.	..
2	2	106·43	Do. do.	..
			South-east Channel.	
0	0	99·76	Floor of culvert ..	99·00

Mileage.		Bed-levels, &c.	Remarks.	Revised bed-levels May 1883.
MS.	F.			
..		100·39	*South-east Channel*—cont.	
..		97·99	On grade stone ..	..
0	1	102·75	Bed newly excavated ..	..
0	2	102·09	On grade stone	..
0	3	102·27	Do. do.	100·00
0	4	102·60	Do. do.	..
0	5	100·85	On bed	101·00
0	6	103·01	On grade stone	..
0	7	103·24	Do. do.	102·00
1	0	104·04	On bed	..
1	1	103·97	Do.	103·00
1	2	103·81	Do.	..
1	3	104·19	Do.	..
			.. ..	..

Copied from level book lent by Mysore Public Works Office. December 1883.

APPENDIX No. 2-A.

Levels of the Upper Main (No. 2) Catchment Channels, Ooparhalli Reservoir, Bangalore Water Supply Projects, taken in October and November 1883.

Mileage.		Bed-levels, &c.	Remarks.
MS.	F.		*North-east Channel.*
0	0	100·62	Bed.
0	1	105·48	Do.
0	2	110·31	Do.
0	3	112·24	Do.
0	4	112·46	Do.
0	5	113·05	Do.
0	6	114·21	Do.
0	7	114·14	Do.
1	0	114·95	Do.
1	1	115·50	Do.
1	2	116·09	Do.
1	3	118·05	Grade stone.
1	4	118·13	Do.
1	5	118·40	Do.
1	6	119·35	Do.
1	7	119·67	Do.
2	0	120·98	Bed.
2	1	121·52	Grade stone.
2	2	122·84	Bed.
2	3	124·72	
			South-west Channel.
0	0	100·84	
0	1	104·33	
0	2	107·70	
0	3	110·75	
0	4	114·66	
0	5	117·31	
0	6	118·07	
0	7	118·74	
1	0	119·15	
1	1	119·84	
1	2	120·52	
1	3	121·29	
1	4	122·52	
...		123·82	End of channel.

Mileage.		Bed-levels, &c.	Remarks.
MS.	F.		*South-east Channel.*
0	0	101·90	
0	1	106·33	
0	2	111·96	
0	3	113·36	
0	4	114·39	
0	5	115·22	
0	6	115·39	
0	7	117·38	
1	0	118·09	
...		118·69	End of channel.
			North-west Channel.
0	0	102·30	
0	1	104·54	
0	2	107·44	
0	3	109·61	
0	4	111·68	
0	5	112·76	
0	6	113·43	
0	7	113·65	
1	0	114·04	
1	1	114·64	
1	2	115·42	
1	3	116·47	
1	4	117·44	
1	5	117·94	On grade stone.
1	6	118 04	Do. do.
1	7	120·02	Do. do.
2	0	121·24	Do. do.
2	1	122·77	Do. do.
2	2	124·02	Do. do.
...		126·95	Do. do.
			End of channel.

Copied from the level books in the office of the Secretary of the Mysore Govt., Public Works Dept., on the 7th January 1884.

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APPENDIX No. 3.

Abstract of the Rainfall registered at Stations of the Bangalore Water Supply Works.

Months.	1876.		1877.		1878.		1879.		1880.		1881.		1882.		1883.		Days.		Inches.	
	Days.	Inches.	Days.	Inches.	Days.	Inches.	Days.	Inches.	Days.	Inches.	Days.	Inches.	Days.	Inches.	Days.	Inches.	Total.	Average.	Total.	Average.
January ..	..	..	..	..	..	..	1	0·27	..	..	..	..	1	0·75	..	..	2	0·28	1·02	0·13
February ..	..	..	..	..	..	..	2	1·24	..	..	..	..	..	..	..	..	2	0·29	1·24	0·15
March ..	..	..	..	..	..	..	2	1·56	..	..	..	..	..	..	..	..	7	1·00	4·24	0·53
April ..	..	..	..	..	..	..	2	0·60	1	0·09	1	0·39	1	0·39	1	0·09	11	1·57	6·95	0·87
May ..	..	..	..	..	1	2·13	2	5·31	1	0·09	5	6·77	5	6·77	5	2·83	47	6·71	36·16	4·52
June ..	..	..	..	..	6	5·31	9	3·23	5	2·83	7	1·83	7	1·34	7	1·34	45	6·43	17·17	2·15
July ..	..	..	..	..	11	5·33	4	14	14	3·94	6	1·03	16	4·89	18	3·94	82	11·71	32·90	4·11
August ..	..	..	..	..	13	12·77	16	3·82	14	6·92	8	2·78	16	7·29	14	6·92	88	12·57	50·31	6·29
September ..	..	..	..	..	15	6·93	7	4·32	4	0·06	21	12·33	12	3·39	4	0·06	77	11·00	37·14	4·64
October ..	..	..	..	..	11	5·11	10	7·48	14	12·96	14	9·95	10	4·73	14	12·96	71	10·14	49·71	6·21
November ..	..	..	..	..	1	0·23	2	1·90	6	3·04	3	2·07	12	8·09	6	3·04	35	5·00	23·12	2·89
December ..	..	..	..	..	..	..	..	..	3	2·03	..	..	..	..	3	2·03	4	0·57	2·61	0·33
Total ..	..	16·52	69	34·25	62	41·03	68	37·75	78	39·56	40	21·63	82	36·92	72	34·91	471	67·28	269·57	32·82

* As registered at the Bangalore Observatory, Bowring Civil Hospital.

APPENDIX No. 4.

TABLE of Area of Waterspread and Capacity of the Ooparhalli Reservoir.

Reduced levels, M.S.D.	Levels of survey contours	Area in acres.	Area in millions of square feet.	Capacity: Between contours, millions of cubic feet.	Capacity: At contours, millions of cubic feet.	Remarks.
	55·00 to					
3004·97	75·00	18·0	0·7841			
	76·00	18·8	0·8189	0·802	6·273	Approximation based on area at 75·00 and estimated mean depth.
	77·00	19·6	0·8538	0·836	0·302	
	78·00	20·4	0·8886	0·870	1·638	
	79·00	21·2	0·9235	0·907	2·508	
3009·97	80·00	22·0	0·9583	0·938	3·415	
	81·00	23·0	1·002	0·980	4·353	
	82·00	24·0	1·045	1·025	5·333	
	83·00	25·0	1·089	1·067	6·358	
	84·00	26·0	1·133	1·111	7·425	Millions of cubic feet.
	85·00	27·0	1·176	1·155	8·536	6·270
	86·00	28·4	1·237	1·205	9·691	16·330
	87·00	29·8	1·298	1·265	10·896	
	88·00	31·2	1·359	1·328	12·161	Total capacity up to sluice sill level. 22·603
	89·00	32·6	1·420	1·390	13·489	
3019·97	90·00	34·0	1·481	1·451	14·879	
	91·00	35·8	1·559	1·511	16·330	
	92·00	37·6	1·638	1·600	1·511	Sluice sill level.
	93·00	39·4	1·716	1·678	3·111	
	94·00	41·2	1·795	1·756	4·789	
	95·00	43·0	1·873	1·835	6·545	
	96·00	44·8	1·951	1·913	8·380	
	97·00	46·6	2·030	1·992	10·293	
	98·00	48·4	2·108	2·070	12·285	
	99·00	50·2	2·187	2·148	14·355	
3029·97	100·00	52·0	2·265	2·224	16·503	
	101·00	54·4	2·344	2·316	18·727	
	102·00	56·8	2·432	2·420	21·043	
	103·00	59·2	2·500	2·525	23·463	
3033·97	104·00	61·6	2·579	2·629	25·988	
	105·00	64·0	2·657	2·734	28·617	Millions of cubic feet.
	106·00				31·351	Weir crest level .. 22·603
	107·00	..	..	2·839		Total capacity to weir crest level. 28·617
	108·00	..	..		34·190	51·220
	109·00	..	..	2·945	37·125	
	110·00	..	..	3·052	40·187	
	110·62	..	..	3·160	43·347	
				3·269	46·616	
				2·095	48·711	

N.B.—Abstracted up to 105·00 from book in Mysore Public Works Office, of which a copy has been made.

The reduced levels refer to provisional mean sea level at Karwar G.T.S. value of bench mark at base line station near Mantapam 3113·26.

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APPENDIX No. 5.

TABLE showing the Periods during which Water was above or below the Level of the Sill of the Ooparhalli Reservoir Sluice, viz., 90·00, or 3019·97.

Years.	Months.	Days: Above Sill.	Days: At or below Sill.	
1878 ..	January	..	31	
	February ..	..	28	
	March	..	31	
	April	..	30	
	May	..	31	
	June	..	30	
	July	14	17	Highest W. L. 91·25 on 19th. Lowest W. L. 87·58 on 9th.
	August	31	..	Do. 99·58 on 26th. Do. 90·48 on 10th.
	September ..	30	..	Do. 100·12 on 29th. Do. 98·69 on 27th.
	October	31	..	Do. 100·25 on 21st. Do. 99·33 on 19th.
	November ..	30	..	Do. 99·62 on 1st. Do. 97·87 on 30th.
	December ..	31	..	Do. 97·77 on 1st. Do. 96·10 on 31st.
	Total ..	167	198	
1879 ..	January ..	31	..	Highest W. L. 96·07 on 1st. Lowest W. L. 94·60 on 31st.
	February ..	28	..	Do. 94·56 on 1st. Do. 93·67 on 28th.
	March	31	..	Do. 93·62 on 1st. Do. 92·50 on 31st.
	April	30	..	Do. 92·44 on 1st. Do. 91·12 on 30th.
	May	31	..	Do. 92·83 on 22nd. Do. 90·29 on 18th.
	June	30	..	Do. 92·92 on 13th. Do. 91·90 on 30th.
	July	31	..	Do. 95·08 on 29th. Do. 91·17 on 16th.
	August	31	..	Do. 94·83 on 1st. Do. 93·79 on 23rd & 31st.
	September ..	30	..	Do. 94·81 on 15th. Do. 93·75 on 1st.
	October	31	..	Do. 96·42 on 11th. Do. 93·42 on 10th.
	November ..	30	..	Do. 96·75 on 5th. Do. 94·93 on 30th.
	December ..	31	..	Do. 94·85 on 1st. Do. 93·12 on 31st.
	Total ..	365	..	
1880 ..	January ..	31	..	Highest W. L. 93·08 on 1st. Lowest W. L. 91·69 on 31st.
	February ..	29	..	Do. 91·63 on 1st. Do. 90·29 on 29th.
	March	5	26	Do. 90·25 on 1st. Do. 89·17 on 31st.
	April	..	30	Do. 89 10 on 1st. Register incomplete.
	May	..	21	Do. 92·33 on 27th. Do.
	June	30	..	Do. 92·17 on 2nd. Lowest W. L. 91·04 on 30th.
	July	31	..	Do. 92·04 on 11th. Do. 90·83 on 5th.
	August	31	..	Do. 96·92 on 16th. Do. 91·04 on 11th.
	September ..	30	..	Do. 95·83 on 1st. Do. 94·33 on 30th.
	October	31	..	Do. 97·85 on 28th. Do. 94·08 on 20th.
	November ..	30	..	Do. 97·58 on 1st. Do. 95·83 on 30th.
	December ..	31	..	Do. 96·04 on 1st. Do. 94·33 on 31st.
	Total ..	289	77	
1881 ..	January ..	31	..	Highest W. L. 94·29 on 1st. Lowest W. L. 92·75 on 31st.
	February ..	28	..	Do. 92·71 on 1st. Do. 91·37 on 28th.
	March	31	..	Do. 91·33 on 1st. Do. 90·06 on 31st.
	April	1	29	Do. 90·04 on 1st. Register incomplete.
	May	..	31	Do. 89·25 on 31st. Lowest W. L. 87·96 on 30th.
	June	11	19	Do. 90·42 on 8th & 9th. Do. 89·00 on 7th.
	July	..	31	Do. 89·37 on 1st. Do. 88·08 on 31st.
	August	4	27	Do. 90·42 on 29th. Do. 87·96 on 7th.
	September ..	13	17	Do. 90·75 on 28th. Do. 89·65 on 15th.
	October	22	9	Do. 90·71 on 6th. Do. 89·67 on 31st.
	November ..	26	4	Do. 93·12 on 13th & 14th. Do. 89·58 on 2nd.
	December ..	31	..	Do. 92·42 on 1st. Do. 91·17 on 31st.
	Total ..	198	167	
1882 ..	January ..	29	2	Highest W. L. 91 12 on 1st. Lowest W. L. 89·94 on 31st.
	February ..	..	28	Do. 89·90 on 1st. Do. 88·77 on 28th.
	March	..	31	Do. 88·73 on 1st. Do. 87·29 on 31st.
	April	..	30	Do. 87·21 on 1st. Do. 85·48 on 30th.
	May	12	19	Do. 92·87 on 20th. Do. 84·69 on 13th.
	June	25	5	Do. 92·25 on 1st. Do. 89·83 on 30th.
	July	..	31	Do. 89·79 on 1st. Do. 89·17 on 24th.
	August	21	10	Do. 91·46 on 11th. Do. 89·35 on 8th.
	September ..	11	19	Do. 90·92 on 1st. Do. 89·67 on 21st & 22nd.
	October ..	22	9	Do. 90·92 on 14th & 16th Do. 89·58 on 9th.
	November ..	30	..	Do. 91·79 on 30th. Do. 90·08 on 5th.
	December ..	31	..	Do. 91·75 on 1st. Do. 90·50 on 31st.
	Total ..	181	184	

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TABLE showing the Periods during which Water was above or below Level, &c.—(*Continued*).

Years.	Months.	Days. Above Sill.	Days. At or below Sill.	—
1883 ..	January ..	11	20	Highest W. L. 90·46 on 1st. Lowest W. L. 83·21 on 31st.
	February ..	..	28	Do. 89·17 on 1st. Do. 88·50 on 28th.
	March	..	31	Do. 88·47 on 1st. Do. 87·37 on 31st.
	April	..	30	Do. 87·34 on 1st. Do. 86·27 on 30th.
	May	..	31	Do. 86·24 on 1st. Do. 85·65 on 31st.
	June	..	30	Do. 85·95 on 3rd. Do. 84·97 on 30th.
	July	..	31	Do. 84·93 on 1st. Do. 84·68 on 17th.
	August	..	31	Do. 89·40 on 19 & 20th. Do. 84·53 on 10th.
	September	..	30	Do. 88·96 on 1st. Do. 88·03 on 30th.
	October	25	6	Do. 98·00 on 17th. Do. 87·95 on 2nd.
	November ..	30	..	Do. 97·96 on 3rd. Do. 95·33 on 30th.
	December ..	31	..	Do. 95·15 on 1st. Do. 91·90 on 31st.
	Total ..	97	268	

SUMMARY.

Years.	Days. Above Sill.	Days. At or below Sill.
1878	167	198
1879	365	77
1880	289	167
1881	181	184
1882	97	268
1883	198	77
Total ..	1,297	894
Average ..	2·16	·149

APPENDIX No. 6.

STATEMENT showing the Differences of Water Level and Contents on the 30th November of each year and the 15th May of the year following, Ooparhalli Reservoir.

Year.	30TH NOVEMBER. Gauge reading.	30TH NOVEMBER. Contents. Millions of cubic feet.	15TH MAY. Gauge reading.	15TH MAY. Contents. Millions of cubic feet.	Difference. Millions of cubic feet.
1878	97·87	14·086	90·42	0·635	13·451
1879	94·93	8·252	89·67 *	0·484	8·736
1880	95·83	9·968	88·58	2·045	12·013
1881	92·46	3·883	85·69	5·808	9·691
1882	91·79	2·775	85·74	5·747	8·522
1883	95·33	9·018	..	..	..
Total ..	..	47·982	..	..	..
Average ..	..	7·997	..	..	..

* An approximation, the register not giving the water-level between 24th April and 22nd May.

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FALL OF SURFACE.

1878 to 1879	.. ..	7·45
1879 to 1880	.. ..	5·26
1880 to 1881	.. ..	7·25
1881 to 1882	.. ..	6·77
1882 to 1883	.. ..	6·05
		32·76
	Average ..	6·55

APPENDIX No. 7.

ABSTRACT Particulars of Water Works.

Name.	Unit of supply Gallons per head per diem.	—	Description of Works.
Halsur Water Works, Bangalore.	14 1 12	Europeans .. Native followers. Horses.	Water pumped into service cisterns holding from 7 to 33 days' supply. Source of supply—a tank and wells below the tank. Cost about Rs. 3,28,000. Population— Europeans .. .. .. 2,460 Native followers .. .. .. 1,302 Horses 834
Almora Water Works.	2	....	Population 8,000. Cost Rs. 21,000. Supply collected from ravines and springs and conveyed in a concrete channel from an extreme distance of 3½ miles to a storage reservoir holding 10,000 cubic feet, or 62,500 gallons. Distribution by water posts.
Ahmedabad Water Works.	About 5⅓	....	Population supplied 25,000 out of 111,680. Consumption 133,000 gallons daily. Water pumped from river Sabarmati by engines of 5 and 6 horse power in 10 hours daily to a height of 52 feet into a settling tank holding but little more than ¼ of a day's supply. Distribution by covered tanks and stand pipes. Cost, prior to substitution of engines for pumping, Rs. 1,09,583.
* Karandwad Water Works at junction of Punchgunga and Kistna rivers.	5	....	Population 8,000. Cost Rs. 23,807. Water pumped by a wind engine from well on bank of river into a stand pipe 20 feet high, and thence into a storage tank (fort ditch) holding 2·4 millions of gallons. No distribution. Works not successful owing to wind engine not working properly.
Inchalkarangi Water Works.	5	....	Population 8,000. Cost Rs. 1,11,174. Lift 80 feet. Source of supply—the river Punchgunga. Water pumped up and conveyed to storage tank holding 1·20 millions of gallons. Distribution by pipes to four dipping wells and two cattle troughs.

Abstract Particulars of Water Works—(*Continued*).

Name.	Unit of supply Gallons per head per diem.	—	Description of Works.
Secunderabad Water Works.	16 80	European troops Officers.	European troops—men 3,719, officers 140. The women and children not included in the above. Source of supply—wells. Water pumped by engines into service reservoirs. Quantity 70,704 gallons per diem. Maximum height of delivery above water in well, 139 feet. Total cost Rs. 3,12,913. Cost of machinery and piping Rs. 1,75,000. *South supply.*—24,160 gallons per diem. One well, 30 feet diameter and 55 feet deep from ground surface. Cost of this part of system Rs. 85,060. Monthly cost of working Rs. 380 *North supply.*—46,544 gallons per diem. Main well and quarter guard well, which are connected. Dimensions not stated. Cost of this part of system Rs. 2,27,852. Monthly cost of working Rs. 500. The service reservoirs hold 3 days' supply. Results satisfactory.
Ootacamund Water Supply.	30	Domestic .. 12 General baths 4 Trade .. 4 Waste .. 10	*North supply.*—300,000 gallons per day. Source of supply—reservoir. Capacity 46·48 millions of gallons. Catchment 260 acres. Supply insufficient and intended to be supplemented by a second reservoir with capacity about 24 millions of gallons and catchment 60 acres. Cost .. Rs. 28,629. Proposed additions „ 1,02,940 ——— 1,31,569 *South supply.*—Reservoir, capacity 3 millions of gallons. Catchment 184 acres. Reservoir too small, as the supply would fill one holding 30 millions of gallons. So far supply not satisfactory, and extensive improvements contemplated.
Royal Alibag Water Works.	16	....	Population 5,500. Reservoir, capacity 22·50 millions of gallons, fed by a stream which can fill the reservoir in 48 hours. Distribution by pipes to about 20 dipping wells or service reservoirs. Cost Rs. 34,000. Reservoir has a small command over town.
Pen Water Works, Kolaba Collectorate.	26⅔	....	Population 6,000. Cost Rs. 28,000, of which reservoir Rs. 18,000 and distribution Rs. 10,000. Catchment basin 100 acres. Annual rainfall 110 inches. Estimated yield of catchment 120 millions of gallons, or 19·20 millions of cubic feet, equivalent to 52·8 inches, draining off the catchment or nearly half the rainfall. Estimated maximum consumption of water 160,000 gallons per diem, equal to 26⅔ gallons per head per diem. Distribution below filter by cast iron mains to 15 tanks or cisterns, with option of house connections at owner's expense.

Abstract Particulars of Water Works—(*Continued*).

Name.	Unit of supply, Gallons per head per diem.	—	Description of Works.
Kolhapur Water Works.	10	....	Population 40,000. Cost— Head works .. .. .. 15,309 Alterations to duct .. .. 40,486 Reservoir .. .. .. 18,403 Pipes .. .. 1,09,373 Fountains, &c. .. .. .. 70,699 Total .. 2,54,270 Source of supply—springs in a water-course 4½ miles south-west of town. Catchment basin of water-course above dam 4 square miles. Water drawn from well 10 feet below bed of stream, and flows into duct which has a fall of 16 feet per mile and can discharge when running full 262 cubic feet per minute, or 2½ millions of gallons a day, or 5 times the daily requirement at 10 gallons per head. Duct discharges into service reservoir, a circular masonry tank 100 feet in diameter and 6 feet deep, holding 294,500 gallons. Distribution by cast iron pipes and 267 stand pipes. Rainfall 40 to 45 inches. Works only partially successful, as the supply has been as little as 112,200 gallons a day in the hot season, or 2·8 gallons per head per diem It is intended to form an impounding reservoir above the head works.
Jalgaon Water Works.	89	3 Presses, 5,500 gallons daily for 6 months. 1 Factory, 6,000 gallons daily for 12 months.	Population (July 1879) 8,406. Source of supply—Mehrun large and small tanks with a catchment of 3·45 square miles. Rainfall 7·68 to 35·92 inches. Average of 8 years (1868 to 1875) 22·20 inches. Capacity of large tank 421 millions of gallons. Depth draining off catchment to fill tank 8·4 inches. Tank filled to overflowing in 1878 and in 1879, but rainfall not stated. Supply available, by gravitation, after deducting allowance for evaporation, 278 millions of gallons for the year, of which 3·2 millions used by factories, &c., and 274·8 millions remain for distribution among population, or over 89 gallons per head per day. Cost of works— Small tank .. .. .. 27,671 Piping .. .. .. 16,136 Large tank .. .. .. 73,588 Total .. 1,17,395 or Rs. 1,743 per million cubic feet stored and Rs. 14 nearly per head of population.

Abstract Particulars of Water Works—(*Continued*).

Name.	Unit of supply, Gallons per head per diem.	—	Description of Works.
Lahore Water Works.	10	....	Population 130,000. Source of supply—wells in Khadir of River Ravi. Supply practically inexhaustible, the Khadir having formerly been the bed of the river and having a constant subsoil flow. Extreme lift 140 feet. Length of pumping main 2,660 feet. Water pumped into covered service reservoir with a capacity of 381,600 cubic feet or 2 days' supply, and distributed thence by iron pipes. Greatest quantity of water pumped 60,000 gallons per hour. Cost of works Rs. 15,00,935. Working expenses per mensem— Rs. A. P. Engine establishment .. .. 356 0 0 Fuel, oil, &c. .. .. 763 8 0 Total .. 1,119 8 0 The outlay is just under Rs. 11·55 per head of the population, and the cost of pumping just under $1\frac{2}{3}$ annas a head per annum. Allowing 10 per cent. on outlay to cover interest, maintenance, and deterioration, the whole cost of the water-supply would be 1·155 + 0·103 = 1·258 rupees per head per annum.
Mysore Water Works.	$6\frac{1}{4}$ Nominal.	....	Population 57,765. Estimated cost 4 lakhs, of which distribution Rs. 80,000 and filters Rs. 30,000. Source of supply—a reservoir about 2 miles from the town. Natural catchment of reservoir, acres 549 Total do. do. .. „ 4,300 Waterspread of do. .. „ 165 Storage capacity of reservoir, millions of cubic feet .. .. 100 Level of waste weir .. .. 2491·00 Level sill of sluice (bottom of lowest opening) .. .. 2469·00 Level centre of sluice .. .. 2470·00 Rainfall 20 inches, of which one-eighth expected to drain into the tank. Depth draining off required to fill the tank 6·40 inches. The water is to be conveyed in a covered masonry or concrete channel, designed to carry the nominal supply in 6 hours, to 2 settling basins, each to hold 60,000 cubic feet. The loss by evaporation, &c., estimated at nearly 40 per cent. The reservoir was ready to store water in March 1881. No water had been drawn off up to October 1883, when the water stood at 2474·85 or 16·15 feet below sill level, and the contents were 10·80 millions of cubic feet. The highest water level so far reached appears to be $9\frac{1}{2}$ feet above sluice sill.

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APPENDIX No. 8.

PARTICULARS of the Calculation of approximate Cost of supplying Bangalore with Water from near Nundidroog.

Storage Reservoir.—The estimate, Rs. 45,000, has been, in the absence of any data for a definite estimate, calculated at Rs. 750 per million cubic feet. The actual cost of storage ranges from Rs. 300 upwards.

2. *Filters.*—The quantity of water being 10,000 cubic feet an hour, and the usual allowance being 2 square feet of filter bed for every cubic foot per hour, the area will be 20,000 square feet, or 200 by 100 feet. A second filter will be necessary to admit of alternate cleansing; so 40,000 square feet of filter bed may be taken as the requirement. The estimated cost of the service reservoir, a covered work, is Rs. 2 a square foot; so Rs. 75,000 will probably suffice for the filters.

3. *Cast Iron Main.*—The length, 150,000 feet, is that indicated as probable by Mr. Andrews' survey. The assumed required discharge being 240,000 cubic feet a day, or 2·778 cubic feet a second, and the head 60 feet, it was found from Jackson's tables that the discharge of a 24-inch cast iron pipe would, with a regular gradient, be 3·51 cubic feet a second, while Nevilles' formula, $v = 140 \sqrt{r.\,s.} - 11 \sqrt[3]{r.\,s.}$, makes the discharge 5·786 cubic feet a second. The main would have to be laid with many variations of gradient, and it was considered therefore advisable to use the formula which gives the lowest discharge and to allow a moderate margin.

Plan No. .

4. The length of 150,000 feet has been divided into 149,000 feet of straight pipe, and 1,000 feet of bends, &c. The bends or changes of direction, both vertical and horizontal, will, for the most part, be so gentle that straight pipes will suffice.

5. The rates are based on information obtained from the Madras municipality, viz., Rs. 80 a ton for straight pipes, and Rs. 120 for bends, &c.; the corresponding rates for the neighbourhood of Bangalore are Rs. 95 and Rs. 135, thus made up:—

	Rs.
Rate per ton at Madras	80
Rail to Bangalore	10
Cartage to work	5
Total ..	95

The weight per foot is for one inch thickness of metal taken from the Madras municipal table, and that for the three-fourth inch thickness has been deduced therefrom and checked by Beardmore's table. The cost of laying the pipes is that paid at Madras and includes all the necessary materials.

Main with 24-inch C. I. Pipe, 1 inch thick.

149,000 feet × 245 lb. = 36,505,000 lb. = 16,297 tons.
1000 „ × 245 „ = 245,000 „ = $109\frac{1}{2}$ „

	Rs.
16,297 tons of straight pipe, at Rs. 95 .. .. .. =	15,48,205
$109\frac{1}{2}$ do. do. at „ 135 .. .. .. =	14,782½
Laying 50,000 yards, at Rs. $2\frac{1}{2}$	1,25,000
Contingencies	82,012½
	17,70,000

Main with 24-inch C. I. Pipe, $\frac{3}{4}$ inch thick.

149,000 × 186 = 27,714,000 lb. = 12,732 tons.
1000 × 186 = 186,000 „ = 83 „

	Rs.
12,732 tons of straight pipe, at Rs. 95 .. .. .. =	11,75,340
83 do. do. at „ 135 .. .. .. =	11,205
Laying 50,000 yards, at Rs. $2\frac{1}{2}$	1,25,000
Contingencies	65,455
	13,77,000

4. *Service Reservoir.*—The capacity is intended to be 1·20 millions of cubic feet, or 5 days' supply, the depth of water 10 feet, and in making the estimate it has been supposed that a clear space for water 600 by 200 will be the form adopted. The length is to be divided into two equal parts by a pier 4 feet thick, and each part into 20 bays of 15 feet by piers $2\frac{1}{2}$ feet thick. The abutments and side-walls to be 6 feet thick at bottom and 3 feet at top. The foundation to be of concrete 5 feet deep from the springing of the inverts, which are to have a versed sine of $1\frac{1}{2}$ feet and a thickness of $1\frac{1}{2}$ feet; the concrete under the inverts will therefore be 2 feet thick.

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The 2½-feet piers will have openings in them, arched both below and above, to allow of the free circulation of the water. The central 4-feet pier will have no opening, and there will be no communication between the two parts of the reservoir except by pipes with regulating valves. The piers and abutments will be 10 feet high, and will carry arches with a versed sine of 3¾ feet, and thickness of 1½ feet. The abutments, spandrils and side-walls will be carried up to the level of the tops of the arches, and over all 3 feet of earth will be placed with slopes of 2 to 1 down to ground-level on all sides, except where the valve house, &c., may be placed. The abutment faces, side-walls, and inverts will be plastered with Surki mortar for a thickness of half-an-inch, and the surface will be rendered with Portland cement. Bricks of good quality to be used for all work above the concrete.

The concrete platform will project 3 feet beyond the base of the walls.

Total length between abutments—

$40 \times 15 + 38 \times 2\frac{1}{2} + 1 \times 4 = 600 + 95 + 4 = 699$ feet

Length of concrete platform $699 + 2 \times 6 + 2 \times 3 = 717$ "

Width of do. do. $200 + 2 \times 6 + 2 \times 3 = 218$ "

Concrete .. .. .. $717 \times 218 \times 5 = 781{,}530$

Deduct .. $600 \times 200 \times \frac{2 \times 1\frac{1}{2}}{3} = 120{,}000$

Do. $40 \times 200 \times 16\frac{1}{2} \times 1\frac{1}{2} = 198{,}000$

318,000

Brickwork— 463,530 c.ft.

Inverts		
Abutments ..	$2 \times 200 \times 4\frac{1}{2} \times 10 =$	198,000
Centre pier	$200 \times 4 \times 10 =$	18,000
Piers	$38 \times 200 \times 2\frac{1}{2} \times 10 =$	8,000
Arches	$40 \times 200 \times 19 \times 1\frac{1}{2} =$	190,000
Backing over abutments	$2 \times 200 \times \frac{10 \times 5\frac{1}{2}}{2}$	228,000
Spandrils ..	$38 \times 200 + \frac{16 \times 4}{2}$	11,000
Do.	$1 \times 200 \times \frac{17\frac{1}{2} \times 4}{2}$	243,200
Sidewalls	$2 \times 711 \times 4\frac{1}{2} \times 10$	6,000
		63,990

Excavation $720 \times 220 \times$ say $6 + 5$ = 1,742,400 — 967,190 c.ft.

Covering in reservoir $705 \times 205 \times 3 = 433{,}575$

Do. .. $2 \times 200 \times 24 \times \frac{12}{2} = 57{,}600$

Do. .. $2 \times 705 \times 24 \times \frac{12}{2} = 203{,}040$

694,215

Plastering 2,436,615 c.ft.

Plastering ..	„ $2 \times 200 \times 10 =$	4,000
Do. ..	„ $2 + 600 \times 10 =$	12,000
Do. ..	„ $40 \times 16 \times 200 =$	128,000

144,000 sq.ft.

	Rs.
4635·30 concrete, at Rs. 9-8-0 per 100	44,035
9671·90 brickwork, at Rs. 16-8-0 per 100	1,59,586
2436·600 earthwork, at Rs. 4-0-0 per 1000	9,746
1440·00 plastering, at Rs. 4-0-0 per square	5,760
Contingencies	14,883
	2,34,000
Pipes, valve-house, dwellings for establishments, &c.	6,000
	2,40,000

5. *Distribution Mains, &c.*—This head includes all the works below the service reservoir, viz., the mains, branches, stand pipes, dipping wells, fountains, &c., which may be needed for bringing the water within easy reach of the population. The rate of Rs. 5 a-head of the population is the actual cost at Madras. If the service reservoir floor can be placed as high as 3029·97, the distribution will probably cost less than the sum allowed.

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APPENDIX No 9.

From Colonel A. C. HAY, Commissioner, Ashtagram Division, to the Secretary to the Chief Commissioner of Mysore, Public Works Department, dated Mysore, 25th August 1874, No. 357-73.

I have the honor to acknowledge the receipt of your No. 1494 of 18th July, forwarding copy of a memorandum to Captain Clive regarding the drainage and water-supply of the town of Mysore.

2. Before Captain Clive arrived, I had directed enquiries to be made regarding the number of wells and other sources of supply, with the object of ascertaining approximately the wants of the population in different quarters of the town, and the extent to which these wants are now met, as well as the wishes of the people regarding any improvements that could be made to enhance the supply by clearing and deepening old wells, sinking new ones or constructing reservoirs when this could be done with advantage.

3. The Mutsaddis of the different Mohallas were accordingly directed to ascertain the number of wells and reservoirs, the quantity of the water obtained from each and whether the supply was constant. They also prepared returns compiled from the statements given by the residents of every house, shewing the source from which the inhabitants of each street obtained water, which were checked by counting the number of persons who drew water in a day from most of the principal wells, &c.

4. In an inquiry of this kind, accuracy is unattainable all that can be expected is, such information as will give a general view of existing circumstances, and to this extent I believe a fair estimate can now be formed of the actual condition of the town as regards water. I propose to mention first the present supply of the town in ordinary seasons, shewing this in detail for each Mohalla, proceeding then to review the results in a condensed form with some remarks on the means by which water is distributed, and on past seasons of actual scarcity. Some of these figures may be tedious, but are necessary to explain the subject. Finally, the proposals and requests of the inhabitants will be stated with such remarks as are required in each case. In order to render this intelligible, a map has been prepared, shewing the limits of each Mohalla, in which the streets have been grouped in convenient blocks and the sources of water-supply indicated according to the quality of the water. There are also 3 statements, A. B. and C., the first shewing the number of existing wells of all descriptions in the dwelling houses, the second containing all the information that can be collected regarding the past history, &c., of the different reservoirs and wells, the water of which is capable of being used for drinking and cooking purposes, and the third the proposals of the inhabitants with my remarks.

5. I shall now, as proposed in para. 4, allude to each Mohalla separately.

6. Mysore is divided into the following Mohallas :—

1. Lashkar.	3. Devaraj.	5. Fort.
2. Mandi.	4. Krishnaraj	6. Nazarbad.

According to the last census and the returns of the municipal overseer, it contains 13,067 inhabited houses and 57,765 inhabitants on an average of 4·5 persons to a house.

7. The number of cattle is supposed to be about 15,000, exclusive of those belonging to the palace.

8. There are—

2 *Large Tanks.*—Dodkere with Bowen's well and others sunk round the margin. Karanji with wells below it.	3 *Kattes.*—Sub Rao, Siniru, Avaduta.
1 *Small Tank.*—Jivan Rao Katte.	1 *Gunta.*—In front of the summer palace.
	5 Ghâts in Purnaiya's channel.

Twenty-six public and 28 private wells, the water of which is considered good for drinking and cooking.

These all lie in the catchment basins of the Dodkere and Karanji and are within municipal limits.

In addition there are seven wells in the valleys running north, viz.—

North Valley.	*North-East.*
Jail Reservoir.	Julpuri.
Telelee Bowrie.	Christian.
Jailane.	Nawab.
Syed Ahmed Makan.	

Also a spring of excellent drinking water flowing down Chamundi Hill, and 2,398 wells scattered over different parts of the town, the water of which being either brackish or hard is only used for drinking and cooking when better is not procurable. The water of the majority is very inferior, and that of many useless for both purposes and only taken for ablution.

The case of the reservoir in the bed of Dodkere known as Bowen's Baoli is different: in consequence of its pollution the water has been only fit for washing cloths, &c.; but there is every prospect of its becoming fairly wholesome and drinkable when the silt is removed.

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25

Lashkar Mohalla.

Houses.	*Population.*
3,581.	14,171.

9. This Mohalla contains three sub-divisions, Basvan, Lashkar, and Yirangere; the latter is believed to be the most ancient part of Mysore and the site of an old Polegar fort. Most of the ground remained unoccupied till the installation of His late Highness, when he is understood to have resided for a short time in a dwelling known as the "Durbin bungalow" in which his parents lived before they were removed to Seringapatam by Tippu. During the administration of Purnaiya, houses sprung up and troops were located there, whence the Mohalla got its present name.

10. No drinking water is procurable within the limits of the Mohalla, the people of which have to go either to the wells in the north-east or north valleys, to Purnaiya's Nalla on the west, or the two wells in the south and to the Karanji on the east. An estimate of the quantity drawn for this purpose only is given below:—

No. of		Sources of supply in ordinary years.	Quantity.			Distance.	
Blocks.	Houses.		Pots.	Total.		For going and returning.	Average.
				Pots.	Gallons.		
		North.					
Parts.							Miles.
1·2	524	Jail well	1,0[illegible]				
3·4	104	Telellee Baoli	3[illegible]	2,284	5,710	1½	1 mile.
		North-east.					
2·3·5	290	Nawab Baoli	580				
2·3·5	381	Christian	762				
3·5·6	122	Julpuri	216	1,558	3,895	2	
		.. ..				2	
		West.				2	2 miles.
44	200	Purnaiya's Channel, Rajput Ghat	400				
4·7	525	Do. Holiyar do. ..	not used.				
7	100	Do. Mochi do. ..	1,765			¾	
7	200	Do. Mir Hayath Gunta ..	150				
7	125	Jivan Rao Katte	400			¼	
		.. .. ..	256	2,965	7,413½	½	
		South.				½	3½ furlongs.
7	100	Gosayi well in fort ditch	100				
7	40	Pir Sabi	80				
7·8	99	Saude Koppal	298	478	1,194	½	
		.. ..				½	½ mile.
		East.					
5·6·7·8·9	771	Karanji	1,542	1,542	3,855	2½	2½ miles.
	3,581	Total ..	8,827	8,827	22,067½		General average excluding the distance of Karanji is ¾ mile.

11. This statement represents 3,581 houses, with a population of 14,171 obtaining per house about 6⅛ gallons of water per day from an average distance of ¾ mile, the maximum distance being 2½, and the minimum ¼ mile.

12. The returns obtained by counting show larger quantities, part of the water being required for other purposes.

13. With the exception of the Karanji tank, the jail reservoir and the original cutting of Purnaiya's Nalla, it may be said that all these are the work of private individuals; though some have been deepened and the approaches to others improved at different times by the Government and the municipality.

North Valley.

14. The jail reservoir is excavated in rock, and contains a spring of brackish water which is not drinkable. The value of the work consists in its catching and retaining the rain water flowing off the slopes above it, and as it is the only reservoir of this description in the neighbourhood it is much prized. I understand that the Executive Engineer is employed in examining this reservoir, and it is therefore unnecessary to give further details.

Constancy of supply.

15. Water in the Telelee well never entirely fails, but is considered hard, and when water is procurable from the jail reservoir, it is only resorted to by pakalis who supply water to families for cooking and bathing purposes and carry it about for sale in the Mohalla.

16. With a rainfall of 21 inches and 63 cents in 1873 and 13¾ inches up to 4th August in 1874, the spring appeared to be capable of supplying at least 10 pakalis making 5 trips a day and drawing from it about 1,000 gallons.

17. The other wells in this valley contain good water, but owing to the distance, are not used till the supply in the jail reservoir fails. They are probably all kept up to some extent by a stone-built katte above used by dhobis, the water from which percolates through to the lower level.

North-east Valley.

18. The Julpuri is said never to run dry, but it is less drawn upon than the other two, the water of which is considered better; the steps are also very steep. The so-called Christian well, which is used by all lower castes, is the only well available for Holayars, and nearly failed last year. With the rainfall mentioned above, the supply from this well and the Nawab's is barely sufficient for the requisitions made on them. The pakalis of the detachment N. I. stationed in Mysore were in the habit of going before daylight to the latter, and by 8 A.M. the water was exhausted, and had to be scooped up half full of mud in saucers and shallow dishes, but was partially replenished during the day. Under those conditions the supply yielded daily by the well seemed to be about 1,500 gallons.

West.

Purnaiya's Channel and Jivan Rao Katte.

19. Though the Rajput Ghât contains more water, the Mochi Ghât is the most important to this Mohalla as it is nearer. The water never fails, but there is a general impression that it gives guineaworm, a circumstance to which I shall recur hereafter. It is unnecessary to give particulars regarding the wells on the south-east additional to those entered in the statement.

20. Part of the water so required is obtained from the wells first mentioned, and the remainder from draw-wells in different streets. As rock formation extends over this whole Mohalla, water is only reached at great depths, and all that is procured in the different wells being either salt, brackish or hard, is used only for domestic purposes, such as washing vessels and cloths and for bathing. The expense of sinking wells is also so great that the poorer inhabitants cannot afford to have private wells, and consequently the northern half of the Mohalla from the Yirangere gate to the taluk cutcherry and part of the south-western quarter possess very few. There are 61 public wells in different other parts of the Mohalla which were originally excavated by private individuals as acts of charity, and these are accessible to all classes. Two only are dry at present. In addition to these, 450 houses contain 489 private wells, of which 100 are dry. The owners of many of these allow their neighbours access, but the want of water for these purposes is often very severely felt, and the supply is never sufficient.

Water for domestic purposes and ablution.

Mandi Mohalla.

Houses.	*Population.*
3,086.	13,981.

21. This Mohalla dates principally from the time of Purnaiya, who induced grain-merchants and other traders to settle at Mysore. Since the death of His Highness the late Maharaj a good many houses in the western portion have been abandoned: it now contains 3,086 inhabited houses with a population of 13,981 persons.

Water for drinking and cooking.

22. The great majority are dependent on Purnaiya's channel, since out of 3,086 houses, it appears that 1,876 are supplied from the ghâts and 460 from three draw-wells, two in the centre and one at the northern extremity of the Mohalla. The residents of about 700 houses were returned as procuring water from the Karanji tank.

23. As regards distance, the inhabitants of this quarter are better off than those of the Lashkar Mohalla; but it is remarkable that according to their statements they procure less water. The explanation given for this is, that the approaches to some of the ghâts are steep and unsafe, and that the women do not bring more than is abolutely necessary. The people are generally poor, and employ neither pakalis nor carts. The households obtaining water from the Karanji are chiefly those of Brahmans and merchants who can afford to send to that distance.

24. Below is statement similar to that given for the Lashkar Mohalla. The estimate is that nearly 5 gallons per house are taken from an average distance of ¼ mile. In calculating the distance, the Karanji is excluded.

No. of Blocks.	No. of Houses.	Names of Wells, &c.	Quantity. Pots.	Quantity. Total Pots.	Quantity. Total Gallons.	Distance. For going and returning, miles.	Distance. Average.
		West.					
2·3	250	Chakkani Well					
3·4	200	Biramsabi	750				
3	10	Minakshi	400	..	..		
			50	..	..		
		Purnaiya's Channel.		..	..		
1·2·3	345	Rajput Ghât				50 yds.	
2·3	70	Holiyar Ghât	1,035				
3·4·5	1028	Mochi Ghât	140	..	..		
4·5	83	Mir Hayath Gunta	2,707	..	..		
4·5	350	Molakalve	259	..	..		
3	50	Jivan Rao Tank	700	..	..	200 yds.	
			50	..	..	do.	
		East.		6,091	15,227½		
3·4·5·6	700	Karanji Tank	700	700	1,750		
3,086		Total ..	..	6,791	16,977½	2½	

The average distance is ¼ of a mile excluding that of Karanji tank.

25. As in the Lashkar Mohalla, the water ascertained by counting to be drawn daily from the different sources includes a good deal of what is used for all domestic purposes, the rest being obtained from draw-wells. In this respect the Mandi Mohalla has no advantage over the Lashkar Mohalla, as there are only 67 wells the water of which is available for all, and 176 wells in private houses; out of the whole, 67 are dry.

Water for ablution, &c.

Devaraj Mohalla.

Houses.	*Population.*
2,271.	10,640.

26. Part of the Devaraj Mohalla is ancient, and part was founded by His Highness the late Raj. It is on the western side of Purnaiya's channel, of which the people make very little use though a few go to the Mochi Ghât.

Water for drinking and cooking.

As long as the Jivan Rao katte holds water it is much resorted to, and it is the accepted opinion that the water of the tank as it sinks into the soil feeds the wells below, of which several contain very good water. These are amongst the most valuable wells in the town, three of them (Advanaiya, Vire Gauda, and Venkatdikshit's well) have never failed, and afforded water to a large number of the inhabitants of other Mohallas when their own supply ceased. The estimated quantity of sweet water used daily in this Mohalla is about 5 gallons per house.

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27. Half of the Mohalla from the Siledar's lines to Pindarkari Street (blocks 1 and 2—788 houses) is well supplied by the Jivan Rao tank, and 8 wells believed to be greatly dependent on it, which have never failed, but the other half from the Pindarkari to Sub Rao katte road containing 1,553 houses has only two wells and one small katte.

28. These wells are classed in the following statement in the order of their value:—

No. of Blocks.	No. of Houses.	Names of Wells.	Quantity. Pots.	Quantity. Total Pots.	Quantity. Total Gallons.	Distance. For going and returning.	Distance. Average.
		West.					
		Devaraj Mohalla.				½ mile.	
1·2·3·4	400	Jivan Rao Katte	800	..	..	200 yds.	
2·3	445	Advanaiya	890	..	..	100 do.	
3	250	Vire Gauda	500	..	..	50 do.	
3	100	Nag Nayik	200	..	..	50 do.	
1	80	Nanjaiya	160	..	..	400 do.	
1·3	75	Venkatdikshit	150	..	..	100 do.	
1·4	75	B. Venkatappa	150	..	..	100 do.	
1	66	Anjanaiya	132	..	..	100 do.	
1·2·3	67	A. Sub Rao's Well	130	..	..	50 do.	
1·3	55	Amruthesvara Temple	110	..	..	1 mile.	
3	50	Avadutta Katte	100	..	..	50 yds.	
2	30	Narnaswami	60	..	..		
		Krishnaraj Mohalla.				½ mile.	
4·5	300	Sanjivaraj Ursu	600	..	..		
		Mandi Mohalla.				200 yds.	
1	60	Purnaiya's Channel Mochi Ghât ..	120	4,102	10,255		
		South.					
		Dodkere	60	60	150	..	
		East.					
		Karanji Tank	200	200	500	..	
		Total ..	..	4,362	10,905	..	

The average distance is ¼ of a mile, excluding that of Karanji.

29. It is represented that there is a great want of water for other purposes as the quantity procurable from wells, the water of which is not good to drink, is scanty and uncertain, nearly one-third out of 371 private wells, and 9 out of 72 public wells are dry, and it is said that the people do not obtain even half of what they need for domestic and personal use.

Water for ablution, &c.

Krishnaraj Mohalla.

Houses.	*Population.*
2,259.	9,603.

30. This Mohalla originated during the administration of Purnaiya, and now contains 2,259 houses with 9,603 inhabitants.

31. There are some very good sweet-water wells within its limits. Some have been constructed for the public and others are in private houses to which access is allowed.

32. In block No. 1, containing 1,055 houses, the supply appears to be tolerably plentiful and constant. The other 3 blocks rely to a great extent on the Siniru katte, a small pond for catching the rain-water on the high ground, to the south.

33. Lately two experimental wells have been sunk below the Dodkere bund, the water of which is considered fair and is taken for drinking and cooking purposes by the people of several streets in the vicinity.

The water of the Dodkere is not drunk but is taken by a few persons for cooking.

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34. The average quantity taken daily in the Mohalla appears to be rather more than in the Devaraj Mohalla, being 6¼ gallons per house, ablutions, &c.

No. of Blocks.	No. of Houses.	Description of Wells.	Quantity. Pots.	Quantity. Total Pots.	Quantity. Total Gallons.	Distance. For going and returning.	Distance. Average.
		West.					
		Krishnaraj Mohalla.					
3	393	Dod Holagere	1572				
1·2	300	P. Puttaiya	1105	..	..	200 yds.	The average distance is nearly half a mile, excluding that of Koranji.
1·3	250	Soppina Kola	700	..	..	250 do.	
1·3	225	Siniru Katte	675	..	..	300 do.	
2·1	155	Sanjivaraj Ursu	310	..	..	¼ mile.	
1·2	100	Bale Muttaiya	200	..	..	½ do.	
1	80	Halgaiya	160	..	..	150 yds.	
1	71	V. Putti	213	..	..	½ mile.	
1	50	Mir Mahomed	100	..	..	100 yds.	
1	50	Chamappaji	100	..	..	50 do.	
				5,135	12,837½	250 do.	
		South.					
1	155	Dodkere	155	155	387½	500 do.	
		East					
1·3	400	Karanji Kere	400				
¼	30	Spring at the foot of Chamundi ..	60	..	..	2½ miles.	
				460	1,150	2 do.	
		Total ..	..	5,750	14,375	..	

35. The Dodkere tank provides all that is necessary in addition to what is obtained from wells * and kattes.

* Public wells 66, private wells 442.

Fort Mohalla.

Houses.	*Population.*
868.	5,785.

36. Tippu, with his usual policy of destroying every monument of the former Government, had razed Mysore and removed the stones of the palace and temples to the neighbouring height called by him Nazarbad, from its commanding an extensive view.

The present fort with the buildings in it date subsequent to the installation of the late Raja, with the exception of four temples, two on the west and two on the east, reputed to be ancient.

37. Water for cooking purposes is procured from 14 wells situated within it, and from the Dodkere tank. For drinking water the inhabitants have to go about 2 miles in all, to the Karanji tank, as the pipes by which this water was conveyed to the interior of the fort and (as is said) to 30 wells, constructed during the late Raja's administration, are now out of order.

38. When the supply in the Karanji tank is exhausted, the water of the fort wells, which is at present used only for cooking, is drunk by nearly half of the population of the fort; others resort to the springs at the foot of Chamundi Hill, and a few wealthy families obtain Cauvery water from Seringapatam.

39. The quantity at present supposed to be consumed for drinking and cooking purposes according to the statement of the people is 2,604 pots, or 6,510 gallons, at an average of 3 pots or 7½ gallons per house, obtained from the sources pointed out in the following statement:—

No. of Blocks.	No. of Houses.	Description of Wells.	Quantity. Pots.	Quantity. Total Pots.	Quantity. Total Gallons.	Distance. For going and returning.	Distance. Average.
		South.					
1	83*	Muniajatti	166				
1.2	70	Venkat Subbaiya	140				
1.2	70	Bale Ars	140				
1	50	Saude Koppal	100				
1	50	P. Linga Shastri	100				
2	50	Guruvaiya	100				
2	50	Annaiya Jois	100				
2	50	Kempanna	100				
1	45	S. Krishna Rao	90				
1	45	Puttiaji	90				
1	40	Balachari	80				
1	40	K. Puttaiya	80				
1	40	K. Linga Shastri	80				
1	20	Tippaiya	40				
1.2	165	Dodkere	330	1,736	4,340	Within half mile.	Half a mile, excluding the distance of the Karanji tank.
		East.					
1.2		Karanji Tank	868	868	2,170	2 miles.	
	868	Total ..		2,604	6,510		

40. Except for drinking water, the fort seems in some respects to be better supplied than other Mohallas. In addition to the public* wells nearly half of the houses are provided, while the Dodkere tank is close to the walls.

* Public wells 31, private wells 380.

Nazarbad Mohalla.

Houses.	*Population.*
1,002.	3,585.

41. This Mohalla, as mentioned above, received its present name from Tippu. He had made considerable progress in the works of a fort on the spot when he began to consider that it afforded no water. He then dug an immense pit cutting down through the solid block rock to a great depth and width without success; and at the time of the siege of his capital the whole work was lying in a mass of confusion, with a few wretched huts in it for the accommodation of his workmen.

42. The Nazarbad Mohalla extends over a large area, but is thinly populated as compared with the others. It contains some of the palace buildings and a good many houses, occupied chiefly by the European and East Indian community; a considerable extent of ground is waste and unoccupied.

43. There are—

11 Minor wells.
3 Principal wells.
1 Tank—Karanji.
1 Gunta—in front of the summer palace within the limits of this Mohalla.

Of these, the 14 wells alluded to contain a moderate supply of water fit for drinking and cooking purposes, and are resorted to chiefly by the poorer native population; about ⅓ of the whole depending upon the Karanji tank for drinking water.

The gunta, which is a small pit originally dug for taking earth for preparing bricks, &c., catches the surface water of the high ground near the summer palace, but this lasts only for three or four months during the rainy season, and is drunk chiefly by Holiyars and others living in Itigegud.

44. The estimated quantity of water at present obtainable from all sources for drinking and cooking purposes is 2,367 pots or 5,917 gallons, at an average of nearly 6 gallons per house, ablution, &c.

No. of Blocks.	No. of Houses.	Description of Wells.	Quantity. Pots.	Quantity. Total Pots.	Quantity. Total Gallons.	Distance. For going and returning.	Distance. Average.
		East.					
1.4	35	Balramsing					
2	10	Karanji Matt					
1	30	Holiray Well	1,160				
5	13	Shama Shastri	100	..	..	200 yds.	
5	19	Gunta	90	..	..	1 mile	
1	25	Pailandi	60	..	..	100 yds.	
1	25	Mallaiya	54	..	..	50 do.	
1	25	Narasappa's Garden	50	..	..	100 do.	
2	15	Aleman Holiray	50	..	..	150 do.	
1	15	Yakub Sab	50	..	..	50 do.	
4	5	Davarasaiya	45	..	..	100 do.	
4	5	Lovery	30	..	..	50 do.	
4	10	Rudraraju	30	..	..	150 do.	
3	5	Mr. Meyors	20	..	..	50 do.	
1.3.4.5.	308	Karanji Tank	20	..	..	50 do.	
			20	..	..	50 do.	
		South.	308	..	..	50 do.	
5	140	Dodkere Wells		2,087	5,217½	1 mile	
		Total ..	280	280	700		
				2,367	5,917½		One-fourth a mile, excluding the distance of the Karanji tank.

45. Regarding the water required for other purposes, the existing number of 226 private and 17 public wells suffices for the ordinary requirements of the people living in the Mohalla.

46. *Distribution.*—At least ⅘ths of this water is brought in the ordinary chatties (each containing 2½ gallons) by men or women on their heads, the rest in similar pots slung on addes (bamboos) by pakalis, in water carts, hand barrows or mankanies, which are panniers containing large vessels loaded on bullocks.

47. *Pakalis.*—There are 36 pakalis regularly employed; 9 of these draw water from the Telelee well and Purnaiya's channel for distribution in the Lashkar and Mondi Mohalla where it is sold at from one to two pies per pot of 2½ gallons. Seven supply the Barr, 11 the Siledars, one the detatchment, 30th native infantry, and 8 the palace stables. The principal places to which these resort are the jail reservoir in the north, Nawab Bowri in the north-east, Purnaiya's channel and Jivan Rao tank on the west, Gosayi well near the fort, and Dodkere tank on the south.

48. *Water Carts.*—Sixteen or seventeen wealthy inhabitants in the town send carts once or twice a day to bring water from the Karanji tank for their own use. In addition, 9 are engaged by the palace, each making three trips daily to the Karanji tank. Another cart brings daily 40 pots of Cauvery water from Seringapatam for the use of the Ranis. The water for ablution and domestic purposes is obtained from two or three brackish wells situated near the palace, as well as from the Dodkere tank and the well lately dug below the bund.

49. *Hand Barrows.*—These have been introduced within the last year or so, and the number at present employed is estimated at 37. They go twice a day to the Karanji tank and fetch 8 pots or 20 gallons of water each at a time.

50. *Mankanies or Panniers.*—These are used by oil-mongers: each mankani contains four pots or ten gallons of water and is conveyed by a single bullock.

51. *Cattle.*—It is necessary to say a few words regarding the cattle and horses, &c., kept by the people.

52. From an old account obtained from the taluk, there must be nearly 15,000 cattle in the town besides the palace cows and bullocks.

53. The cattle generally go to the marginally-noted places for drinking water, but when the supply is exhausted in the hot weather, brackish or hard water from the wells in the town is used. There are about 20 public totties (stone and brick in chunam cisterns) constructed by private individuals in different places, which are daily filled by the owners as an act of charity for cattle, and especially cows which do not go to a distance daily to graze.

North.
1. Boppanhalli Tank.
2. Joginkere do.

West.
1. Jivan Rao Tank.
2. Purnaiya's Channel.
3. Pudvarhalli Katte.
4. Siniru Katte.
5. Subba Rao.

South.
1. Dodkere.
2. Halkola.

East.
1. Devanur Katte.
2. Karanji Tank.

54. The total quantity of water required by the cattle is estimated at 60,000 gallons on an average of 4 gallons per head.

55. *Washermen.*—It is reported that there are nearly 200 washermen in Mysore, or at an average of one to 65 houses or 285 persons, who go to various * places for the purpose of washing clothes.

North.
* 1. Cauvery river, Seringapatam.
2. Boppanhalli tank.
3. Purnaiya's channel.

West.
1. Kukanhalli tank.

South.
1. Dodkere tank.
2. Boblikatte do.
3. Dalvoy do.

56. *Summary.*—I shall now proceed to review the returns for the whole town.

57. In addition to the Karanji and Dodkere tanks, there are Purnaiya's channel, the minor reservoirs, and the wells, public and private, all of which are resorted to by the people; but the peculiar difficulty at Mysore consists in the fact that only a few contain good and wholesome water, and that these are situated at a considerable distance from the occupied areas.

58. With some classes of natives the most important quality of water is that it should be palatable to drink; others consider it absolutely necessary that water should not be hard, for in that case dhall cannot be boiled owing to the coating found on it during the process, and hence they generally refer to this as the best test. For other domestic purposes and for bathing brackish or hard water suffices.

59. In Mysore the Karanji water is referred to as the type of purity and excellence; but the water of all the rain reservoirs except that of the Dodkere is good for every purpose. That in the wells in the north and north-east valleys, if not perfectly pure, is palatable and believed to be quite wholesome, and there are also a few wells in different places which are considered to furnish very good water.

60. The reservoir in the bed of the Dodkere tank, known as Bowea's bauri, contains a good spring, but owing to silt and other causes the water had hitherto been of no use; after the reservoir is cleared, it is believed that the water will be found fit for drinking and cooking purposes. The wells in the upper part of the bed have been found to yield very good water, and are regularly used by those living within a convenient distance from them.

61. The remaining wells give water of every degree of brackishness, that of some being almost salt and of others only slightly hard.

62. Opinions differ regarding the water in Purnaiya's nalla. The general impression is that the water of the channel and especially that of the Mochi Ghât produces guinea-worm; but many persons who suffer from it ascribe the complaint to other causes. Hindu doctors are of opinion that drinking stagnant water produces it, while Mussalman hakims do not attribute it to water at all, and many of the people consider it arises from filth, and can be remedied by clearing the reservoirs. Whatever the true explanation may be, it is demonstrable as a matter of fact that the population of the Mandi and Lashkar Mohallas who make use of that water suffer more than others. Within three or four years over 3 per cent. of the residents of the Mandi Mohalla and nearly 3 per cent. of those of the Lashkar Mohalla have been attacked by guinea-worm; 65 persons have migrated from these Mohallas elsewhere with the special object of getting rid of the disease.

63. The Civil Surgeon states that the general opinion that the drinkers of Purnaiya's nalla water are most liable to disease is correct. Mild cases of guinea-worm rarely come under hospital treatment, and the average ratio of guinea-worm cases to total sick in the hospital is, for the last five years, 4 per mille per annum.

64. By the statement given of the quantity of water fit for drinking and cooking purposes used daily, it appears that the whole amounts from 25,000 to 30,700 † ordinary chatties or pots, each containing 2½ gallons, giving, if the higher figure be taken, about one and one-fourth gallons per head, or 6¼ per house.

† 76,750 gallons.

65. If we arrange the sources of supply according to the quantity of water obtained from each, their values are represented roughly by the following numbers:—

	Gals.
Public wells	28,985
Rain reservoirs	21,855
Purnaiya's channel	19,190
Private wells	6,720
Total ..	76,750

66. *North-East.*—The wells ‡ in the north-east valley were returned as supplying 793 houses with an estimated quantity of 3,875 gallons; this was found to be tolerably accurate by the experiment of counting the number of persons resorting to each in a day.

Relative importance of different wells.
‡ Julpuri, Christian, Nawab.

Jail reservoir and Telelee bauri.

1. Chikni.	7. Vera Gauda.
2. Biram.	8. Sanjivarai.
3. A. Subba Rao.	9. P. Puttaiya.
4. Nunjaiya.	10. Soppina or body guard.
5. Venkatdikshita.	11. Dod Holgere, 7,111 houses.
6. Advanaiya.	

69. *South.*—The Dodkere on the south is scarcely used except for bathing, but there are two principal wells and twelve minor wells supposed to supply 1,267 houses, 6,772 gallons. Bowen's bauri, to which allusion is made in paragraphs 7 and 60, is now being cleared.

Soudi Koppal near the fort.
Munya Jettis well in the fort.

70. *East.*—On the east is the Karanji; by counting it was ascertained that 2,582 pots or 6,455 gallons were taken from this tank in a day. There are two or three * important wells and thirteen minor wells containing drinkable water. The total quantity consumed on the east is 14,642 gallons by 3,268 houses.

* Balram Sing, Rudraraju, Karanji Matt.

71. It must be understood that all estimates made above have referred to the supply obtainable in ordinary seasons, and after a fair rainfall, when the tanks and wells have been partially filled. In the hot weather not more than half is said to be taken, and in seasons of drought the scarcity is very great.

72. Owing to the deficient rainfall in the last hot weather, viz., 21 inches and 63 cents, which was lower than that of 1871 and 1872, and far below 31 inches, the average of the previous years, the Karanji tank and rain reservoirs, with several wells and kattes upon which nearly one-third of the population of the town are dependent for drinking water, appear to have been actually dry. A large number of wells containing brackish water also failed, and the supply, in most, decreased considerably.

73. The scarcity was severely felt everywhere, for though the ghâts and some of the wells did not fail, there was very little water to be had, and what was procurable was often muddy and unwholesome.

The most valuable wells were those noted in the margin, and temporary wells were sunk by the palace and municipality in the tract of land between the Karanji and Dodkere, and even in the bed of the Boppenhalli tank, which proved of great service; but the people had to go long distances, and many incurred considerable expense in sending carts and barrows to fetch water from the places where it was to be got. A few wealthy families obtain water from Seringapatam.

North.		
1. Telelee bauri.	Beyond the town.	
2. Syed Ahmed Makan.		
3. Jailane.		
North-East.		
1. Julpuri.	Do.	
2. Christian.		
3. Nawab.		
West.		
1. Chikani.	Mandi Mohalla.	
2. Purnaiya's channel with its five ghâts.		
3. Asham Subba Rao.		
4. Amruthesvara.	Devraj Mohalla.	
5. B. Venketappa.		
6. Anjaniya.		
7. Nanja.		
8. V. Dikshit.		
9. Adavanaiya.		
10. Vire Gauda.		
11. Sanjivarai.		
12. P. Puttaiya.		
13. Soppin well.	Krishnaraj.	
14. Dod Holgeri.		
South.		
1. Wells dug by the municipality near the end of Dodkere.		
2. Saudekoppal.		
3. Chamundi spring.		
4. Muniya jetti.		
East.		
1. Karanji Matt.	Nazarbad.	
2. Balram Sing.		
3. Rudraraju.		
4. Shanker Das.		

74. The total expenditure hitherto incurred on account of works carried out from the year 1859—60 by different departments in connection with the water-supply of Mysore is shown as Rs. 72,190-9-4, of which Rs. 9,444-3-5 were spent by the municipality, Rs. 13,000-12-8 by the Public Works Department, and Rs. 49,745-9-3 by the Revenue authorities on various works, such as strengthening the bunds of the tanks of Dodkere, Karanji, and Jivan Rao katte, including repairs to their feeders and to several spring-fed wells. A great deal of the work to the Dodkere was undertaken at the special request of His Highness the late Maharaj, and had no effect in increasing the supply.

Measures adopted by Government towards water-supply of the town.

75. To increase the supply of drinking water the people desire the improvement of the following tanks and wells:—

West.

1. Clearing and improving Purnaiya's channel.
2. Improving the Jivan Rao katte tank.
3. Do. Suba Rao katte.
4. Deepening the well in the bed of Suba Rao katte.
5. Do. Sunjivaraj Arsu well.
6. Shiniru katte.

South.

7. Restoring the Karanji duct feeding the wells in the fort.

East.

8. Improving the gunta in front of the Summer Palace.
9. Karanji tank.

76. In addition to these the construction of reservoirs, one in the centre of the Lashkar and Mandi Mohallas, and the other in the Krishnaraj Mohalla, is urged.

77. In my opinion a careful examination should be made of the northern and north-eastern valleys containing the wells upon which so large a proportion of the inhabitants depend for water, and it should be ascertained whether the supply in the existing wells can be increased by deepening them, and whether others can be dug, as there are numerous wells in the valley just below them. The possibility of constructing small reservoirs to catch and retain the water so as to feed the wells should also be considered. There is an impression among the natives that the best spring in the Nawab's well has been suppressed by clay underlying the stone-work built to prevent the earth at the sides from falling in.

78. The steps to the Julpuri and Christian wells should be improved, as they are now too steep for women and children. Though the jail reservoir only holds rain-water, it is of the greatest value to the whole neighbourhood, and I should strongly recommend additional feeders being led to it, and if it is found that more water is brought than the reservoir will hold, another should be constructed below it.

79. Makan well in the north valley, dug by the municipality, should have stone revetments, and I believe another at an intermediate point could be sunk with advantage. The municipality have been instructed to do so as an experiment.

80. I understand that Major Johnson once recommended the construction of a katte or tank in the valley behind the jail, and the project though not emergent is worth further inquiry. A small reservoir for intercepting the water flowing from the Residency high ground might be formed at the bottom of the compound.

81. This great work failed in its original object, but has proved of an infinite service in tapping a number of excellent springs, the water of which though inferior in quality is indispensable and not objected to by a large section of the population.

Purnaiya's channel.

Apparently springs are to be met with throughout the whole length of the channel from the Rajput Ghât to the fort walls, and many natives believe that there was once a continuous stream from the Rajput Ghât downwards. Communication is, however, now entirely interrupted both by land slips and the general silting up of the bottom of the channel, as also by the excavation of the pits at the ghâts, the earth from which has been thrown up round them, and by the new road to the Civil Hospital. Everything has been done that could be done to render the channel a nuisance instead of a benefit. In parts it is overgrown with vegetation, it is used as a latrine and receptacle of filth, and the drainage of the market and several streets has been discharged into it contaminating the soil and stopping up one, if not more, of the springs. A professional officer is required to survey the channel and determine the best mode of remedying the damage, and also to decide on what should be done to the present ghâts, whether a continuous flow of water should be brought down, or the ghâts isolated and kept as separate wells. Considering the number of women, children and infirm persons who have to ascend and descend, the approaches to all the ghâts should be laid out with steps at easy slopes widened and protected by railings at the side.

82. It has been sometimes supposed that the Jivan Rao katte has been a failure, and it is in some respects defective, as the water does not remain at the tank; but there is little doubt that what disappears feeds the wells below, and that fresh wells could be sunk with success below it. The improvement of this work is in all respects desirable. I have heard that Sub Rao katte has been examined, but with what result I do not know. If it can be improved it should be, as the situation is convenient.

The Jivan Rao and other kattes.

83. This pond is situated a few yards above the Benne Hardanhalli feeder of the Dodkere, and the people in the neighbourhood have pointed out to me that it can possibly be filled from the feeder by making a small dam and a cut leading the water to the katte. Some years ago a project was proposed for constructing a second katte just below and filling it from the feeder, but this has passed out of notice. Both these proposals should receive attention, as it does not appear that the projects would be expensive and the people are much in favor of them. It may indeed be possible to find a still better site, but this is a point on which I am uncertain.

Siniru katte.

84. The advantages of bringing water from the Karanji tank and distributing it at the cistern now under construction by the Public Works Department cannot be over-estimated

Karanji water.

when the great distance of the Karanji tank is considered; but it would be still better if the pipes could be continued from the fort to a reservoir on the open space now called the People's Park. It is not probable that the water in Bowen's well will be drunk by any one who can get water from the Karanji cistern, but when purified the well will no doubt afford an excellent supply of water which will be quite drinkable, will probably be found good for cooking, and will be preferred to that of the Dodkere for all purposes.

85. The Dodkere must simply be regarded as the cess-pool of Mysore until the sewage which now pollutes it is cut off; when this is done there is no apparent reason why the water should not be tolerably good.

86. Having now reviewed the whole question, it must be evident that if all that is suggested was carried out, and every reservoir and well improved to its utmost capacity, Mysore would still have only an uncertain and often insufficient quantity of water at command. In dry seasons the people must suffer considerably, and in a year of drought undergo actual privation; and it is therefore necessary to look beyond the limits which have been referred to.

87. The possibility of bringing water from the Cauvery is a point to be decided by professional officers; but whatever may be the result the project for supplying some high level in the town with water from Benne Hardanhalli and Bogadi tanks, a scheme originally suggested by Major Johnson, should be carried out if found to be as good as it promises. The survey for this, the drainage project, Bowen's well, the Karanji tank feeders and duct, and the Jivan Rao katte, are either under survey or execution, and it only remains for me to recommend that a Public Works officer take up in succession the examination of the different valleys on the north and north-east, Purnaiya's channel, the Siniru and Sub Rao kattes, and the proposed continuation of the Karanji duct. The work of cleaning out and deepening wells of drinking water, sinking new ones within the town, improving others useful for any purpose, and the enforcing of conservancy, may be left to the municipality.

Sir Richard Meade, who has seen the principal wells and ghâts, considers that among the points for consideration by the municipality is the possibility of raising water from the main wells at the public expense and discharging it into cisterns from which it could be obtained by the people uncontaminated and without the risk and labor of descending to the level of the springs. I believe that with the information now collected, the municipality would have no difficulty in determining how money may be best expended for all these purposes.

APPENDIX No 10.

TABLE of Area of Water-spread and Capacity of the Halsur Lower and Upper Tanks.

Reduced level, M.S.D.	Survey contour level.	Gauge readings.	Area in millions of square feet.	Capacity: Between contours millions of cubic feet.	Capacity: At contours millions of cubic feet.	Remarks.
2920·97 ..	41·00	9·00	1·8504		1·628	The mean depth 0·88 below this contour has been taken from the cross sections shown on the survey, which is supposed to be that made in the early part of 1877 and referred to in Lieut. F. J. Romilly's report, dated 30th September 1879.
	41·25	8·75	1·988	0·480	2·108	
	41·50	8·50	2·126	0·514	2·622	
	41·75	8·25	2·286	0·551	3·173	
2921·97 ..	42·00	8·00	2·446	0·591	3·764	
	42·25	7·75	2·616	0·633	4·397	
	42·50	7·50	2·787	0·675	5·072	
	42·75	7·25	2·968	0·719	5·791	The areas at 41·00, 44·00, 47·00, and 50·00 have been measured from the contour lines shown on the survey.
2922·97 ..	43·00	7·00	3·149	0·764	6·555	
	43·25	6·75	3·341	0·811	7·366	
	43·50	6·50	3·533	0·859	8·225	
	43·75	6·25	3·738	0·909	9·134	The areas at each half foot between the above contours have been deduced on the supposition that each three feet layer is the frustrum of a cone.
2923·97 ..	44·00	6·00	3·9432	0·960	10·094	
	44·25	5·75	4·001	0·993	11·087	
	44·50	5·50	4·060	1·007	12·094	
	44·75	5·25	4·120	1·022	13·116	
2924·97 ..	45·00	5·00	4·181	1·037	14·153	The areas at the quarter feet are the means of the areas at the half feet.
	45·25	4·75	4·243	1·053	15·206	
	45·50	4·50	4·305	1·065	16·274	The capacities between contour are found by multiplying the area of the mean contour by the depth. They are therefore only approximations, but are probably quite as accurate as the data will allow.
	45·75	4·25	4·368	1·084	17·358	
2925·97 ..	46·00	4·00	4·431	1·100	18·458	
	46·25	3·75	4·495	1·116	19·574	
	46·50	3·50	4·560	1·132	20·706	
	46·75	3·25	4·624	1·148	21·854	
2926·97 ..	47·00	3·00	4·6884	1·164	23·018	
	47·25	2·75	4·720	1·176	24·194	
	47·50	2·50	4·752	1·184	25·378	
	47·75	2·25	4·782	1·192	26·570	
2927·97 ..	48·00	2·00	4·812	1·199	27·769	
	48·25	1·75	4·842	1·207	28·976	
	48·50	1·50	4·872	1·214	30·190	
	48·75	1·25	4·902	1·222	31·412	
2928·97 ..	49·00	1·00	4·932	1·229	32·641	
	49·25	0·75	4·962	1·237	33·878	
	49·50	0·50	4·993	1·244	35·122	
	49·75	0·25	5·023	1·252	36·374	
2929·97 ..	50·00	0·00	5·0532	1·259	37·633	Weir crest lower tank.
	50·25	..	5·083	1·267	38·900	
	50·50	..	5·113	1·274	40·174	
	50·75	..	5·143	1·282	41·456	
2930·97 ..	51·00	..	5·173	1·290	42·746	
	50·00	..	0·453		0·600	The area at the 50·00 and 53·00 contours have been taken from a survey signed C. B. Target, Exct. Engineer, No. 11, Tank Division, obtained from the office of the Secretary to Government of Mysore, Public Works Department, and those at 54·00 and 56·00 from a survey, dated 22nd November 1880, signed by Lieut. F. J. Romilly, R.E., the 54·00 contour being deduced from that at 54·08 shown on the survey.
	50·25	..	0·544	0·125	0·725	
	50·50	..	0·636	0·147	0·872	
	50·75	..	0·742	0·172	1·044	
	51·00	..	0·848	0·197	1·241	
	51·25	..	0·970	0·227	1·468	
	51·50	..	1·092	0·258	1·726	
	51·75	..	1·229	0·290	2·016	
	52·00	..	1·366	0·324	2·340	
	52·25	..	1·518	0·360	2·700	
	52·50	..	1·671	0·399	3·099	
	52·75	..	1·839	0·439	3·538	
	53·00	..	2·007	0·481	4·019	Based on survey of 22nd November 1880.
	53·25	..	2·056	0·508	4·527	
	53·50	..	2·106	0·520	5·047	
	53·75	..	2·156	0·533	5·580	
	54·00	..	2·207	0·545	6·125	
	54·25	..	2·284	0·561	6·686	
	54·50	..	2·372	0·582	7·268	
	54·75	..	2·462	0·604	7·872	
	55·00	..	2·553	0·627	8·499	
	55·25	..	2·646	0·650	9·149	
	55·50	..	2·740	0·673	9·822	
	55·75	..	2·837	0·697	10·519	
	56·00	..	2·934	0·721	11·240	
	41·00	9·00	1·8504		1·628	Weir crest, upper tank.
	41·25	8·75	1·988	0·480	2·108	
	41·50	8·50	2·126	0·514	2·622	
	41·75	8·25	2·286	0·551	3·173	
	42·00	8·00	2·446	0·591	3·764	
	42·25	7·75	2·616	0·633	4·397	
	42·50	7·50	2·787	0·675	5·072	
	42·75	7·25	2·968	0·719	5·791	
	43·00	7·00	3·149	0·764	6·555	
				0·811		

TABLE of Area of Water-spread and Capacity of the Halsur Tank prior to the Construction of the upper Tank in 1877.

Reduced level, M.S.D.	Survey contour level.	Gauge readings.	Area in millions of square feet.	Capacity		Remarks.
				Between contours, millions of cubic feet.	At contour, millions of cubic feet.	
	43·25	6·75	3·341	0·859	7·366	
	43·50	6·50	3·533	0·909	8·225	
	43·75	6·25	3·738	0·960	9·134	
	44·00	6·00	3·9432	0·993	10·094	
	44·25	5·75	4·001	1·007	11·087	
	44·50	5·50	4·060	1·022	12·094	
	44·75	5·25	4·120	1·037	13·116	
	45·00	5·00	4·181	1·053	14·153	
	45·25	4·75	4·243	1·068	15·206	
	45·50	4·50	4·305	1·084	16·274	
	45·75	4·25	4·368	1·100	17·358	
	46·00	4·00	4·431	1·116	18·458	
	46·25	3·75	4·495	1·132	19·574	
	46·50	3·50	4·560	1·148	20·706	
	46·75	3·25	4·624	1·164	21·854	
	47·00	3·00	4·6884	1·180	23·018	
	47·25	2·75	4·754	1·197	24·198	
	47·50	2·50	4·820	1·213	25·395	
	47·75	2·25	4·887	1·230	26·608	
	48·00	2·00	4·954	1·247	27·838	
	48·25	1·75	5·021	1·264	29·085	
	48·50	1·50	5·089	1·281	30·349	
	48·75	1·25	5·157	1·298	31·630	
	49·00	1·00	5·226	1·315	32·928	
	49·25	0·75	5·295	1·332	34·243	
	49·50	0·50	5·365	1·350	35·575	
	49·75	0·25	5·435	1·368	36·925	
	50·00	0·00	5·5062		38·293	

APPENDIX No. 11.

Halsur Tank.

STATEMENT showing Particulars of Water-supply for the Year 1880.

Date.	Gauge readings.	Contents, millions of cubic feet.	Volume expended.			Volume received, millions of cubic feet.	Rainfall, inches.	Remarks.
			Total, millions of cubic feet.	Used for troops, millions of cubic feet.	Lost, millions of cubic feet.			
January 1 ..	0·52	35·023	..	..	..	..	..	The zero of the gauge is level with the crest of the waste weir and its value is M.S.D. 2,929·97. Survey contour level 50·00.
,, 20 ..	0·92	..	..	..	..	..	..	
,, 21 ..	0·92	..	..	..	..	..	0·62	
,, 22 ..	0·94	..	2·972	0·247	2·725	..	..	
,, 31 ..	1·12	32·051				..	..	
February 1 ..	1·15	..	..			..	..	
,, 3 ..	1·20	31·658	0·393			..	..	
,, 4 ..	1·00	..	..			..	..	
,, 5 ..	0·67	..	..	0·283	2·689	..	..	
,, 6 ..	0·50	35·122	..			..	..	
,, 7 ..	0·51	..	..			3·464	..	
,, 29 ..	1·02	32·543	2·579			..	..	From upper tank.
	..	..	2·972	0·283	2·689	..	..	
March 1 ..	1·06	..				..	..	
,, 20 ..	1·66	..				3·464	0·00	
,, 21 ..	1·67	..	4·774	0·332	4·442	..	..	
,, 22 ..	1·70	..				..	0·17	
,, 31 ..	2·00	27·769				..	0·27	
	..	..	4·774	0·332	4·442	..	..	
April 4 ..	2·10	..	..	..	..	0·000	0·14	
,, 7 ..	2·17	..	..	..	..	..	0·07	
,, 11 ..	2·25	26·570	1·199			..	0·07	
,, 12 ..	1·83	28·590	..	0·337	3·693	2·020	..	
,, 19 ..	..	..	..			..	1·20	
,, 30 ..	2·42	25·759	2·831			..	0·16	
	..	..	4·030	0·337	3·693	2·020	..	
							1·50	

Statement shewing Particulars of Water-supply for the Year 1880—(*Continued*).

Date.	Gauge readings.	Contents, millions of cubic feet.	Volume expended.			Volume received, millions of cubic feet.	Rainfall, inches.	Remarks.
			Total, millions of cubic feet.	Used for troops, millions of cubic feet.	Lost, millions of cubic feet.			
May 6 ..	2·59	..	..	..	..	..	..	
,, 7 ..	2·59	..	..	..	..	..	0·48	
,, 8 ..	2·61	24·857	0·902	..	..	0·902	0·59	
,, 9 ..	2·42	25·759	..	..	..	..	0·23	
,, 10 ..	2·42	..	..	..	..	..	0·19	
,, 11 ..	2·42	..	..	..	..	..	..	
,, 12 ..	2·44	..	..	..	..	..	..	
,, 13 ..	2·46	25·569	0·190	..	..	..	0·40	
,, 14 ..	2·38	..	..	..	..	..	0·60	
,, 15 ..	2·25	..	..	0·279	1·538	2·828	0·58	
,, 16 ..	2·17	..	..	..	..	..	0·79	
,, 17 ..	1·87	28·397	..	..	..	..	..	
,, 18 ..	1·90	..	..	..	..	..	0·15	
,, 19 ..	1·92	..	..	..	..	..	0·20	
,, 21 ..	1·96	..	..	..	..	..	0·09	
,, 23 ..	2·00	..	..	..	..	..	0·65	
,, 24 ..	1·71	27·769	0·628	..	..	..	0·47	
,, 25 ..	1·67	..	..	..	..	1·693	0·33	
,, 26 ..	1·65	..	..	..	..	..	..	
,, 27 ..	1·67	29·462	..	..	..	..	0·48	
,, 28 ..	1·67	29·365	0·097	..	..	2·047	1·27	
,, 29 ..	1·33	..	..	..	..	..	..	
,, 30 ..	1·33	..	..	..	..	..	0·66	
,, 31 ..	1·25	..	..	..	..	..		
	..	31·412	..	..	..	7·470	8·16	
June 6 ..	1·42	..	1·817	0·279	1·538	..	..	
,, 7 ..	1·38	30·581	0·831			..	..	
,, 8 ..	1·38	..	..			0·195	0·50	
,, 10 ..	1·30	30·776	..			..	0·21	
,, 11 ..	1·30	..	0·195			..	0·43	
,, 12 ..	1·25	..	..			..	0·66	
,, 13 ..	1·04	..	..	0·254	1·756	..	0·14	
,, 14 ..	1·03	..	..			..	0·06	
,, 15 ..	1·03	..	..			..	0·14	
,, 16 ..	1·03	..	..			1·913	0·05	
,, 17 ..	1·03	32·494	..			..	0·09	
,, 18 ..	1·04	..	..			..	0·23	
,, 29 ..	1·23	..	..			..		
,, 30 ..	1·23	..	0·984			..		
	..	31·510	..	..	..	2·108	3·11	
July 1 ..	1·19	..	2·010	0·254	1·756	..	..	
,, 2 ..	1·20	31·707	..			0·197	0·35	
,, 3 ..	1·21	..	..			..	0·14	
,, 4 ..	1·10	31·609	0·098			..	..	
,, 5 ..	1·00	..	..			..	0·75	
,, 6 ..	1·00	32·641	..			1·032	0·71	
,, 7 ..	1·01	..	..			..	0·16	
,, 8 ..	1·02	..	..			..	0·03	
,, 9 ..	0·75	32·543	0·098			1·335	0·08	
,, 10 ..	0·77	33·878	..			..	0·99	0·94 in one hour.
,, 18 ..	0·87	..	..			..	0·46	
,, 21 ..	0·94	..	..			..	..	
,, 22 ..	0·92	32·938	0·940	0·272	1·211	..	0·50	
,, 23 ..	0·92	33·037	..			0·099	0·03	
,, 25 ..	0·94	..	..			..	0·33	
,, 26 ..	0·95	..	..			..	0·08	
,, 27 ..	0·87	32·888	0·149			..	0·41	
,, 28 ..	0·87	..	..			..	0·25	
,, 29 ..	0·88	33·284	..			0·396	0·02	
,, 30 ..	0·89	..	..			..	0·05	
,, 31 ..	0·91	..	..			..	0·15	
	..	33·086	0·198			..	5·49	
August 1 ..	0·92	33·037	1·483	0·272	1·211	3·059	..	
,, 8 ..	..	..	0·049			..	0·35	
,, 10 ..	1·03	..	..	..	..	..	0·12	
,, 11 ..	0·87	32·494	0·543	..	..	..	..	
,, 12 ..	0·87	..	..	..	..	..	1·00	
,, 13 ..	0·83	..	..	..	..	..	0·50	
	..	..	..	..	..	..	0·25	

Statement showing Particulars of Water-supply for the Year 1880—(*Continued*).

Date.	Gauge readings.	Contents, millions of cubic feet.	Volume expended. Total, millions of cubic feet.	Volume expended. Used for troops, millions of cubic feet.	Volume expended. Lost, millions of cubic feet.	Volume received, millions of cubic feet.	Rainfall, inches.	Remarks.
August 14..	1·50	* 37·633						
,, 15..	0·75	..	..	..	..	5·139	5·10	* For gauge reading .. 0·00
,, 16..	0·25	..	..	..	..	..	0·63	Millions of C. F.
,, 17..	0·25	..	..	..	..	..	..	
,, 18..	0·17	..	..	..	..	..	0·27	Discharged to waste .. 22·763
,, 19..	0·12	..	63·476	0·302	0·296	..	..	Do. .. 24·655
,, 20..	0·10	..	..	..	63·476	..	0·27	Do. .. 7·667
,, 21..	0·08	..	..	..	..	..	..	Do. .. 2·446
,, 22..	0·08	..	..	..	..	..	..	Do. .. 1·917
,, 23..	0·07	..	..	..	..	63·476	0·02	Do. .. 1·057
,, 24..	0·06	..	..	..	..	..	0·12	Do. .. 0·727
,, 25..	0·04	..	..	..	..	..	..	Do. .. 0·528
,, 26..	0·03	..	..	..	..	..	..	Do. .. 0·462
,, 27..	0·04	..	..	..	..	..	0·22	Do. .. 0·396
,, 28..	0·03	..	..	..	..	..	0·22	Do. .. 0·330
,, 30..	0·00	..	..	..	..	..	0·22	Do. .. 0·198
,, 31..	0·00	37·633	..	..	..	..	0·10	Do. .. 0·132
	..	..	64·068	0·302	63·766	68·615	9·12	Do. .. 0·132
September 1..	0·00	37·633					0·02	Do. .. 0·066
,, 4..	0·02	..	..	..	..	..	0·40	Total .. 63·476
,, 5..	0·03	..	..	..	..	..	0·02	
,, 8..	0·06	37·331	..	..	..	..	..	Discharged to waste .. 0·079
,, 9..	0·04	37·633	0·302	..	..	..	1·00	Do. .. 0·132
,, 10..	0·03	..	..	..	..	..	..	Do. .. 0·066
,, 11..	0·02	..	..	..	..	0·302	..	Do. .. 0·264
,, 12..	0·08	..	..	..	..	..	0·60	Do. .. 0·330
,, 13..	0·21	..	..	..	..	..	0·55	Do. .. 1·652
,, 14..	0·17	..	..	..	..	..	..	Do. .. 1·124
,, 15..	0·13	..	..	0·274	..	..	0·03	Do. .. 0·661
,, 16..	0·08	..	5·884	..	6·869	..	..	Do. .. 0·396
,, 17..	0·06	..	..	..	..	5·884	..	Do. .. 0·198
,, 19..	0·02	..	..	..	..	..	..	Do. .. 0·165
,, 20..	0·01	..	..	..	..	..	0·03	Do. .. 0·016
,, 21..	0·01	..	..	..	..	..	..	Total .. 5·884
,, 30..	0·19	36·676	0·957	..	..	..	..	
	..	..	7·143	0·274	6·869	6·186	2·62	
October 1..	0·21	..	..	..	..	..	0·13	
,, 2..	0·23	..	..	..	..	..	0·18	
,, 3..	0·25	36·374	0·302	..	..	1·259	2·06	
,, 4..	0·25	37·633	..	..	..	..	..	Discharged to waste .. 1·223
,, 5..	0·21	..	..	..	..	..	0·70	Do. .. 2·181
,, 6..	0·29	..	..	..	..	..	..	Do. .. 2·512
,, 7..	0·21	..	..	..	..	..	..	Do. .. 2·512
,, 8..	0·17	..	..	..	..	..	..	Do. .. 1·652
,, 9..	0·08	..	..	..	..	..	..	Do. .. 0·925
,, 10..	0·04	..	..	..	..	..	..	Do. .. 0·304
,, 11..	0·02	..	..	..	..	..	..	Do. .. 0·106
,, 12..	0·04	..	..	..	..	..	..	Do. .. 0·106
,, 13..	0·17	..	..	..	..	..	..	Do. .. 0·793
,, 14..	0·17	..	..	..	..	..	0·16	Do. .. 1·388
,, 15..	0·08	..	..	..	..	..	0·25	Do. .. 0·925
,, 16..	0·06	..	..	0·245	65·678	..	..	Do. .. 0·370
,, 17..	0·12	..	..	..	..	..	..	Do. .. 0·542
,, 18..	0·08	..	65·621	..	..	65·621	..	Do. .. 0·021
,, 19..	0·06	..	..	..	..	..	0·23	Do. .. 0·370
,, 20..	0·21	..	..	..	..	..	0·50	Do. .. 1·104
,, 21..	0·17	..	..	..	..	..	..	Do. .. 1·652
,, 22..	0·58	..	..	..	..	..	1·00	Do. .. 3·030
,, 23..	0·58	..	..	..	..	..	..	Do. .. 8·725
,, 24..	0·37	..	..	..	..	..	1·75	Do. .. 6·610
,, 25..	0·33	..	..	..	..	..	1·58	Do. .. 4·698
,, 26..	0·67	..	..	..	..	..	..	Do. .. 7·337
,, 27..	0·33	..	..	..	..	..	0·70	Do. .. 7·271
,, 28..	0·21	..	..	..	..	..	0·63	Do. .. 2·343
,, 29..	0·19	..	..	..	..	..	0·10	Do. .. 1·785
,, 30..	0·17	..	..	..	..	..	..	Do. .. 1·520
,, 31..	0·12	37·633	..	..	..	..	..	Do. .. 1·057
	..	..	65·923	0·245	65·678	66·880	0·24	Do. ..
							10·21	Total .. 65·621

2458.

Statement showing Particulars of Water-supply for the Year 1880—(*Continued*).

Date.	Gauge readings.	Contents, millions of cubic feet.	Volume expended. Total, millions of cubic feet.	Volume expended. Used for troops, millions of cubic feet.	Volume expended. Lost, millions of cubic feet.	Volume received, millions of cubic feet.	Rainfall, inches.	Remarks.
November 1..	0·10	..	..	..	..	..	..	Millions of C. F. Discharged to waste .. 0·727
,, 2..	0·08	..	..	..	..	..	..	Do. .. 0·529
,, 3..	0·06	..	..	..	..	..	..	Do. .. 0·397
,, 4..	0·04	..	..	..	..	..	..	Do. .. 0·198
,, 5..	0·03	..	..	..	..	..	..	Do. .. 0·132
,, 6..	0·02	..	..	..	..	..	..	Do. .. 0·079
,, 7..	0·01	..	..	..	..	..	..	Do. .. 0·033
,, 8..	0·04	..	..	..	..	..	..	Do. .. 0·086
,, 9..	0·03	..	2·762	..	..	2·762	0·26	Do. .. 0·132
,, 10..	0·02	..	..	..	..	..	..	Do. .. 0·079
,, 11..	0·01	..	..	..	..	..	0·02	Do. .. 0·033
,, 12..	0·04	..	..	..	..	..	0·18	Do. .. 0·086
,, 13..	0·03	..	..	..	..	..	0·13	Do. .. 0·132
,, 14..	0·02	..	..	..	..	..	..	Do. .. 0·079
,, 15..	0·01	..	..	0·281	..	..	..	Do. .. 0·033
,, 16..	0·00	..	..	..	..	..	..	Do. .. 0·007
,, 17..	0·01	37·633	..	..	..	..	..	
,, 18..	0·02	..	..	..	..	..	0·12	
,, 20..	0·05	..	..	..	..	..	..	
,, 21..	0·00	37·381	0·252	..	..	..	..	
,, 22..	0·06	37·633	..	..	..	0·252	0·60	Do. .. 0·145
,, 23..	0·04	..	..	..	..	..	0·37	Do. .. 0·198
,, 24..	0·04	..	..	..	..	..	..	Do. .. 0·132
,, 25..	0·03	..	..	..	..	..	0·05	Do. .. 0·132
,, 26..	0·02	..	..	..	..	..	..	Do. .. 0·079
,, 27..	0·01	..	1·182	..	..	1·182	..	Do. .. 0·033
,, 28..	0·02	..	..	..	..	..	..	Do. .. 0·333
,, 29..	0·12	37·633	..	..	..	..	0·33	Do. .. 0·033
,, 30..	..	..	..	..	..	..	0·03	Do. .. 0·397
	..	..	4·196	0·281	3·915	4·196	0·60	Total .. 3·944
December 1..	0·08	..	..	..	..	..	2·69	
,, 2..	0·06	..	..	..	..	..	0·02	Discharged to waste .. 0·595
,, 3..	0·04	..	..	..	..	..	..	Do. .. 0·330
,, 4..	0·03	..	1·374	..	..	1·374	..	Do. .. 0·198
,, 5..	0·02	..	..	..	..	..	..	Do. .. 0·132
,, 6..	0·01	..	..	..	..	..	..	Do. .. 0·079
,, 7..	0·00	..	..	0·273	3·462	..	..	Do. .. 0·033
,, 31..	0·47	37·633	..	..	..	..	..	Do. .. 0·007
	..	35·272	2·361	..	..	..	..	Total .. 1·374
			3·735	0·273	3·462	1·374	0·02	

Summary.

January ..	0·52	35·023				0·62
February ..	..	..	2·972	0·247	2·725	..
March	..	..	2·972	0·283	2·689	* 3·46
April	..	..	4·774	0·332	4·442	..
May	..	..	4·030	0·337	3·693	2·020
June	..	..	1·817	0·279	1·538	7·479
July	..	..	2·010	0·254	1·756	2·108
August ..	..	..	1·483	0·272	1·211	3·059
September ..	..	..	64·068	0·302	63·766	68·615
October ..	..	..	7·143	0·274	6·869	6·186
November ..	..	..	65·923	0·245	65·678	66·880
December ..	0·47	35·272	4·196	0·281	3·915	4·196
			3·735	0·273	3·462	1·374
Difference ..	..	0·249	165·123	3·379	161·744	165·372

0·00	0·62
0·00	0·00
0·00	0·44
0·00	1·50
0·00	8·16
0·00	3·11
0·00	5·49
0·00	9·12
0·00	2·62
0·00	10·21
0·00	2·69
0·00	0·02
0·00	43·98

* From upper tank.

APPENDIX No. 12.

Halsur Tank.

STATEMENT showing Particulars of Water-supply for the Year 1881.

Date.	Gauge readings.	Contents, millions of cubic feet.	Volume expended. Total, millions of cubic feet.	Volume expended. Used for troops, millions of cubic feet.	Volume expended. Lost, millions of cubic feet.	Volume received, millions of cubic feet.	Rainfall, inches.	Remarks.
January 1 ..	0·49	35·172	..		..	..	..	
,, 12 ..	0·68	..	..	0·328	..	..	0·23	
,, 18 ..	0·79	..	..		..	..	0·02	
,, 31 ..	1·06	32·346	2·826		..	..	..	
	..	..	2·826	0·328	2·498	0·000	0·25	
February 1 ..	1·08	..	..		..	..	..	
,, 16 ..	1·48	..	..	0·305	..	..	..	Syphon over upper tank weir in work.
,, 23 ..	1·48	30·288	2·058		..	* 0·146	..	* From upper tank, exclusive of that which compensated from evaporation, &c.
,, 28 ..	1·45	30·434	..		..	..	..	
	..	..	2·058	0·305	1·753	0·146	0·00	
March 1 ..	1·45	30·434	..		..	..	..	
,, 27 ..	1·67	..	..		..	..	0·42	
,, 28 ..	1·68	29·364	1·070	0·309	..	..	..	
,, 29 ..	1·50	30·190	..		..	0·826	0·04	
,, 31 ..	1·54	29·996	0·194		..	..	..	
	..	..	1·264	0·309	0·955	0·826	0·46	
April 1 ..	1·56	..	..		..	..	..	
,, 17 ..	2·00	..	..	0·252	..	..	..	
,, 30 ..	2·40	25·855	4·141		..	..	0·45	
	..	..	4·141	0·252	3·889	0·000	0·45	
May 1 ..	2·42	..	..		..	..	..	
,, 10 ..	2·70	24·431	1·424		..	..	..	
,, 11 ..	2·50	25·378	..		..	0·947	..	
,, 12 ..	2·52	..	..	0·292	..	..	0·67	
,, 14 ..	2·56	..	..		..	..	0·07	
,, 16 ..	2 58	..	..		..	..	0·20	
,, 30 ..	3·00	23·018	..		..	1·365	..	
,, 31 ..	2·71	24·383	2·360		..	..	0·81	
	..	..	3·784	0·292	3·492	2·312	1·75	
June 1 ..	2·73	..	..		..	..	..	
,, 4 ..	2·77	..	..		..	..	..	
,, 6 ..	2·81	23·912	0·471		..	..	..	
,, 7 ..	2·35	26·093	..		..	..	0·24	
,, 8 ..	2·35	..	..		..	2·181	..	
,, 9 ..	2·36	..	..	0·270	..	..	1·28	
,, 20 ..	2·60	..	..		..	..	..	
,, 26 ..	2·73	..	..		..	..	..	
,, 28 ..	2·78	..	..		..	..	..	
,, 29 ..	2·80	..	..		..	..	..	
,, 30 ..	2·83	23·818	2·275		..	..	..	
	..	..	2·746	0·270	2·476	2·181	2·14	
July 1 ..	2·85	..	..		..	..	..	
,, 3 ..	2·90	..	..		..	..	..	
,, 10 ..	3·02	22·925	0·893	0·276	..	..	0·10	
,, 17 ..	2·60	24·904	..		..	1·979	..	
,, 31 ..	3·09	23·018	1·886		..	..	..	From upper tank.
	..	..	2·779	0·276	2·603	1·979	0·10	

Statement showing Particulars of Water-supply for the Year 1881—(*Continued*).

Date.	Gauge readings.	Contents, millions of cubic feet.	Volume expended. Total, millions of cubic feet.	Volume expended. Used for troops, millions of cubic feet.	Volume expended. Lost, millions of cubic feet.	Volume received, millions of cubic feet.	Rainfall, inches.	Remarks.
August 1 ..	3·00	..	..		..	..	0·23	
,, 3 ..	..	..	..		..	..	0·19	
,, 4 ..	..	..	..		..	..	0·08	
,, 5 ..	..	..	..		..	..	0·18	
,, 6 ..	..	..	..		..	..	0·15	
,, 8 ..	..	..	..		..	..	0·08	
,, 9 ..	3·10	22·552	0·466		..	1·407	0·37	
,, 10 ..	2·80	23·959	..		..	..	1·20	
,, 14 ..	2·88	..	..		..	..	0·09	
,, 19 ..	..	..	..		..	..	0·33	
,, 21 ..	..	..	..	0·264	..	..	0·10	
,, 22 ..	..	..	..		..	..	1·30	
,, 23 ..	..	..	..		..	..	0·13	
,, 25 ..	2·92	23·394	0·565		..	..	..	
,, 26 ..	2·79	..	..		..	..	1·00	
,, 27 ..	2·75	..	..		..	..	0·66	
,, 28 ..	2·65	..	..		..	..	0·70	
,, 29 ..	2·59	..	..		..	..	0·46	
,, 30 ..	2·58	..	..		..	..	0·37	
,, 31 ..	2·58	24·999	..		..	1·605	..	
	..	..	1·031	0·264	0·767	3·012	7·62	
September 5 ..	2·69	..	..		..	..	0·12	
,, 11 ..	2·81	23·912	1·087		..	0·141	0·06	
,, 12 ..	2·78	24·053	..		..	..	0·21	
,, 13 ..	2·80	..	..		..	..	0·02	
,, 14 ..	2·82	..	..		..	..	0·04	
,, 16 ..	2·86	22·676	0·377		..	..	0·10	
,, 17 ..	2·71	..	..		..	..	1·25	
,, 18 ..	2·60	..	..	0·302	..	1·228	0·20	
,, 19 ..	2·60	24·904	..		..	..	0·37	
,, 21 ..	2·62	..	..		..	..	0·12	
,, 22 ..	2·64	..	..		..	..	0·05	
,, 27 ..	2·71	24·289	0·615		..	..	0·33	
,, 28 ..	2·71	..	..		..	..	0·10	
,, 29 ..	2·71	..	..		..	..	0·20	
,, 30 ..	2·29	26·379	..		..	2·090	2·10	
	..	..	2·079	0·302	1·777	3·459	5·27	
October 1 ..	2·12	..	..		..	..	0·40	
,, 2 ..	1·87	28·397	..		..	2·018	0·94	
,, 5 ..	1·94	..	..		..	..	0·03	
,, 6 ..	1·98	..	..	0·252	..	..	0·10	
,, 31 ..	2·50	25·378	3·019		..	..	..	
	..	..	3·019	0·252	2·767	2·018	1·47	
November 1 ..	2·52	..	..		..	..	0·06	
,, 2 ..	2·53	..	..		..	..	0·23	
,, 3 ..	2·54	25·189	..		..	..	..	
,, 4 ..	2·49	25·426	0·189		..	0·237	0·32	
,, 5 ..	2·50	..	..		..	..	0·03	
,, 6 ..	2·51	25·331	..		..	..	..	
,, 7 ..	2·35	26·093	0·095		..	0·762	1·16	Probably evening of 6th. Duration, 7 to 11 P.M.
,, 11 ..	2·40	25·855	..	0·222	..	..	..	
,, 12 ..	2·27	..	0·238		..	..	1·64	
,, 13 ..	2·27	26·475	..		..	0·620	0·09	
,, 14 ..	2·28	..	..		..	..	0·06	
,, 17 ..	2·32	..	..		..	..	0·05	
,, 19 ..	2·34	..	..		..	..	0·04	
,, 30 ..	2·50	25·378	1·097		..	..	..	
	..	..	1·619	0·222	1·397	1·619	3·68	
December 9 ..	2·66	..	..		..	..	0·04	
,, 12 ..	2·69	..	..		..	..	0·05	
,, 21 ..	2·87	23·630	1·748	0·228	..	..	..	Sluice of upper tank opened on the 22nd.
,, 25 ..	2·48	25·473	..		..	1·843	..	
,, 31 ..	2·64	24·715	0·758		..	..	..	
	..	..	2·506	0·228	2·278	1·843	0·09	

Statement showing Particulars of Water-supply for the Year 1881—(*Continued*).

Date.	Gauge readings.	Contents, millions of cubic feet.	Volume expended. Total, millions of cubic feet.	Used for troops, millions of cubic feet.	Lost, millions of cubic feet.	Volume received, millions of cubic feet.	Rainfall, inches.	Remarks.
			Summary.					
January ..	0·49	35·172	2·826	0·328	2·498	0·000	0·25	
February ..	..	..	2·058	0·305	1·753	* 0·146	0·00	* From upper tank.
March ..	..	..	1·264	0·309	0·955	0·826	0·46	
April ..	..	..	4·141	0·252	3·889	0·000	0·45	
May ..	..	..	3·784	0·292	3·492	2·312	1·75	
June ..	..	..	2·746	0·270	2·476	2·181	2·14	
July ..	..	..	2·779	0·276	2·503	† 1·979	0·10	† From upper tank.
August ..	..	..	1·031	0·264	0·767	3·012	7·62	
September ..	..	..	2·079	0·302	1·777	3·459	5·27	
October ..	..	..	3·019	0·252	2·767	2·018	1·47	
November ..	..	..	1·619	0·222	1·397	1·619	3·68	
December ..	2·64	24·715	2·506	0·228	2·278	‡ 1·843	0·09	‡ From upper tank.
Difference ..	..	10·457	29·852	3·300	26·552	19·395	23·28	

APPENDIX No. 13.

Halsur Tank.

Statement showing Particulars of Water-supply for the Year 1882.

Date.	Gauge readings.	Contents, millions of cubic feet.	Volume expended. Total, millions of cubic feet.	Used for troops, millions of cubic feet.	Lost, millions of cubic feet.	Volume received, millions of cubic feet.	Rainfall, inches.	Remarks.
December 31 ..	2·64	24·715	..		..			
January 1 ..	2·59	24·952	..		..			
,, 2 ..	2·59	..	..	0·206	..	0·237	..	
,, 3 ..	2·59	..	..		..		0·46	
,, 31 ..	3·26	21·808	3·144		..	..	0·05	
	..	..	3·144	0·206	2·938	0·237	..	
February 1 ..	3·28	..	..		..			
,, 28 ..	4·00	18·458	3·350	0·250	..	..	0·51	
	..	..	3·350	0·250	3·100	0·000	..	
March 1 ..	4·02	..	..		..			
,, 31 ..	4·92	14·490	3·968	0·268	..	..	0·00	
	..	..	3·968	0·268	3·700	0·000	..	
April 1 ..	4·95	..	..		..			
,, 13 ..	5·33	..	..	0·276	..	..	..	
,, 30 ..	5·83	10·769	3·721		..	..	0·42	
	..	..	3·721	0·276	3·445	0·000	0·42	
May 1 ..	5·86	..	..		..			
,, 9 ..	6·10	..	..		..	..	..	
,, 10 ..	6·13	9·595	1·174		..	..	0·01	
,, 11 ..	6·11	..	..		..	..	..	
					..	..	0·70	Duration 30 minutes, 10th.
,, 13 ..	6·09	9·748	..					
,, 14 ..	6·11	9·672	0·076		..	0·153	0·41	Duration 15 minutes, 10th.
,, 15 ..	6·00	..	..		..	..	..	
,, 16 ..	6·00	..	..	0·268	..	..	0·90	3 to 8 P.M.
,, 17 ..	6·00	..	..		..	..	0·55	8 P.M. to 4 A.M., 17th.
,, 18 ..	5·83	..	..		..	..	0·18	
,, 19 ..	5·74	..	..		..	..	0·40	
,, 20 ..	5·72	11·208	..		..	1·536	0·67	
,, 30 ..	5·94	..	..		..	..	0·21	
,, 31 ..	5·96	10·253	0·955		..	..	0·01	
	..	..	2·205	0·268	1·937	1·689	..	
							4·04	

Statement showing Particulars of Water-supply for the Year 1881—(*Continued*).

Date.	Gauge readings.	Contents, millions of cubic feet.	Volume expended. Total, millions of cubic feet.	Used for troops, millions of cubic feet.	Lost, millions of cubic feet.	Volume received, millions of cubic feet.	Rainfall, inches.	Remarks.
June 1 ..	5·98	..	..		..	..	..	
,, 2 ..	5·99	..	..		..	..	0·07	
,, 3 ..	6·01	..	..		..	..	0·01	
,, 5 ..	6·05	..	..		..	..	0·01	
,, 6 ..	6·07	..	..		..	..	0·04	
,, 7 ..	6·10	..	..		..	..	0·05	
,, 8 ..	6·12	..	..		..	..	0·25	
,, 10 ..	6·18	..	..		..	..	0·03	
,, 11 ..	6·20	..	..		..	..	0·02	
,, 13 ..	6·25	..	..	0·292	..	..	0·05	
,, 15 ..	6·31	..	..		..	..	0·18	
,, 22 ..	6·49	..	..		..	..	..	
,, 23 ..	6·33	8·261	1·992		..	..	..	Sluice of upper tank opened.
,, 24 ..	6·18	..	..		..	..	0·33	
,, 25 ..	6·16	..	..		..	1·219	..	
,, 29 ..	6·27	9·480	..		..	..	..	
,, 30 ..	6·25	9·061	0·419		..	0·073	0·78	
		9·134	..		..			
	..	..	2·411	0·292	2·119	1·292	1·82	
July 1 ..	6·27	9·061	0·073		..	..	..	
,, 2 ..	6·25	9·134	..		..	0·073	0·40	
,, 3 ..	6·26	..	..		..	..	0·03	
,, 4 ..	6·27	..	..		..	..	0·03	
,, 5 ..	6·25	9·061	0·073		..	..	0·18	
,, 6 ..	6·25	..	..		..	..	0·25	
,, 7 ..	6·25	..	..		..	..	0·16	
,, 8 ..	6·26	9·134	..		..	0·073	0·04	
,, 9 ..	6·27	..	..		..	..	0·02	
,, 10 ..	6·28	..	..		..	..	0·01	
,, 13 ..	6·33	..	..		..	..	0·02	
,, 14 ..	6·34	..	..		..	..	..	
,, 15 ..	6·33	8·807	0·327		..	0·036	0·26	
,, 19 ..	6·44	8·843	..	0·241	..	..	0·04	
,, 20 ..	6·46	..	..		..	..	0·02	
,, 21 ..	6·48	..	..		..	..	0·02	
,, 23 ..	6·50	..	..		..	..	0·06	
,, 24 ..	6·50	..	..		..	..	0·09	
,, 25 ..	6·46	8·225	0·618		..	..	0·78	
,, 26 ..	6·46	..	..		..	..	0·21	
,, 27 ..	6·46	..	..		..	..	0·01	
,, 28 ..	6·42	..	..		..	..	0·35	
,, 29 ..	6·37	..	..		..	..	0·52	
,, 30 ..	6·25	..	..		..	..	0·58	
,, 31 ..	6·25	..	..		..	0·609	0·07	
		9·134	..		..			
	..	..	1·091	0·241	0·850	1·091	4·15	
August 1 ..	6·25	..	..		..	..	0·07	
,, 2 ..	6·23	..	..		..	..	0·24	
,, 6 ..	6·26	9·211	..		..	0·077	..	
,, 7 ..	6·25	9·098	0·113		..	..	0·15	
,, 8 ..	6·16	..	..		..	..	0·76	
,, 9 ..	6·15	..	..		..	..	..	
,, 10 ..	5·94	..	..		..	..	0·62	
,, 11 ..	5·95	10·332	..		..	1·234	0·07	
,, 18 ..	6·02	..	..		..	..	0·16	
,, 20 ..	6·05	..	..		..	..	0·08	
,, 21 ..	6·07	..	..		..	..	0·02	
,, 23 ..	6·09	..	..	0·248	..	..	0·70	
,, 24 ..	5·94	9·748	..		..	..	0·66	
,, 25 ..	5·94	..	0·584		..	..	0·02	
,, 27 ..	5·94	..	..		..	..	0·28	
,, 28 ..	5·94	..	..		..	..	0·45	
,, 29 ..	5·83	..	..		..	..	0·60	
,, 30 ..	5·85	10·769	..		..	1·021	0·13	
,, 31 ..	5·87	..	..		..	..	0·03	
		10·619	..		..			
	..	..	0·856	0·248	0·608	2·332	5·02	

Statement showing Particulars of Water-supply for the Year 1881—(*Continued*).

Date.	Gauge readings.	Contents, millions of cubic feet.	Volume expended. Total, millions of cubic feet.	Used for troops, millions of cubic feet.	Lost, millions of cubic feet.	Volume received, millions of cubic feet.	Rainfall, inches.	Remarks.
September 1 ..	5·89	..	..					
,, 3 ..	5·94	..	..		..	..	0·02	
,, 4 ..	5·96	..	..		..	..	0·09	
,, 5 ..	5·96	..	..		..	..	0·05	
,, 7 ..	5·98	..	..		..	..	0·23	Duration 2 to 2¼ P.M.
,, 11 ..	6·04	..	..		..	..	0·15	
,, 16 ..	6·15	..	..		..	..	0·06	
,, 21 ..	6·23	9·211	1·399	0·255	..	..	0·17	Duration 7½ to 9 P.M.
,, 22 ..	5·96	10·253	..		..	..	0·29	
,, 25 ..	6·02	..	..		..	1·042	0·68	
,, 26 ..	6·04	9·940	0·313		..	..	0·26	
,, 27 ..	6·02	..	..		..	..	..	
,, 28 ..	6·02	..	..		..	..	0·42	
,, 29 ..	5·98	10·173	..		..	..	0·12	
,, 30 ..	6·00	10·094	0·079		..	0·233	0·21	
	..	..	1·791	0·255	1·536	1·275	..	
October 1 ..	6·00	10·094					2·75	
,, 2 ..	5·96	10·253	..		..	..		
,, 3 ..	5·98	..	..		..	..		
,, 4 ..	5·98	..	..		..	0·159	0·01	
,, 5 ..	5·98	10·173	0·080		..	..	0·38	
,, 7 ..	5·94	..	..		..	..	0·02	
,, 8 ..	5·73	..	..		..	..	0·19	
,, 10 ..	5·67	..	..		..	..	..	
,, 12 ..	4·58	..	..	0·263	..	..	..	Syphon working over upper tank weir.
,, 13 ..	4·33	..	..		..	..	0·88	
,, 14 ..	4·33	..	..		..	..	0·13	
,, 15 ..	4·21	..	..		..	..	0·75	
,, 18 ..	4·21	17·534	..		..	..	0·61	
,, 21 ..	4·22	..	..		..	..	0·15	
,, 31 ..	4·42	16·621	0·913		..	..	0·35	
	..	..	0·993	0·263	0·730	7·530	0·68	
November 1 ..	4·44	..	..		..	..	..	
,, 4 ..	4·50	16·274	0·347		..	..	3·67	
,, 5 ..	4·44	..	..		..	..	..	
,, 6 ..	3·88	..	..		..	..	0·02	
,, 9 ..	3·50	20·706	..		..	..	..	
,, 15 ..	3·59	..	..		..	..	1·08	
,, 16 ..	3·60	20·263	..		..	..	2·35	
,, 17 ..	3·50	20·706	0·463		..	4·432	0·84	
,, 23 ..	3·59	20·299	..		..	..	0·06	
,, 24 ..	3·08	..	0·407	0·231	..	..	0·03	
,, 25 ..	2·87	..	..		..	0·463	0·25	
,, 26 ..	2·75	..	..		..	..	6·48	
,, 27 ..	2·71	..	..		..	..	1·58	
,, 28 ..	2·42	..	..		..	..	0·51	
,, 29 ..	2·32	..	..		..	..	0·25	
,, 30 ..	2·23	23·666	..		..	..	0·01	
	..	..	1·207	0·231	..	6·367	0·70	
December 1 ..	2·21	26·782	..		0·976	11·252	..	
,, 31 ..	2·62	24·810	1·952	0·251	..	..	3·66	
	..	..	1·952	0·251	..	0·000	..	
January ..	* 2·64	24·715	3·144	0·206	1·701	0·000	6·56	
February ..	..	..	3·350	0·250	2·938	0·237	0·51	* 31st December 1881.
March ..	..	..	3·968	0·268	3·100	0·000	0·00	
April	..	..	3·721	0·276	3·760	0·000	0·00	
May	..	..	2·205	0·268	3·215	0·000	0·43	
June	..	..	2·411	0·292	1·937	0·000	1·82	
July	..	..	1·091	0·241	2·113	1·689	4·04	
August ..	..	..	0·536	0·248	0·850	1·292	1·82	Since of upper tank opened.
September ..	..	..	0·391	0·255	0·603	1·041	5·16	
October ..	..	..	0·363	0·255	0·536	2·332	2·76	
November ..	..	..	1·207	0·231	0·720	1·270	3·57	
December ..	2·62	24·810	1·952	0·251	0·976	7·530	3·85	Syphon working over upper tank weir.
Difference ..	..	+ 0·095	26·689	3·043	23·846	1·701	0·00	
						26·784	31·13	

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APPENDIX No. 14.

Halsur Taluk.

Statement showing Particulars of Water-supply for the Year 1883.

Date.	Gauge readings.	Contents, millions of cubic feet.	Volume expended. Total, millions of cubic feet.	Used for troops, millions of cubic feet.	Lost, millions of cubic feet.	Volume received, millions of cubic feet.	Rainfall, inches.	Remarks.
1882.								
December 31 ..	2·62	24·810	..	0·264	..	..	..	
January 1 ..	2·65	..	..		..	..	..	
,, 31 ..	3·27	21·762	3·048		..	..	..	
	..	..	3·048	0·264	2·784	0 000	0·00	
February 1 ..	3·29	..	..	0·244	..	..	..	
,, 28 ..	3·96	18 637	3·125		..	..	..	
	..	..	3·125	0·244	2·881	0·000	0·00	
March 1 ..	3·99	..	..	0·289	..	..	..	
,, 2 ..	4·02	..	..		..	..	0·07	
,, 31 ..	4·83	14·869	3·768		..	..	..	
	..	..	3·768	0·289	3·479	0·000	0·07	
April 1 ..	4·87	..	..	0·341	..	..	0·16	
,, 24 ..	5·60	..	..		..	..	0·23	
,, 27 ..	5·67	..	..		..	..	..	
,, 29 ..	5·69	11·329	3·540		..	0·080	0·37	Duration 4 to 7 P.M., 29th.
,, 30 ..	5·67	11·409	..		..			
	..	..	3·540	0·341	3·199	0·080	0·76	
May 1 ..	5·70	..	..	0·323	..	..	..	
,, 2 ..	5·73	..	..		..	..	0·17	
,, 13 ..	6·03	..	..		..	..	0·19	
,, 15 ..	6·07	..	..		..	..	0·18	
,, 18 ..	6·17	9·441	1·968		..	0·192	0·61	
,, 19 ..	6·12	9·633	..		..	..	..	
,, 24 ..	6·25	..	..		..	..	0·35	
,, 25 ..	6·25	..	..		..	..	0·17	
,, 28 ..	6·30	..	..		..	..	0·20	
,, 29 ..	6·31	..	..		..	..	0·005	
,, 30 ..	6·33	..	..		..	..	..	
,, 31 ..	6·36	8 807	0·826		..	..	..	
	..	..	2·794	0·323	2·471	0·192	1·875	
June 1 ..	6·39	..	..	0·303	..	..	..	
,, 14 ..	6·76	..	..		..	..	0·13	
,, 21 ..	6·95	..	..		..	..	0·12	
,, 22 ..	6·96	..	..		..	..	0·26	
,, 25 ..	7·02	..	..		..	..	0·02	
,, 28 ..	7·06	..	..		..	..	0·09	
,, 30 ..	7·09	6·280	2·527		..	..	..	
	..	..	2·527	0·303	2·224	0·000	0·62	
July 1 ..	7·11	..	..	0·296	..	..	..	
,, 2 ..	7·13	..	..		..	..	0·04	
,, 5 ..	7·21	..	..		..	..	..	
,, 6 ..	7·02	5·913	0·367		..	0·581	0·82	
,, 7 ..	7·03	6·494	..		..	..	0·08	
,, 8 ..	7·04	..	..		..	..	0·14	
,, 9 ..	7·04	..	..		..	..	0·10	
,, 10 ..	7·05	..	..		..	..	0·01	
,, 12 ..	7·07	..	..		..	..	0·02	
,, 13 ..	7·08	..	..		..	..	0·07	
,, 14 ..	7·10	..	..		..	..	0·23	
,, 17 ..	7·16	..	..		..	..	0·24	
,, 18 ..	7·12	6·066	0·428		..	..	0·38	
,, 19 ..	7·12	..	..		..	..	0·65	
,, 20 ..	7·04	..	..		..	0·367	..	
,, 21 ..	7·05	6·433	..		..	..	..	
,, 22 ..	6·84	6·403	0·030		..	..	0·93	Duration 3 to 8 P.M., 21st.
,,		..	..		..	..	0·63	Duration 3-15 to 3-45 P.M., 22nd.
,, 23 ..	6·73	7·435	..		..	1·032		

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Statement showing Particulars of Water-supply for the Year 1883—(*Continued*).

Date.	Gauge readings.	Contents, millions of cubic feet.	Volume expended. Total, millions of cubic feet.	Volume expended. Used for troops, millions of cubic feet.	Volume expended. Lost, millions of cubic feet.	Volume received, millions of cubic feet.	Rainfall, inches.	Remarks.
July 24 ..	6·74	7·401	0·034		..	..	..	
,, 25 ..	6·72	7·469	..		..	..	0·22	
,, 26 ..	6·73	..	..	0·296	..	0·068	0·10	
,, 27 ..	6·73	..	..		..	..	0·16	
,, 28 ..	6·74	..	..		..	..	0·05	
,, 31 ..	6·80	7·204	0·265		..	..	..	
	..	..	1·124	0·296	0·828	2·048	4·87	
August 1 ..	6·82	..	..		..	..	..	
,, 4 ..	6·90	..	..		..	..	0·39	
,, 6 ..	6·94	..	..		..	..	0·03	
,, 7 ..	6·95	..	..		..	..	0·08	
,, 8 ..	6·97	..	..		..	..	0·04	
,, 9 ..	6·99	6·587	0·617		..	..	..	
,, 10 ..	6·55	..	..		..	1·711	1·62	Duration from 7 P.M. 9th to 5 A.M. 10th.
,, 12 ..	6·48	8·298	..		..	..	0·22	
,, 13 ..	6·37	..	..		..	..	0·20	
,, 14 ..	6·33	..	..		..	..	0·11	
,, 15 ..	6·29	..	..	0·285	..	..	0·01	
,, 16 ..	6·25	..	..		..	..	0·46	
,, 17 ..	6·25	..	..		..	..	0·33	
,, 18 ..	6·21	..	..		..	1·220	0·16	
,, 19 ..	6·17	..	..		..	..	0·46	
,, 20 ..	6·17	..	..		..	..	0·29	
,, 21 ..	6·15	9·518	..		..	..	0·04	
,, 22 ..	6·17	..	..		..	..	0·02	
,, 24 ..	6·19	..	..		..	..	0·09	
,, 26 ..	6·21	..	..		..	..	0·03	
,, 27 ..	6·22	..	..		..	..	0·05	
,, 29 ..	6·24	..	..		..	..	..	
,, 31 ..	6·26	9·098	0·420		..	..	..	
	..	..	1·037	0·288	0·752	2·931	4·64	
September 1 ..	6·27	..	..		..	..	..	
,, 5 ..	6·34	8·807	0·291		..	..	..	
,, 6 ..	6·13	..	..		..	..	0·54	
,, 7 ..	6·05	9·902	..		..	1·095	..	
,, 10 ..	6·09	..	..	0·285	..	..	0·02	
,, 12 ..	6·13	..	..		..	..	0·02	
,, 13 ..	6·16	..	..		..	..	0·13	
,, 25 ..	6·46	..	..		..	..	0·03	
,, 30 ..	6·58	7·950	1·952		..	..	..	
	..	..	2·243	0·258	1·985	1·095	0·74	
October 1 ..	6·60	7·881	0·069		..	..	..	
,, 2 ..	6·56	..	..		..	..	0·76	
,, 3 ..	6·56	..	..		..	..	0·30	
,, 4 ..	6·31	..	..		..	..	0·85	
,, 5 ..	6·12	..	..		..	..	0·90	
,, 6 ..	5·92	..	..		..	2·888	0·90	
,, 8 ..	5·83	10·769	..		..	..	..	
,, 9 ..	5·85	10·690	0·079		..	2·262	0·16	
,, 10 ..	5·29	12·952	..	0·280	..	3·151	1·70	
,, 11 ..	4·54	16·103	..		..	..	1·80	
,, 12 ..	4·33	..	..		..	..	0·04	
,, 13 ..	4·23	..	..		..	..	0·16	
,, 14 ..	4·12	..	..		..	2·179	0·13	
,, 15 ..	4·04	18·282	..		..	..	0·07	
,, 16 ..	3·42	..	..		..	3·021	2·22	
,, 17 ..	3·37	21·303	..		..	..	0·03	
,, 29 ..	3·60	20·253	1·050		..	..	..	
,, 30 ..	3·58	..	..		..	1·601	0·27	
,, 31 ..	3·25	21·854	..		..	..	1·65	
	..	..	1·198	0·280	0·918	15·102	11·88	

Statement showing Particulars of Water-supply for the Year 1883—(*Continued*).

Date.	Gauge readings.	Contents, millions of cubic feet.	Volume expended. Total, millions of cubic feet.	Volume expended. Used for troops, millions of cubic feet.	Volume expended. Lost, millions of cubic feet.	Volume received, millions of cubic feet.	Rainfall, inches.	Remarks.
November 1 ..	3·25	..	..		..	..	0·05	
,, 2 ..	3·17	..	..		..	..	0·85	
,, 4 ..	3·16	22·273	..		..	0·419	0·19	
,, 5 ..	3·18	..	..	0·281	..	..	0·07	
,, 7 ..	3·18	..	..		..	..	0·03	
,, 18 ..	3·35	..	..		..	..	0·05	
,, 19 ..	3·35	..	..		..	..	0·19	
,, 30 .	3·53	20·570	1·703		..	..	..	
	..	..	1·703	0·281	1·422	0·419	1·43	
December 1 ..	3·55	..	..		..	..	..	
,, 4 ..	3·59	20·298	0·272		..	3·143	..	From upper tank.
,, 8 ..	2·91	23·441	..		..	..	0·28	
,, 12 ..	2·98	23·112	0·329		..	..	0·30	
,, 13 ..	2·90	..	..	0·273	..	..	1·04	
,, 14 ..	2·60	..	..		..	..	0·21	
,, 15 ..	2·52	..	..		..	..	0·04	
,, 16 ..	2·52	25·283	..		..	2·171	..	
,, 31 ..	2·76	24·147	1·136		..	..	1·87	
	..	..	1·737	0·273	1·464	5·314		

Summary.

January ..	2·62	24·810	3·048	0·264	2·784	0·000	0·00
February ..	..	..	3·125	0·244	2·881	0·000	0·00
March ..	..	..	3·768	0·289	3·479	0·080	0·76
April	..	..	3·540	0·341	3·199	0·192	1·875
May	..	..	2·794	0·323	2·471	0·000	0·62
June	..	..	2·527	0·303	2·224	2·048	4·87
July	..	..	1·124	0·296	0·828	2·931	4·64
August ..	..	..	1·037	0·285	0·752	1·095	0·74
September ..	..	..	2·243	0·258	1·985	15·102	11·88
October ..	..	..	1·198	0·280	0·918	0·419	1·43
November ..	..	..	1·703	0·281	1·422	5·314	1·87
December ..	2·76	24·147	1·737	0·273	1·464		
Difference ..	..	0·663	27·844	3·437	24·407	27·181	28·75

APPENDIX No. 15.

Halsur Tank.

SUMMARY of Particulars of Water-supply from 1880 to 1883 inclusive.

Years.	Gauge readings.	Contents, millions of cubic feet.	Volume expended. Total, millions of cubic feet.	Used for troops, millions of cubic feet.	Lost, millions of cubic feet.	Volume received, millions of cubic feet.	Rainfall, inches.	Area of catchment basin, square miles.	Proportion of rainfall received.	Percentage of rainfall received.
1880	0·52	35·023								
	0·47	35·272	165·123	3·379	161·744	165·372	43·98	4·64	0·349	34·90
1881	0·49	35·172								
	2·64	24·715	29·852	3·300	26·552	19·395	23·28	Do.	0·077	7·70
1882	2·64	24·715								
	2·62	24·810	26·689	3·049	23·640	26·784	31·13	Do.	0·080	8·00
1883	2·62	24·810								
	2·76	24·147	27·844	3·437	24·407	27·181	28·75	Do.	0·087	8·70
	..	..	..	..	..	238·732	127·14	..	0·174	17·40
							Rainfall, Bowring Civil Hospital, inches.			
1880	..	..	..	..	..	..	51·69			
1881	..	..	..	..	..	..	27·44	..	0·297	29·70
1882	..	..	..	..	..	..	37·02	..	0·065	6·50
1883	..	..	..	..	..	..	34·80	..	0·067	6·70
	..	..	..	..	..	238·732	150·95	..	0·072	7·20
Years 1881, 1882, and 1883, Halsur rock rain register	..	..	..	..	..	73·360	83·16	..	0·146	14·60
Do. do. Bowring Civil Hospital rain register	..	..	..	..	..	Do.	99·26	..	0·0851	8·51
									0·0713	7·13

N.B.—A square mile = 3,097,600 square yards = 27·8784 millions of square feet; 4·64 square miles = 129·356 millions of square feet.

APPENDIX No. 16.

APPROXIMATE Abstract Estimate for diverting Drainage of Western Feeder from Halsur Tank.

Quantity.	Description.	Unit.	Rate.	Amount.	Work Totals.
	Bund from culvert at mouth of western feeder to main bund of Halsur tank .. 10,95,465	C. FT.	RS. A. P.	RS. A. P.	RS. A. P.
	Diverting drainage puddle wall 1,21,770				
	Diverting drainage revetment 1,20,540				
789,195	Diverting drainage gravel backing 63,960				
121,770	Puddle wall 3,06,270				
1205·40	Revetment (formed of sized stones)	1,000			
639·60	Gravel backing	1,000	3 7 6	2,738 0 0	
		100	4 11 0	571 0 0	
	New Waste Weir—Crest, 90 feet.	100	9 8 0	11,451 0 0	
			2 0 0	1,279 0 0	
24·42	Concrete				16,039 0 0
100·50	Rubble masonry	100			
24·44	Rough stone apron	100	12 8 0	305 0 0	
	Excavation and filling	100	14 1 0	1,417 0 0	
	Lowering old Waste Weir 4 feet.	..	9 8 0	232 0 0	
				39 0 0	
	Diverting North-west Drain into western feeder.				
42·126	Earthwork forming channel				1,993 0 0
	A culvert under cross road	1,000			300 0 0
		..	2 14 3	122 0 0	
	Contingencies	..		300 0 0	
					422 0 0
		..		..	18,754 0 0
					96 0 0
					18,850 0 0

N.B.—The rates were obtained from the office of the Executive Engineer, Presidency Division.

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ESTIMATE FORM.

ABSTRACT.

Quantity.	Description of Work.	Rate.	Per	Amount.	Total.
	Detailed Data for 100 Cubic Feet of concrete of the following proportions.	RS. A. P.	C. FT.	RS. A. P.	RS. A. P.
50	Broken stones, ¾" to 1" cube	6 0 4	100	3 0 2	
8½	Screened and washed gravel	3 0 0	..	0 4 0	
16⅔	Slaked lime	0 4 3	C. FT.	4 6 10	
16⅔	Soorkee	0 1 9	..	1 13 2	
25	Sand	1 13 9	100	0 7 5	
4	Men coolies	0 3 0	Each.	0 12 0	
12	Women coolies	0 1 8	Do.	1 4 0	
	Contingencies	..	..	0 8 5	
	Total for 100 cubic feet ..	..	..	..	12 8 0
	Do. 1 cubic foot ..	..	..	..	0 2 0
	Grand Total of Estimate ..	..	..	..	..

NOTES.

REFERENCE TO MADRAS P.W.D. CODE.

PARAGRAPHS 1074, 1075, 1086, 1087, 1091 TO 1094, 1108, 1111 TO 1114, 1130 AND 1145 TO 1147.

1. Abstract of estimates should be prepared under such sub-heads as are to be separately shown in the accounts (register of works, work-vouchers, &c.) of the work. For repairs of buildings and roads, the classification of the budget estimate should be strictly followed, one estimate only being framed for each budget entry, and if a further estimate is required, it should be supplemental to the first; by this means, as the work abstracts follow the estimates, the register of works, the schedule of expenditure, and the books of the Central Office will show by one entry the entire outlay on repairs to each work for the whole year, which is not the case when several estimates are sanctioned for the repairs of one work in the course of the year.

2. Quantities are to be entered as so many units.

3. All rates are to be quoted in rupees, annas and pies.

4. Annas and pies are to be excluded from the abstract estimates, the cost of each item being brought to the nearest rupee. Totals of estimate need not be brought to round numbers.

SPECIFICATION for the Diversion of the Western Feeder of the Halsur Lower Tank.

1. A bund 2,460 feet in length, as shown on the survey, from which the table of waterspread and capacity was prepared, to be run from near the left wing of the 5 vent culvert at the lower end of the feeder, in a curve to near the point marked M, and thence nearly parallel to the road, at a minimum distance of 90 feet between the rear top edge of the bund and the top edge of the road, up to 50 from the site of the new weir whence the bund will curve to the eastward to connect with the weir wing.

Plan No. 11.

2. The ground to be cleared of all vegetation, and a trench 6 feet wide and 3 feet deep to be excavated and filled with puddle formed of well-tempered clayey soil taken from the bed of the tank before the formation of the bund is commenced.

3. The top width of the bund to be 8 feet, the interior slope 1½ to 1, and the exterior slope 2 to 1. The top of the bund will be 3½ feet above full tank level.

4. A puddle wall to be carried up simultaneously with the bund, and to terminate at 1½ feet below the top of the latter with a width of 2 feet. The faces to have a batter of 1 in 6.

5. The interior slope to be revetted to ½ a foot above full tank level with stones 1½ feet long laid at right angles to the slope on 1 foot of gravel backing. This height of revetment has been deemed sufficient because at the time of the year (March) when the easterly winds are strong, the water level will be from 3 to 3½ feet below the top of the revetment. The rear slope to be similarly revetted to the level 2,927·97. The revetments to be carried up simultaneously with the earthwork.

6. All earthwork to be well watered and rammed.

7. The general arrangement of the channel between the bund and the road is shown on the section.

8. The present waste weir of the tank to be lowered 4 feet or to 2,925·97. This is supposed to be as low a level as can be secured without reconstructing the bridge, but it would be advantageous to lower it still further if found to be feasible.

9. A new waste weir with a crest 90 feet long and 1 foot above the present full tank level, *i.e.*, at 2,930·97 instead of 2,929·97, to be constructed a few feet from the present main bund in the line of the new bund, as shown on the survey.

Plan No. 12.

It is calculated that the new weir will with a depth of 1½ feet passing over discharge 654 cubic feet a second, whereas the present weir with a nominal length of 90 feet but actual only 76½ feet and with a wide irregular crest does not discharge more than 422 cubic feet. Consequently maximum water level will not be more than 18 inches above the new crest level, and it probably will very rarely exceed 1 foot.

$$D = 90 \times 3{\cdot}56 d \sqrt{d}.$$

$$D = 76\tfrac{1}{2} \times 3d \sqrt{d}.$$

10. The drainage channel which now enters the tank at its north-west corner to be diverted along the west of the road forming the western boundary of the tank, and to be dropped into the channel now called the western feeder.

The diversion channel to be 4½ feet wide at bottom with side slopes of ½ to 1.
Its length will be 2,340 feet.

APPENDIX No. 17.

Approximate Estimate for constructing a Channel 5 Miles in length to bring into the Halsur Lower Tank the Drainage of 2·174 Square Miles to the Eastward.

Length.	Area of Cross Section.	Thousands of Cubic Feet.
5,280	48	
5,280	$\frac{48+28}{2}$	253,440
5,280	$\frac{28+21}{2}$	200,640
5,280	$\frac{21+13}{2}$	129,360
5,280	$\frac{13+10}{2}$	89,760
		60,720
		733,920

Quantities.	Description.	Unit.	Rate.	Amount.	Totals of Works.
			Rs. A. P.	Rs.	Rs.
733·920	Cutting channel and forming left bank ..	1,000 cubic feet ..	2 14 3	2,121	
	Rock cutting	Do. ..	..	500	
					2,621
300	Waste weirs	Running foot ..	5 0 0	1,500	
					1,500
	Culvert for cross road, Knoxpett ..	..	..	330	
	Do. for main road, Binnamangalam ..	..	..		330
	Four other culverts for village tracks ..	..	..	200	
		..	120 0 0	300	
				480	
	Contingencies ..	..	..		980
					5,431
		..	..	..	29
					5,460
20	Compensation for land	Acres	50 0 0	..	1,000
					6,460
	Compensation for diversion of water ..	..	..	..	?

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APPENDIX No. 17 A.

Approximate Estimate for constructing a Channel, 9⅓ Miles in length, to bring into the Halsur Lower Tank the Drainage of 3·10 Square Miles to the Eastward.

Length.	Area of Cross Section.	Thousands of Cubic Feet.
5,280	48	253·440
5,280	$\frac{48+40}{2}$	232·320
5,280	$\frac{40+36}{2}$	200·640
5,280	$\frac{36+30}{2}$	174·240
5,280	$\frac{30+26}{2}$	147·840
5,280	$\frac{26+22}{2}$	126·720
5,280	$\frac{22+18}{2}$	105·600
5,280	$\frac{18+14}{2}$	84·480
5,280	$\frac{14+10}{2}$	63·360
2,640	$\frac{10+8}{2}$	23·760
	Total ...	1,412·400

Quantities.	Description.	Unit.	Rate.	Amount.	Total of Works.
			Rs. A. P.	Rs.	Rs.
1,412·400	Cutting channel and forming left bank ..	1,000 cubic feet ..	2 14 3	3,083	
	Rock cutting 6th and 7th mile	..	..	800	
	Rock cutting elsewhere	..	..	700	
					4,583
500	Waste weirs	Running foot ..	5 0 0	2,500	
					2,500
	Tail weir	..	..	330	
					330
	Culvert for cross road, Knoxpett	..	..	225	
	Do. for main-road, Binnamangalam ..	..	..	335	
	Do. do. near 5th mile stone ..	..	..	220	
	Nine other culverts for village tracks ..	..	125 0 0	1,125	
					1,905
					2,318
	Contingencies	..	..	..	52
					2,370
35	Compensation for land	..	50 0 0	..	1,750
					11,120
	Compensation for diversion of water ..	..	..	..	?

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APPENDIX No. 17 B.

Dimensions, &c., of Channels for additional Catchment to eastward of Halsur Lower Tank.

(1) Channel for Catchment of 3·10 square miles.

Miles from Lower End.	Side Slopes.	Depth of Water.	Bottom Width.	Area of Waterway.	$\sqrt{r}$.	C. $\sqrt{r}$. S.	$\sqrt{}$ Feet per second.	Discharge Cubic Feet per Second.	Area of Catchment approximate.	Discharge, in Inches, draining off per Day.
		Ft.	Ft.	Sq. Ft.					Sq. Mls.	
1 ..	..	3	12	40·50	1·47	1·236	1·817	83·59	1	
2 ..	..	3	12	40·50	1·47	1·236	1·817	83·59	3·10	do.
3 ..	..	3	11	39·62	1·36	1·175	1·817	83·59	3·10	do.
4 ..	..	$2\frac{3}{4}$	8	23·12	1·30	1·139	1·60	59·60	1·80	do.
5 ..	do.	$2\frac{3}{4}$	8	20·53	1·25	1·48	1·48	84·22	1·44	do.
6 ..	do.	2	8	18·00	1·20	1·106	1·33	28·33	1·00	do.
7 ..	do.	2	6	14·00	1·16	1·074	1·29	23·22	0·84	do.
8 ..	do.	2	$4\frac{1}{2}$	11·00	1·10	1·049	1·22	17·08	0·67	do.
9 ..	do.	$1\frac{3}{4}$	4	8·53	1·04	1·005	1·11	12·21	0·45	do.
$9\frac{1}{2}$ ..	do.	$1\frac{1}{2}$	3	5·62	0·94	0·887	0·83	8·53	0·30	do.
								4·66	0·15	do.

(2) Channel for Catchment of 2·174 square miles.

1 ..	..	$\frac{1}{2}$ to 1	$2\frac{1}{2}$	12	33·12	1·37	1·180	1·62	53·66	
2 ..	..	do.	$2\frac{1}{2}$	12	33·12	1·37	1·180	1·62	53·66	2·17
3 ..	..	do.	2	8	18·00	1·20	1·074	1·29	23·22	1
4 ..	..	do.	2	5	12·00	1·13	1·026	1·16	13·92	2·17
5 ..	..	do.	$1\frac{1}{2}$	4	7·12	0·98	0·916	0·887	6·39	0·85 do.
										0·50 do.
										0·23 do.

APPENDIX No. 17 C.

Specification for Catchment Channels to bring in Drainage from the eastward to the Halsur Lower Tank.

The channels, whichever may be adopted, are intended to convey a quantity of water equal to 1 inch draining off the catchment in 24 hours; this is about the equivalent of a rainfall of 3 inches. Any supply in excess will be discharged to waste by means of surplus weirs.

2. The surface fall throughout will be 2 feet a mile. The changes in depth, where such occur, will be secured by raising the bed, or in other words increasing the bed-fall, where such 3rd mile, the bed-fall will be $2\frac{1}{2}$ feet instead of 2 feet as in the 1st and 2nd miles. Thus, in the

3. The height of the banks above normal full supply level to be equal to the depth of water as a minimum.

4. The depth of water passing over the surplus weirs to be one-third of the depth of water (normal) in the channel as a maximum, the crests of the weirs being of course at normal full supply level.

5. Except in the part of the first mile, where the channel will run alongside a road, the alignment can be made so as to give approximately just about the quantity of cutting to make up the banks to the required section. Only one, the left bank will be required, and its top width may conveniently be made double the normal depth of water.

6. The estimated quantities of cutting and bank forming are necessarily approximations, as, until the channel is marked out and cross sections of the ground taken, the exact quantities cannot be determined. Generally the depth of cutting allowed is about 6 inches in excess of the depth of water.

7. Lump sums have been entered for rock cutting. There will be but little in the 5 miles channel; and only in the 6th mile and a short length of the 7th mile is much likely to be met with in constructing the $9\frac{1}{2}$ miles channel, should that be selected for execution.

APPENDIX No. 18.

Comparative Statement of Rainfall as gauged at the Halsur Rock and Bowring Civil Hospital.

Year.		January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Total.
		IN. C.	IN. C.	IN. C.	IN. C.	IN. C.	IN. C.	IN. C.	IN. C.	IN C.	IN. C.	IN. C.	IN. C.	IN. C.
1880	Halsur Rock ...	0·62	...	0·44	1·50	8·16	3·11	5·49	9·125	2·62	10·21	2·69	0·02	43·985
	Bowring Civil Hospital.	0·670	...	0·410	2·160	9·350	3·905	6·680	11·740	2·780	10·950	2·840	0·210	51·695
1881	Halsur Rock ...	0·25	...	0·46	0·45	1·75	2·14	0·10	7·62	5·27	1·47	3·68	0·09	23·28
	Bowring Civil Hospital.	0·390	...	0·360	0·630	3·200	2·100	0·220	8·080	3·790	4·430	4·210	0·030	27·440
1882	Halsur Rock ...	0·51	...	...	0·42	4·04	1·82	4·15	5·02	2·75	3·57	8·85	...	31·13
	Bowring Civil Hospital.	0·680	...	...	0·530	4·410	1·690	5·600	5·720	4·050	4·475	9·870	...	37·025
1883	Halsur Rock ...	...	...	0·07	0·76	1·875	0·62	4·87	4·64	0·74	11·78	1·43	...	28·75
	Bowring Civil Hospital.	...	...	0·050	0·720	1·810	0·800	5·280	7·660	1·050	12·560	2·860	2·01	34·80

APPENDIX No. 19.

Comparison by Months of Rainfall as registered at the Halsur Rock and Bowring Civil Hospital.

Months.	Years.	Rainfall.		Difference.	Percentage.
		Halsur Rock.	Bowring Civil Hospital.		
		INCHES.	INCHES.	INCHES.	
January	1880	0·62	0·67	+ 0·05	+ 8·06
Do.	1881	0·25	0·39	+ 0·14	+ 56·00
Do.	1882	0·51	0·68	+ 0·17	+ 33·33
Do.	1883	...	...	...	...
		1·38	1·74	+ 0·36	+ 26·09
March	1880	0·44	0·41	— 0·03	— 6·82
Do.	1881	0·46	0·36	— 0·10	— 21·74
Do.	1882	...	...	...	...
Do.	1883	0·07	0·05	— 0·02	— 28·57
		0·97	0·82	— 0·15	— 15·46
April	1880	1·50	2·16	+ 0·66	+ 44·00
Do.	1881	0·45	0·63	+ 0·18	+ 40·00
Do.	1882	0·42	0·53	+ 0·11	+ 26·19
Do.	1883	0·76	0·72	— 0·04	— 5·26
		3·13	4·04	+ 0·91	+ 29·07
May	1880	8·16	9·35	+ 1·19	+ 14·58
Do.	1881	1·75	3·20	+ 1·45	+ 82·85
Do.	1882	4·04	4·41	+ 0·37	+ 9·15
Do.	1883	1·87	1·81	— 0·06	— 3·46
		15·82	18·77	+ 2·95	+ 18·65
June	1880	3·11	3·90	+ 0·79	+ 25·56
Do.	1881	2·14	2·10	— 0·04	— 1·87
Do.	1882	1·82	1·69	— 0·13	— 7·14
Do.	1883	0·62	0·80	+ 0·18	+ 29·03
		7·69	8·49	+ 0·80	+ 10·40
July	1880	5·49	6·68	+ 1·19	+ 21·67
Do.	1881	0·10	0·22	+ 0·12	+ 120·00
Do.	1882	4·15	5·60	+ 1·45	+ 34·94
Do.	1883	4·87	5·28	+ 0·41	+ 8·42
		14·61	17·78	+ 3·17	+ 21·69
August	1880	9·12	11·74	+ 2·62	+ 27·56
Do.	1881	7·62	8·08	+ 0·46	+ 6·04
Do.	1882	5·02	5·72	+ 0·70	+ 13·94
Do.	1883	4·64	7·66	+ 3·02	+ 65·09
		26·40	33·20	+ 6·80	+ 25·76
September	1880	2·62	2·78	+ 0·16	+ 6·10
Do.	1881	5·27	3·79	— 1·48	— 28·08
Do.	1882	2·75	4·05	+ 1·30	+ 47·27
Do.	1883	0·74	1·05	+ 0·31	+ 41·89
		11·38	11·67	+ 0·29	+ 2·55

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Comparison by Months of Rainfall as registered at the Halsur Rock and Bowring Civil Hospital—(*Continued*).

Months.	Years.	Rainfall.		Difference.	Percentage.
		Halsur Rock.	Bowring Civil Hospital.		
		INCHES.	INCHES.	INCHES.	
October	1880	10·21	10·95	+ 0·74	+ 7·24
Do.	1881	1·47	4·43	+ 2·96	+ 201·36
Do.	1882	3·57	4·47	+ 0·90	+ 25·35
Do.	1883	11·88	12·56	+ 0·68	+ 5·72
		27·13	32·41	+ 5·28	+ 19·46
November	1880	2·69	2·84	+ 0·15	+ 5·57
Do.	1881	3·68	4·21	+ 0·53	+ 14·40
Do.	1882	8·85	9·87	+ 1·02	+ 11·53
Do.	1883	1·43	2·86	+ 1·43	+ 100·00
		16·65	19·78	+ 3·13	+ 18·80
December	1880	0·02	0·21	+ 0·19	+ 950·00
Do.	1881	0·09	0·03	— 0·06	— 66·66
Do.	1882	...	...	...	...
Do.	1883	1·87	2·61	+ 0·74	+ 39·57
		1·98	2·85	+ 0·87	+ 43·94
		Summary.			
1880		43·98	51·69	+ 7·71	+ 17·53
1881		23·28	27·44	+ 4·16	+ 17·87
1882		31·13	37·02	+ 5·89	+ 18·98
1883		28·75	34·80	+ 6·05	+ 21·04
		127·14	150·95	+ 23·19	+ 18·24

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Halsur Rock Rain Register, Monthly Fall and Number of Rainy Days.

Year.	January.		February.		March.		April.		May.		June.		July.		August.		September.		October.		November.		December.		Annual.		Remarks.
	Inches.	Days.	Inches.	Days.	Inches.	Days.	Inches.	Days.	Inches.	Days.	Inches.	Days.	Inches.	Days.	Inches.	Days.	Inches.	Days.	Inches.	Days.	Inches.	Days.	Inches.	Days.	Inches.	Days.	
1873	..	..	0·45	3	..	..	2·08½	8	0·20	2	1·36½	6	0·56	3	4·12½	11	2·78½	7	9·42	15	0·10	2	..	..	21 09	55	
1874	..	..	..	..	..	..	0·50	1	12·50	11	1·22½	7	3·76	9	8·82½	14	12·23	20	5·67½	7	0·90	6	..	..	46·60½	82	
1875	..	..	..	..	1·86	3	0·55	3	3·01	7	3·25	11	1·86½	7	4·16	13	1·77	7	1·59	6	0·82	3	0·05	2	18·42½	62	
1876	..	..	..	..	0·50	3	0·80	2	4·93½	9	2·03½	6	1·71	11	3·22½	15	1·81¼	6	1·70	3	0·45½	3	..	..	17·17½	57	
1877	..	..	..	..	0·61½	4	1·70	1	2·63	8	2·60	8	0·97	7	2·49½	12	10·47½	19	6·82	18	2·20	7	0·20	3	30·70½	86	
1878	..	..	..	..	..	..	1·14	2	2·56	8	2·13¼	6	4·82	10	2·32	16	6·02	15	4·68	11	0·61	3	..	..	34·08½	71	
1879	..	..	0·21	1	1·53	3	2·77	3	0·15	1	4·90	9	2·41	5	5·95	16	2·76	13	3·79	9	8·35	12	0·66	4	..	..	33·48	73	
1880	..	..	0·62	1	..	..	0·44	2	1·50	4	8·16	17	3·11	11	5·49	18	9·49½	14	2·62	7	10·21	15	2·69	11	1·43	1	43·98½	101	
1881	..	..	0·25	2	..	..	0·46	2	0·45	1	1·75	4	2·14	8	0·10	1	7·06	18	5·27	16	1·47	4	3·68	8	0·09	2	23·28	67	
1882	..	..	0·51	2	..	..	..	..	0·42	1	4·04	10	1·82	12	4·15	23	5·07½	17	2·75	13	3·57	12	8·85	14	7	1	31·13	104	
1883	..	..	..	..	..	..	0·07	1	0·76	3	1·87½	8	0·62	5	4·87	18	4·64½	20	0·74	5	11·78	16	1·43	7	1·87	6	28·65½	88	
Means ..	0·14	·5	0·18	·5	0·56	1·6	0·91	2·5	1·23	5·5	2·06	7·5	3·11	11·2	5·85	14·8	11·18	4·57	5·92	11·5	2·3	6·2	0·20	1	29·73	77	

N.B.—The rain-gauge is at the top of the Rock, and the record is on the average about 18½ per cent. below that given by the gauge at the Bowring (Civil Hospital, about 1 mile distant.

(Signed) J. MELLINS, Col., R.E.,
Chief Engineer on Special Duty.

(Signed) J. SMITH,
Engineer in charge, Halsur Water Works.

Bangalore,
2nd January 1884.

Register of the Rainfall gauged daily at 7 A.M., at the Halsur Rock for the Month of December 1883.

Month and Date.	Rainfall.		Remarks.
	Inches.	Cents.	
1st December 1883.	..	..	Rainfall to the end of December 1883 for the following years:—
2nd ,, ,,	..	..	
3rd ,, ,,	..	..	
4th ,, ,,	..	..	
5th ,, ,,	..	..	
6th ,, ,,	..	..	
7th ,, ,,	..	..	
8th ,, ,,	..	..	
9th ,, ,,	..	..	
10th ,, ,,	..	..	
11th ,, ,,	..	..	
12th ,, ,,	..	·280	
13th ,, ,,	..	·300	
14th ,, ,,	1	·040	
15th ,, ,,	..	·210	
16th ,, ,,	..	·040	
17th ,, ,,	..	..	
18th ,, ,,	..	..	
19th ,, ,,	..	..	
20th ,, ,,	..	..	
21st ,, ,,	..	..	
22nd ,, ,,	..	..	
23rd ,, ,,	..	..	
24th ,, ,,	..	..	
25th ,, ,,	..	..	
26th ,, ,,	..	..	
27th ,, ,,	..	..	
28th ,, ,,	..	..	
29th ,, ,,	..	..	
30th ,, ,,	..	..	
31st ,, ,,	..	..	
Total ..	1	·870	

Years.	Inches.	Cents.
1873	21	·090
1874	45	·605
1875	18	·425
1876	17	·175
1877	30	·705
1878	34	·085
1879	33	·480
1880	43	·985
1881	23	·280
1882	31	·130
1883	28	·655

Bangalore,
2nd January 1884.

(Signed) J. SMITH,
Engineer in Charge, Halsur Water Works.

APPENDIX No. 20.

Waste Weir.

LEVEL of Water below the Koday on the undermentioned dates.

Years.	31st January.	28th February.	31st March.	30th April.	31st May.	30th June.	31st July.	31st August.	30th September.	31st October.	30th November.	31st December.
	FT. IN.	FT. IN.	FT. IN.	FT. IN.	FT. IN.	FT. IN.	FT. IN.	FT. IN.	FT. IN.	FT. IN.	FT. IN.	FT. IN.
1873	0 11	1 5	2 2½	2 4	3 2½	3 5½	3 11	2 9	2 5	*	0 5½	1 2
1874	1 8½	2 3½	3 1¼	3 9½	*	0 1½	*	*	*	*	*	0 6¼
1875	1 1½	1 7½	2 0	2 7	2 7⅝	2 9⅞	2 11½	2 11½	3 2½	3 4½	3 10¼	4 5
1876	4 11½	5 7	6 2½	6 10¼	5 8	6 0	6 4⅞	6 6½	6 8¼	6 9½	7 4	8 0
1877	8 10¼	†	†	9 7⅝	9 6¼	9 3⅝	10 1	9 8½	3 5¼	1 1½	0 7½	1 1
1878	1 9	2 6⅜	3 5	3 0	3 0	3 3	2 4	*	*	0 ¼	0 6⅛	1 1¼
1879	1 2¼	1 ½	0 8¾	1 7½	1 5	1 5¾	0 5	0 7½	0 5	*	0 3½	0 6
1880	1 1½	2½	2 0	2 5	1 3	1 2½	0 10⅞	*	0 2¼	*	*	0 5⅜
1881	1 ¾	1 5⅜	1 6½	2 4¾	2 8½	2 10	3 0	2 7	2 3½	2 6	2 6	2 7⅜
1882	3 3½	4 0	4 11	5 10	5 11½	6 3	6 3	5 10½	6 0	4 5	2 2¾	2 7½
1883	3 3¼	3 11½	4 10	5 8	6 4⅜	7 1½	6 9⅝	6 3½	6 7	3 3	3 6⅜	2 9 1/16
1884	...	...	...	...	...	...	...	...	...	...	...	...
1885	...	...	...	...	...	...	...	...	...	...	...	...

* Overflowing. † Dried up.

APPENDIX No. 21.

STATEMENT showing the Quantity of Water pumped into Barracks from 1st January 1880 to 31st December 1883.

Months.	1880.		1881.		1882.		1883.		Remarks.
	Gallons.	Cubic Feet.	Gallons.	Cubic Feet.	Gallons.	Cubic Feet.	Gallons.	Cubic Feet.	
January	1,546,155	247,385	2,050,768	328,123	1,287,610	206,018	1,651,025	264,164	
February	1,768,848	283,016	1,909,111	305,454	1,560,997	249,760	1,525,611	244,097	
March	2,072,318	331,571	1,933,897	309,424	1,672,599	267,616	1,806,906	289,105	
April	2,103,776	336,604	1,573,369	251,739	1,728,029	276,485	2,129,982	340,797	
May	1,746,597	279,456	1,824,984	291,997	1,677,910	268,466	2,019,481	323,113	
June	1,585,168	253,627	1,687,072	269,932	1,825,481	292,077	1,896,280	303,405	
July	1,699,338	271,898	1,727,428	276,388	1,503,986	240,638	1,849,755	295,961	
August	1,889,608	302,337	1,651,321	264,211	1,548,497	247,756	1,779,623	284,740	
September	1,709,843	273,575	1,885,543	301,687	1,591,941	254,711	1,613,033	258,085	
October	1,531,657	245,065	1,575,696	252,111	1,641,803	262,688	1,751,046	280,167	
November	1,756,350	281,016	1,388,406	222,145	1,442,475	230,796	1,780,573	284,892	
December	1,704,696	272,751	1,426,100	228,176	1,567,219	250,755	1,704,318	272,691	
Total ..	21,114,354	3,378,301	20,633,695	3,301,391	19,048,547	3,047,766	21,507,633	3,441,217	

SUMMARY.

Years.	Millions of Cubic Feet.
1880	3·378
1881	3·301
1882	3·048
1883	3·441
Total ..	13·168
Average ..	3·292

Greatest monthly quantity, April 1883	0·341 cls.
Greatest hourly quantity ..	2,960
Average hourly quantity ..	2,349

APPENDIX No. 22.

REGISTER of Pumping Operations at No. 2 Well on right bank of Water-course, 760 yards south of South Station Hospital.

Date.	Pumping. Time of Starting. Hours.	Time of Starting. Minutes.	Time of Stopping. Hours.	Time of Stopping. Minutes.	Water-levels. Feet.	Water-levels. Inches.	Times and Water-levels. Times. Hours.	Times. Minutes.	Water-levels. Feet.	Revolutions of Fly Wheel. Number per Minute.	Time at which taken. Hours.	Time at which taken. Minutes.	Remarks.
1884.													
	14	50	..	..	5	5½	14	53	6·50				
	..	..	..	..	..	..	14	57	7·50	90	14	55	40 lb. steam.
17th March ..	..	..	..	..	..	..	15	1	8·50		14	56	
	..	..	..	..	..	..	15	4	9·50	72	15	2	38 lb. ,,
	..	..	..	..	..	..	15	7½	10·50		15	3	
	..	..	15	16½	..	..	15	11	11·50	73	15	8	
	15	20	15	22	13	..	15	14½	12·50		15	9	
	11	7	..	..	13	6	15	22	13·50	..	..	..	
	..	..	..	..	11	4	11	9	12·00	..	..	..	
	..	..	..	..	..	..	11	13	13·00	..	..	..	40 lb. ,,
18th ,, ..	..	..	..	..	..	..	11	16	14·00	..	..	..	
	..	..	..	..	..	..	11	19	15·00	..	..	..	
	..	..	..	..	..	..	11	23	16·00	94	11	19	
	..	..	11	30	17	10	11	27	17·00		11	20	
	..	..	..	..	..	..	11	30	17·83	92	11	27	
19th ,, ..	..	..	..	..	..	..	17	30	17·50		11	28	
	..	..	..	..	..	..	6	25	15·75	..	..	..	
20th ,, ..	..	..	..	..	..	..	16	30	15·08	..	..	..	
	..	..	..	..	..	..	6	..	13·92	..	..	..	
21st ,, ..	..	..	..	..	..	..	16	30	13·08	..	..	..	
24th ,, ..	..	..	..	..	..	..	6	..	12·17	..	..	..	
	..	..	..	..	..	..	6	..	8·38	..	..	..	

Diameter of well 0·00 from B.M. at top to 7·50 — 11·50 Area, Square Feet 103·87.
Do 7·50 do. to 14·00 — 10·50 do. do. 86·59.
Do. 14·00 do. to 26·00 — 9·25 do. do. 67·19.

Summary of Results.—Engine 6-horse power, nominal, Clayton and Shuttleworth, Lincoln, No. 21199. Pump 4-inch centrifugal, Tangye Brothers and Holman. Suction and delivery pipes both 4 inches. Height from B mark to centre of delivery pipe 3·25 feet.

1st pumping.—First 7 minutes 211·89 c. ft. raised on the average 6·50 + 3·25 = 9·75 ft.
Afterwards.— 21½ do. 519·54 do. raised do. 10·50 + 3·25 = 13·75 ,,
2nd pumping.—First 9 do. 231·19 do. raised do. 12·66 + 3·25 = 15·91 ,,
Afterwards.— 14 do. 257·34 do. raised do. 15·92 + 3·25 = 19·17 ,,

$\frac{211·89}{7} = 30·27 \times 9·75 \times 62 = 18,298$ foot pounds per minute = 0·55 horse-power nominal.

$\frac{519·54}{21½} = 24·16 \times 13·75 \times 62 = 20,596$ do. do. = 0·62 do.

$\frac{231·19}{9} = 25·69 \times 15·91 \times 62 = 25,341$ do. do. = 0·77 do.

$\frac{257·34}{14} = 18·38 \times 19·17 \times 62 = 21,845$ do. do. = 0·66 do.

	98·50	..	86,080
	24·62	14·10	21,520
equivalent to		13·88	25·00
do. to gallons		86·77	do.
			2·60
			0·65

Messrs. J. and H. Gwynne put the duty of their centrifugal pumps of the same size at 250 gallons raised 25 feet with an expenditure of 25 × ·078 = 1·95-horse power. The duty was in

this case, about one-third of this standard, the chief cause being that the pump was too small for the engine; a 7-inch c. pump would have been more suitable.

Inflow between the two days' pumping =	Rise 2·17 feet	× 86·59 =	187·90	cubic feet.
Time 19·75 hours, or per hour .. .. =			9·51	,,
Inflow after second day's pumping .. =	Rise 3·83 ,,	× 67·19 =	257·34	,,
	do. 1·83 ,,	× 86·59 =	158·46	,,
			415·80	
Time 66·50 hours, or per hour .. .. =			6·25	,,
Equivalent to 39·06 gallons per hour				
Average inflow in 138½ hours, per hour .. .. =			5·37	,,

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APPENDIX No. 23.

SPECIFICATION and Approximate Estimate for the Supply of the European Cavalry Regiment two Batteries of Field Artillery, and the South Station Hospital with Water for Drinking and Cooking from Wells in the Small Valley to the south of the Hospital.

1. *Wells.*—The wells to be seven in number and 20 feet in diameter.

The sump well to be in the centre and to be placed at or close to the present well No. 2, with its bottom at 2886·00.

Vide plan 12.

The remaining six wells to be arranged as a hexagon, at a distance of 500 feet from the sump well, centre to centre, and consequently 500 feet apart. Their bottoms to be at 2888·00. It is estimated that these wells will collect the water from 72 acres, or from a circle with a radius of 1,000 feet. The six wells to be connected with the sump well by 6-inch cast iron pipes laid with their ends at the external wells at 2890·00 and at the sump well at 2888·00. All the wells to be steined with stone in mortar from 1 foot above ground level to 5 feet below that level, and below this with dry stone. The space at the back of the masonry steining be filled in with red soil, like that used for compound walls, well puddled and carefully trodden in, so as to prevent any surface drainage getting into the wells.

The steining from the level 2902·00 or 10 feet below the top to be stepped in 4 inches for each course (of 8 inches) so as to reduce the top diameter of the wells to 10 feet, a width convenient for beam-stones.

The platform of the sump well to be at 2912·00, the beam-stones for the pump at 2909·33, and the rose of the suction pipe at 2890·00, the lowest level to which the water is to be drawn off being 2891·00, or 18·33 feet below the valve of the pump.

2. The water-supply required being taken at 400 gallons per hour, or 9,600 gallons a day, and the pumping time at ten hours, the pump should be capable of raising 960 gallons an hour.

J. Taylor and Sons' treble barrel 3½-inch pumps with frame, Fig. $\frac{204}{2}$, price £31, are estimated to raise 940 gallons an hour to a height of 100 feet with four men.

The greatest lift required is from 2891·00 to about 2988·00 * or 97 feet.

* Floor of cistern of female hospital 2984·75.

Two sets of coolies, or eight men, taking turn and turn would be needed. The cost of this arrangement including suction pipe and fixing, freight and carriage may be taken to be Rs. 600. With bullock gear treble 5-inch pumps would be better, and the cost would be about Rs. 1,200. This latter will be entered in the estimate, as the work would be hard for coolies.

3. For laying the pipes connecting the outer wells with the sump well, a deep trench, 3 feet wide, will have to be cut and properly shored. The quantity of soil to be removed will be 6 × 500 × 3 × 23 = 207,000 cubic feet, costing about 1,500 rupees. The rest of the item of 3,000 rupees allowed is for planks and bars for shoring.

4. Pumping will be necessary in connection with the well sinking and the laying of the connecting pipes, and as it is difficult to estimate the time required, Rs. 3,000 will be allowed.

Approximate Estimate—

		RS.
7 wells at Rs. 650 .. .. =		4,550
6 × 510 = 3,060 feet of 6-inch C. I. pipes, ⅜ inch, metal, at 23·4 lb. per foot, 71,604 lb. or	32 tons.	
4,500 feet of 3-inch C. I. pipe, ⅜ inch, at 12·4 lb. per foot, 55,800 lb. or	24 tons.	
1,000 feet of 2-inch C. I. pipe, ⅜ inch, at 8·7 lb. per foot 8,700 lb. or	4 tons	
	60 tons.	

				Rs.
60 tons of C. I. pipe, at Rs. 95				
2,000 feet of 1½-inch wrought iron pipe, at Rs. 0-8-5			=	5,700
Laying 1,020 yards of 6-inch pipe, at Rs. 0-10-0			=	1,063
Do. 1,500 yards of 3-inch pipe, at Rs. 0-7-6	637-8-0			
Do. 1,000 yards of 2-inch pipe, at Rs. 0-4-0	703-2-0			
	250-0-0			
Pump with gear				1,591
Trench for connecting pipes				1,200
Unwatering during construction				3,000
Taps and fittings				3,000
Contingencies				2,000
				1,896
		Total		24,000

APPENDIX No. 24.

SPECIFICATION and Approximate Estimates for the Supply of the Troops from Agaram Tank.

1. *Data for Supply.*—The ordinary supply, on the average of four years, has been 56,376 gallons per day, the greatest 71,040 gallons. It is probable that 60,000 gallons would be sufficient, which are equivalent to 9,600 cubic feet, but to allow of a possible extension of the distribution, it is proposed to provide for a maximum quantity of 14,400 cubic feet a day.

It is desirable that this supply should be capable of delivery into the cisterns in 8 hours and the quantity per minute will then be 30 cubic feet.

The Agaram tank is about 3 miles from the old Race Course Barracks and nearly 4½ miles from the cistern which supplies the European Infantry Barracks.

This latter cistern is also at the highest level at which water has to be delivered, viz., 2999·62. The present full tank level of the Agaram tank is 2873·35.

To obtain the required head for discharge through the pipes, the water must be lifted or forced over a stand pipe, the bend (centre) of which is intended to be at 3015·00.

2. There are two alternative ways of obtaining water from the Agaram tank :—

(i) from a supply well sunk in the bed of the tank, in which case clear water would be obtained and artificial filters would not be needed ;

(ii) from the tank direct, and in that case filtration prior to pumping would be requisite. It would for this arrangement be necessary also to increase the capacity of the tank.

It is doubtful whether the quality of the water would not suffer from filtration through the soil into a supply well sunk in the tank bed, seeing that water taken from wells, not many yards from and above the tank, has been found to be inferior to that of the tank itself, though it remains to be determined whether a well sunk in the tank, or perhaps below the tank, would give similar results.

The maximum height to which water would have to be raised under this arrangement would be 161 feet.

With the alternative arrangement the maximum height is estimated at 151 feet.

3. *Engines and Pumps.*—The quantity of water being 30 cubic feet a minute, and the maximum lift 161 feet, the nominal engine horse power required is $\frac{30 \times 62 \times 161}{33{,}000}$ = just over 9-horse power.

It is intended therefore to provide two engines each of 12-horse power nominal, and these should be of the compound condensing type ; there should be 3 boilers, each capable of supplying, with wood fuel, full steam to one engine. The three boilers to be fixed side by side and to be connected by means of the usual steam domes and pipes with valves, so that any one or two adjacent boilers may be used at a time.

Fuel being dear, the present price being Rs. 8·34 per ton equivalent to Rs. 33·36 a ton for coal, it is essential that, in designing the engines and boilers, economy of consumption should be specially studied.

Pumps.—These should be of the ordinary plunger kind, and there should be a set for each engine. Each set to consist of 3 barrels about 8 inches in diameter and from 20 to 24 inches stroke. The delivery with the former stroke would require 17·20 strokes a minute nearly, and with the latter 14·33 strokes a minute.

The other requirements will be noticed in connection with the alternative arrangements.

An air vessel of ample capacity to be provided to equalize the pressure and flow. The amount entered for engines and pumps is based on the cost of the machinery at Dhobies' wells, which is said to have been £1,138 in England.

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4. *Stand-pipes.*—These to be three in number, and with 10 inches internal diameter, one up pipe and one down pipe connected by a bend at the top, and one waste pipe connected with a vertical pipe from the summit of the bend ; such connection to be at 4 feet above the centre of the bend and 4 feet below the open top of the pipe.

Vide plan 14.

The length of the pipes above the masonry platform will differ by about 7 feet in the two arrangements for the supply, but in either case the pipes are intended to be set up with a batter of 1 in 12, and to be strutted and braced at intervals of 2, or at most 3, lengths of pipe, *i.e.*, probably at every 18 or 27 feet, so as to make the whole structure quite rigid and able to withstand the severe gales at times experienced.

The pipes should rest on a base plate of suitable form, and they, as well as the connecting pipes below, should be securely bolted thereto.

The metal is supposed to be ⅜ inch thick, and a special rate is allowed to cover the subsidiary parts.

490×79 = 38,710 lbs. .. .. = 18 tons.
6 sets of struts and braces.

Bed plates—		Rs.
18 tons at Rs. 120	=	2,160
Erecting		340
Total	..	2,500

Masonry foundation if water drawn from tank direct	.. ..	1,430
Do. do. if drawn from supply well in tank	.. ..	1,000

5. *Delivery Mains.*—The main from the foot of the stand-pipe to a short distance from the Race Course cistern, Cavalry Barracks, a distance of about 18,000 feet, will be of 10 inches diameter and ⅜ of an inch thick.

Flanged pipes are provided for. The working head, exclusive of the margin for bends, which will however be very slight, is arranged to give a gradient of 0·60 of a foot in a thousand feet.

By Nevilles' formula—

$V = 140\sqrt{r.s} - 11\sqrt[3]{r.s.}$

$R = \frac{10}{4 \times 12} = .2083 \qquad S = .0006$

$\therefore V = 140 \times .01118 - 11 \times .05 = 1.56 - .55 = 1.01$

A = ·5454 and D = ·55 cubic feet a second = 33 cubic feet a minute.

By Jackson's Tables the discharge would be 29·64 cubic feet a minute.

The proportional discharge into the Race Course cistern will be 18·60 cubic feet a minute, and the gradient to this cistern being high, viz., 1·94 feet in a thousand, a 7-inch pipe will be ample. The length of this branch will be about 500 feet.

The discharge of the other branch will, for 1,500 feet to the head of the Horse Artillery cistern branch pipe, be 11·40 cubic feet a minute, and for the rest of the distance, about 5,000 feet, to the E.I.B. cistern, 9 cubic feet a minute ; a 7-inch pipe has been allowed for all through. For the R.H.A. pipe 3 inches will be a suitable diameter. Its length will be about 1,200 feet—

18,000 feet 10-inch pipe, ¾ inch thick, × 79 = 1,422,000 lb. = 635 tons.
7,000 feet of 7-inch pipe ⅝ inch thick × 46·7 = 326,900 lb. = 146 „
1,200 feet 3-inch pipe, ⅜ inch thick × 12·4 = 14,880 lb. = 6½ „

		Rs.
787½ tons of C. I. Pipe, at Rs. 120		94,500
Laying 6,000 yards, at „ 1-2-0		6,750
„ 2,333 yards, at „ 0-10-0		1,452
Contingencies		5,298
		1,18,000

6. The cisterns and subsidiary distribution are intended to be left as at present.

7. *Arrangements at Agaram Tank and Pumping Station.*—First—With a supply well in or below the tank. In this case the only special works required would be a well in the bed of the tank at the deepest part of the small bay near the waste weir bridge, and a pipe therefrom to the engine at the pumping station.

45 43

The well would be 30 feet in diameter at top with its bottom at 2850·00, and its top a 2880·00, the excavated soil being arranged round that part of the steining which would be above tank bed level, so as to prevent any surface water passing into the well. The steining to be constructed in masonry down to 5 feet below bed or ground level, * and below that in dry stone.

* About 2868·63.

The steining above bed level may be arched as shown in the section, or it may be stepped in 6 inches for each course, and then covered in at top with slab stones.

Plan No. 14.

The well will be 30 feet in diameter for 3 feet below bed level, 27 feet for the next 7 feet, and 24 feet for the last 7 feet. The contents of the well, from estimated L.W.L. 2855·63 to bed level, are 7485·64 cubic feet, or rather more than half the supply required in the 24 hours.

The calculated required inflow of water is $\frac{14,400-7,485}{8 \text{ hours}} = 864\frac{1}{2}$ c.ft. per hour.

The surface for inflow is—

1st. The area of the bottom of the well .. .. .. 452·39 sqr. ft.

2nd. The sides, where lined with dry stone, 1404·29 square feet which may be taken as $\frac{1}{8}$ unobstructed .. .. 175·54

so that 1·4 cubic foot per square foot per hour will be needed. 627·93

The probable cost of the well will be 9·300 earth-work, at Rs. 15-10-0 per 1,000 cubic feet .. .. .. Rs. 148

17·82 dry stone steining at Rs. 12-8-0 per 100 cubic feet 223

17·17 steining stone in mortar, at Rs. 18-12-0 322

Slab stones 50

Sundries 37

780

Contingencies 120

Total .. 900

Suction pipe, 12 inches diameter, $\frac{3}{4}$ inch thick, about 500 feet.

$500 \times 93·7 = 46,850$ lbs. = say 21 tons of C. I. Pipe at Rs. 95 per ton = Rs. 1,995

Laying 167 yards at Rs. 1-4-0 per yard .. .. .. = 210

Trench to pumping station, for laying pipe, average depth about 12 feet, $500 \times 4 \times 12 = 24,000$ cubic feet, at Rs. 10 per thousand 240

Sundries 125

Total .. 2,570

The suction pipe would have a connection, with a suitable valve, with each set of pumps

Secondly—If water be drawn off direct from the tank. The special works are—

(1) A suction pipe from the tank to the pumps;

(2) A pair of filters with a pure water well attached and a suction pipe therefrom to the pumps;

(3) An increase to the capacity of the tank;

(1) The suction pipe, which would be connected with each set of pumps to be 12 inches in diameter, and to be run out into the deep part of the tank, so as to be able to draw off water to about the 2866·63 level, or 6·72 feet below present full tank level. The length will be about 960 feet.

960 feet $\times$ 93·7 = 89,952 lb. = 40 tons.

40 tons C. I. pipe at 95 .. .. Rs. 3,800

Laying 320 yards at Rs. 1-4-0 .. .. = 400

Trench for pipe, average depth 6 feet, $960 \times 4 \times 6 = 23,040$ cubic feet at Rs. 7 per thousand .. .. = 161

Sundries .. .. = 239

4,600

Another suction pipe will be required from the pure water well: it will be 10 inches in diameter, $150 \times 79 = 11,850$ lb. = 5 tons.

2438.

Rs.

5 tons of C. I pipe at Rs. 95 .. .. = 475

Laying 50 yards at Rs. 1-2-0 per yard .. .. = 56

Sundries .. .. = 29

560

(2) The quantity of water to be filtered being 30 cubic feet a minute, or 1,800 cubic feet an hour, and the usual allowance being 2 square feet of filter bed for every cubic foot per hour, 3,600 square feet will be the area of each filter, or say 90 by 40 feet. The filters will be placed side by side, with a pure water well in connection with both. Depth of filters 10 feet and of well 13 feet; diameter of well 15 feet. Probable cost of the whole Rs. 15,000.

(3) The present capacity of the tank above the sill of the lowest sluice is 24·068 millions of cubic feet. It is proposed to raise the full tank level 3 feet, which will increase the capacity by 20·601 millions, or to 44·669 millions of cubic feet altogether. The present height of the bund varies considerably. There is only one waste weir, 119 feet in length, of which about 115 feet are effective, and this is not sufficient for the area of the catchment basin, 32·10 square miles. There was formerly a bywash at the other (east) end of the tank, but this was closed some time ago. The lowest estimate of the maximum discharge would be 2,646 cubic feet a second, viz.:—

$D = 350 \sqrt[3]{32^2} =$ 3,528 cubic feet a second, with the time extended one-third by the action of the upper tanks.

The difference between full tank level and M. W. L. should be limited to 3 feet and the proper length of weir will then be 157 feet, say 160 feet, or 45 feet additional are required.

The revetment being out of section from settlements, will be rebuilt with a gravel and small stone backing, and the addition to the bund will be made, as is always desirable, on the inside, so far as may be practicable with due regard to securing a good alignment for the road.

The top of the bund will be 6·28 feet above full tank level, and the clear width of roadway 15 feet; a width of 18 feet has been allowed at road level, so as to admit of side ridging, which adds to the security of the traffic and tends to maintain the edges of the bank in good order.

There being a great length of bund at the east end with but very little water-spread, it will be cheaper and better to make a cross bund to the high ground immediately west of the village of Agara, and the connection of this bund with the main bund will be at about 2,920 feet on the longitudinal section, the zero of which is at the 7th furlong of the 6th mile. For this new bund a top width of 6 feet and slopes of $1\frac{1}{2}$ to 1 inside and 2 to 1 outside have been allowed, and revetment $1\frac{1}{2}$ feet thick up to 2 feet below the top, which is the height to which the revetment generally will be carried up.

The new weir will be built towards the south end of this cross bund. The estimate for it has been made out on the supposition that the crest will be at 3 feet above ground level, but it is probable that a good site may be found on a higher level, in which case the cost will be proportionately reduced.

There is a small irrigation sluice to the eastward of the position of the cross bund, and it is proposed to put a 6-inch pipe in or under the crest wall of the new weir to supply the lands under that sluice. The discharge of water through the pipe can be regulated by a wooden plug.

The surplus from the new weir will have to be passed across the road at the old outfall by lowering the road to about 1·28 feet about present full tank level with ramps of 1 in 25 at either end.

If the low level road be 200 feet in length, the maximum depth of water passing over will not exceed one foot, and if the lower side be well revetted with 3 or 4 feet of rough stone apron at the toe of the revetment, no other protection will be required. Moreover, if a cut, 9 feet wide, be made on the south side of the road to the two-vent culvert, which is on a low level, no water will pass over the road in ordinary seasons. Rs. 500 have been allowed for these alterations: sufficient stone will be obtainable from the present bund to the east of the cross bund.

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The zero of the tank gauge is 11·95 feet below the bench mark on the offset on the south face of the Rock engine house, and the difference between that bench mark and the floor of the cavalry hospital is 7·60 feet, so the latter is 19·55 feet above Halsur full tank level, or a difference of 0·67 feet.

476 454

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1st. The area of the bottom of the well		452·39 sqr. ft.
2nd. The sides, where lined with dry stone, 1404·29 square feet which may be taken as $\frac{1}{8}$ unobstructed		175·54
		627·93

so that 1·4 cubic foot per square foot per hour will be needed.

The probable cost of the well will be 9·300 earth-work, at Rs. 15-10-0 per 1,000 cubic feet .. .. Rs. 148
17·82 dry stone steining at Rs. 12-8-0 per 100 cubic feet 223
17·17 steining stone in mortar, at Rs. 18-12-0 „ 322
Slab stones 50
Sundries 37
Contingencies 780
120
Total .. 900

Suction pipe, 12 inches diameter, $\frac{3}{4}$ inch thick, about 500 feet.

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Laying 167 yards at Rs. 1-4-0 per yard .. .. = 210
Trench to pumping station, for laying pipe, average depth about 12 feet, $500 \times 4 \times 12 = 24,000$ cubic feet, at Rs. 10 per thousand 240
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Total .. 2,570

The suction pipe would have a connection, with a suitable valve, with each set of pumps Secondly—If water be drawn off direct from the tank. The special works are—

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960 feet $\times$ 93·7 = 89,952 lb. = 40 tons.

	Rs.
40 tons C. I. pipe at 95	3,800
Laying 320 yards at Rs. 1-4-0	400
Trench for pipe, average depth 6 feet, $960 \times 4 \times 6 = 23,040$ cubic feet at Rs. 7 per thousand	161
Sundries	239
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Another suction pipe will be required from the pure water well: it will be 10 inches in diameter, $150 \times 79 = 11,850$ lb. = 5 tons.

2438.

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5 tons of C. I pipe at Rs. 95	= 475
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The surplus from the new weir will have to be passed across the road at the old outfall by lowering the road to about 1·28 feet about present full tank level with ramps of 1 in 25 at either end.

If the low level road be 200 feet in length, the maximum depth of water passing over will not exceed one foot, and if the lower side be well revetted with 3 or 4 feet of rough stone apron at the toe of the revetment, no other protection will be required. Moreover, if a cut, 9 feet wide, be made on the south side of the road to the two-vent culvert, which is on a low level, no water will pass over the road in ordinary seasons. Rs. 500 have been allowed for these alterations: sufficient stone will be obtainable from the present bund to the east of the cross bund.

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The surplus from the new weir will have to be passed across the road at the old outfall by lowering the road to about 1·28 feet about present full tank level with ramps of 1 in 25 at either end.

If the low level road be 200 feet in length, the maximum depth of water passing over will not exceed one foot, and if the lower side be well revetted with 3 or 4 feet of rough stone apron at the toe of the revetment, no other protection will be required. Moreover, if a cut, 9 feet wide, be made on the south side of the road to the two-vent culvert, which is on a low level, no water will pass over the road in ordinary seasons. Rs. 500 have been allowed for these alterations: sufficient stone will be obtainable from the present bund to the east of the cross bund.

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4/6 15/5

The reduced level (Karwar mean sea level) of the zero of the Halsur lower tank gauge is 2929·97, so the floor of the Cavalry hospital is 2949·52, and the bench mark on the offset 2950·48. In levelling to the Agaram tank the valve, 18·88 + 2929·97 = 2948·85 was used for this bench mark; hence the connection of 1·63 feet requiring to be added to the plotted levels above referred to. The levels entered on plan 14 have been corrected as regards the Agaram tank, but the levels of the several parts of the garrison distribution have been left as given in Lt. Romilley's section, as no connected series of check levels of the cisterns have been taken, and the stand pipe has been designed so as to secure ample head.

9. The following is an abstract approximate estimate of the cost of enlarging the Agaram tank :—

Quantities.	Description.	Unit.	Rate.	Amount.	Work Totals.
			Rs. A. P.	Rs.	
476,857	Earthwork to bund and forming cross bund.	1000 C.Ft.	3 7 6	1,654	
506,02	Rebuilding old revetment	100 C.Ft.	1 8 0		
337,35	Gravel backing to do.	do.	2 0 0	760	1,654
363,44	New revetment	do.		675	
242,29	Gravel backing to revetment	do.	9 8 0		
			2 0 0	3,453	1,435
	Alterations to waste weir and 11-vent culvert.	..	..	485	
	Alterations to west sluice	..	..		3,938
	New waste weir, 45 feet crest with sluice pipe	..	..	840	
46,25	Rubble masonry	..	..	350	
12,24	Rough stone apron	..	..		1,190
5	Feet sluice pipe 6 inches in diameter and ½ inch thick with elbow at tank end	100 C.Ft.	14 1 0	..	
	Sundries	do.	9 8 0	650	
		..	..	116	
	Lowering road to pass surplus from new weir, with cut on south side of road to two-vent culvert.	..	..	10	
53·3	Land compensation for additional water-spread.	..	..	37	813
	Contingencies	Acres	..	500	
	Total ..	..	60 0 0	3,198	500
		..	..	..	272
		..	..	..	13,000

The additional capacity being in round numbers 20½ millions of cubic feet, the cost of storage would be per million cubic feet Rs. 634, which seems reasonable, as the rebuilding of the old revetment and the new waste weir are works appertaining to the security of the present tank, and without these two items the cost per million would be under Rs. 525.

10. The ground selected for the pumping station measures 4·54 acres, and provision has been made for enclosing the whole with a wall of stone in mud pointed with mortar, and coped with stone in mortar. The wall to be 6 feet in height. The item, Rs. 4,000, is a considerable one, but it seems to be important to exclude all but employés, as otherwise perfect cleanliness cannot be ensured. *Vide* plan 13.

11. Subjoined is a general abstract of the alternative arrangements for the supply of the troops from this source. As the present establishment at the Halsur rock water works would suffice for the Agaram works, and as the working expenses generally would be much the same, no provision has been made on this account.

Particulars.	Water drawn direct from Tank. Amount.	Water drawn from Supply Wells in or below Tank. Amount.
	Rs.	Rs.
Engines and pumps	36,500	36,500
Stand pipes	2,500	2,500
Masonry foundation pipes	1,430	1,000
Delivery mains	1,18,000	1,18,000
Suction pipe from supply well	..	2,570
Supply well	..	900

Particulars.	Water drawn direct from Tank. Amount.	Water drawn from Supply Wells in or below Tank. Amount.
	Rs.	Rs.
Suction pipe from tank	4,600	..
Do. do. from pure water well	560	..
Two filters	15,000	..
Enlarging tank	13,000	..
Ground for pumping station	250	250
Engine house and chimney	12,500	12,500
Quarters for Engineer, &c.	3,000	3,000
Enclosure walls	4,000	4,000
	2,11,340	1,81,220
Contingencies	8,660	6,780
Total ..	2,20,000	1,88,000

2435

CONDENSER LIST No. 1.

PURE COLD FRESH WATER FROM SEA-WATER WITH GREAT ECONOMY OF COAL.

For Yachts, Ships, or on Land.

Four-thousand and five-hundred Gallons, or 20 tons for 1 ton of Coal. (Results guaranteed abroad if required.)

Normandy's Improved Patent Fresh-Water Distilling Machinery.

This machinery converts sea, or other impure, water into *pure, cold, fresh water*, equal in appearance and taste to the best river or spring water, and fit for immediate use as it leaves the machinery, which will also force it to any distance, and to a height of 40 yards or metres, or more if desired.

It is well known that an *insufficient* or *impure* water-supply *is a constant source of danger from a sanitary point of view*. There are many places where such a state of things exists, and where the introduction of this machinery would at once provide a *cheap, pure, and abundant water-supply*. Over 1,030 machines have been supplied, and some of the land stations and ships supplied are given on the last page.

The process may be briefly stated as follows :—

Water distilled by the ordinary process, viz, by a boiler for generating steam, and a worm for condensing steam into water, is open to these objections:

1. *The entire heat of the condensed steam is lost.*

2. The water formed by the condensed steam contains organic impurities, which give it a disagreeable flavour.

3. This water is destitute of air, which it has lost in the process of boiling, and it is hence flat and vapid to the taste, besides being somewhat heavy if drunk in quantity.

These objections may be, to a certain extent, removed by exposing the water to air for a long time. *But on board ship, and in doubtful places, the water may absorb air which is not pure.*

Normandy's Improved Apparatus removes all these objections, by using over again the heat liberated by one or more successive condensations of steam, thus increasing the amount of distilled water to from 1¾ to 2¼ times the water evaporated by the boiler. The distilled water is aerated in the process of condensation and is cooled down to the temperature of ordinary water in the outer air, and the taint of organic matter is completely removed from the distilled water by passing it through a filter of prepared animal charcoal, from which it flows out cold, pure, well ærated, and equal in taste and appearance to the best river water as usually supplied to towns.

RESULT of the Trial of Normandy's Improved Patent Distilling Machinery, erected at Flushing for the Dutch Government, January and February 1877.

This machinery was supplied as suitable for producing 6,000 gallons of pure fresh water, per 24 hours, from sea water.

By the direction of Mr. Van Diesen, Chief Engineer of the Waterstaat, in the Province of Zealand, Holland, this machinery was carefully tested by being worked under the inspection of officials appointed for the purpose, the result being that *in 19 hours' work* this machinery produced 28,500 litres of fresh water, and consumed 1,545 kilos. of coal. This is equal to 6,270 gallons (or 28 tons) of fresh water, produced with 1½ tons of coal in 19 *hours' work*.

The fresh water produced, as it flowed from the machinery, *was bright-looking, clear, cold, and agreeable, without any peculiar taste, and, in fact, equal in appearance and taste to the best river or spring water*

It will be seen, therefore, that this machinery, when worked *for* 19 *hours*, produced 33 *per cent. more water than it was sold to produce* in that time, and yielded 4,100 *gallons (or* 18·3 *tons) per* 1 *ton of coal*; it would have produced more had the machinery been less overworked, as similar machines at Aden and elsewhere have yielded over 20 tons or 4,500 gallons of water per ton of coal.

In the above trial, the productive power and consumption of coal were ascertained as follows :—The machinery having been fairly started, *the coals were removed from the furnaces*, and the working was continued, under inspection, with *weighed coals*. After 19 *hours'* working, *the unconsumed coals were removed from the furnaces and weighed*, and their weight was deducted from the quantity of weighed coals put into the furnaces, the difference being taken as the weight consumed. The fresh water produced from the sea water was collected in an iron tank and carefully measured.

REPORTS on the Quality of the Fresh Water produced by Normandy's Improved Patent Machinery for producing from Sea Water, Pure, Cold, and Agreeable Fresh Water for Drinking Purposes.

Alicante, 11th September 1879.

OPINION of DON JOSE SOLER Y SANCHEZ, Licentiate in Pharmacy, Doctor in Sciences, late Professor of Chemistry to the Faculty of Sciences of University of Madrid, Professor of Chemistry and Physics to the Institute of Alicante, &c., &c.

I hereby certify that having analysed in my laboratory a sample of pure fresh water in order to see if the same was drinkable, and which sample was delivered to me by the Presidente Alcalde (Mayor) of the most illustrious Municipality of Alicante, the said sample being drawn according to his declaration from Mr. Normandy's Distilling Engine.

This sample of fresh water was received in the presence of the Notary, Mr. Nereo Albert, in two glass bottles duly sealed and stamped with the letters J.C.B., the result being as follows :—

1st. Its hyrotimetrical degree is 5°.
2nd. A litre of water contains 0·085 grammes of mineral substance.
3rd. Does not contain any organic matter.
4th. Contains 17·64 c.c. of air per litre of water.
5th. Does not prevent soap from dissolving.
6th. Is clear, without colour, limpid, and transparent.

Therefore, by its character and condition, it is to be considered *a most eminently drinkable water*.

Dr. J. SOLER Y SANCHEZ.

REPORT of Dr. NOAD, F.R.S., Professor of Chemistry at St. George's Hospital, London.

I find the water to be *absolutely free from organic matter*, which all river and well waters contain, more or less, and which is acknowledged to be a predisposing cause of disease. It is also bright, colourless, well aerated and agreeable, and it contains an exceedingly small percentage of saline matter, which is the case with all waters derived from the best natural sources.

From a sanitary point of view, I consider this water to be quite equal, and, in its absolute freedom from organic matter, superior to that obtained from the purest natural sources; it is therefore well suited for alimentary purposes.

REPORT of Dr. LETHEBY, M.B., M.A., Professor of Chemistry in the Medical College of the London Hospital, and Medical Officer of Health for the City of London.

The sample was colourless and well aerated and it was agreeable to the palate. It contained a very small proportion of saline matter, which I regard as an advantage, as it approximates the quality of the water to that derived from the best natural sources. For dietetical purposes, the proper aeration of the water is essential. *The water was absolutely free from organic matter*, and it is very soft.

I am of opinion, from these results, that the water is very wholesome and is well adapted for all domestic purposes.

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LIST of Particulars of Normandy's Improved Patent Distilling Machinery for converting Sea Water into Pure, Cold, Fresh Water, equal in appearance and taste to the best River or Spring Water, and fit for immediate use as it flows from the machinery, which will also force it to any distance and to a height of 40 yards (or metres) or more, if desired.

[See Reports and Result of Government Trial at Flushing, on other side.]

(Results guaranteed abroad if required).

	Quantity of Cold, Fresh Water produced from Sea Water in 24 hours. Under favorable circumstances the production will be about 30 per cent. more.		Quantity of Fresh Water produced by one Ton (or 1000 Kilos.) of Coal. Under favorable circumstances the Quantity will be about 10 per cent. more.					
			Single distilling Arrangement.		Double distilling Arrangement.		Treble distilling Arrangement.	
	Gallons.	Tons or Cub. Metres.	Gallons.	Tons or Cub. Metres.	Gallons.	Tons or Cub. Metres.	Gallons.	Tons or Cub. Metres.
These include as described Note A on next page.	1,000	4·5	1,560	7·0	..	..	..	..
	1,125	5·0	1,560	7·0	..	..	..	..
	1,250	5·6	1,560	7·0	..	..	..	..
	1,500	6·7	1,600	7·2	2,660	11·9	..	..
	1,750	7·8	1,600	7·2	..	..	..	..
	2,000	9·0	1,700	7·6	2,700	12·2	3,400	15·3
	2,250	10·0	1,740	7·7	..	..	..	..
	2,500	11·2	1,740	7·7	2,700	12·2	3,500	15·7
	3,000	13·4	1,790	8·0	2,950	13·2	3,500	15·7
	3,500	15·6	1,830	8·2	..	..	..	..
	4,000	17·9	1,830	8·2	3,000	13·8	3,650	16·3
	4,500	20·1	1,880	8·4	..	..	..	..
	5,000	22·3	1,950	8·8	3,100	14·0	3,900	17·7
	6,000	27·0	1,950	8·8	3,200	14·3	4,000	18·0
	7,000	31·2	..	..	3,200	14·3	4,000	18·0
	8,000	35·7	..	..	3,300	14·8	4,100	18·4
	9,000	40·2	..	..	3,400	15·4	4,200	18·8
	10,000	44·6	..	..	3,400	15·4	4,300	19·3
	11,000	49·1	..	..	3,400	15·4	4,400	19·6
	12,000	53·6	..	..	3,470	15·5	4,500	19·8
	13,000	58·0	..	..	..	..	4,500	20·0
	14,000	62·5	..	..	..	..	4,500	20·0
	15,000	67·0	..	..	..	..	4,500	20·0
These include as described Note B on next page.	100	0·5	1,000	4·5	1,680	7·5	..	..
	150	0·7	1,000	4·5	1,680	7·5	..	..
	225	1·0	1,000	4·5	1,680	7·5	..	..
	300	1·4	1,230	5·5	1,680	7·5	..	..
	400	1·8	1,230	5·5	1,900	8·5	..	..
	500	2·2	1,230	5·5	2,120	9·5	..	..
	625	2·8	1,230	5·5	..	..	..	..
	750	3·3	1,230	5·5	..	9·5	..	..
	875	4·0	1,230	5·5	2,120	..	..	..
	1,000	4·5	1,230	5·5	..	9·5	2,800	12·5
	1,125	5·0	1,230	5·5	2,120	..	..	..
	1,250	5·6	1,340	6·0	..	10·0	2,800	12·5
	1,500	6·7	1,340	6·0	2,240	10·5	2,910	13·0
	1,750	7·8	1,340	6·0	2,350	..	..	..
	2,000	9.0	1,450	6·5	..	10·5	3,020	13·5
	2,250	10·0	1,450	6·5	2,350	..	..	..
	2,500	11·2	1,450	6·5	..	10·5	3·130	14·0
	3,000	13·4	1,450	6·5	2,350	10·5	3,130	14·0
	3,500	15·6	1,560	7·0	2,350	..	..	..
	4,000	17·9	1,560	7·0	..	11·0	3,130	14·0
	5,000	22·3	..	..	2,460	12·0	3,250	14·5
	6,000	27·0	..	..	2,680	12·0	3,360	15·0
	7,000	31·2	..	..	2,680	..	3,360	15·0

See Condenser List, No. 2, for particulars of Normandy's Improved Patent Double Distilling Condensers (without boilers) for steamships, yachts, and torpedo boats, for working with greasy steam from main boilers supplying the engines, so as to produce good, cold, fresh water for drinking, and also hot fresh water, to keep up the full supply of fresh water in these boilers, to prevent scale accumulating therein.

See Condenser List, No. 3, for particulars of Single Distilling Condensers (without boilers) for producing from sea water good, cold, fresh water for drinking, when worked with clean steam from boilers fed with sea-water, but with less economy of fuel.

Estimate for complete sets of Normandy's Improved Patent Distilling Machinery for producing good, cold, drinking water from sea-water, and for forcing the fresh-water to a great height or distance, with letter, dated 21st February 1884, to General Hyde.

The drinking water as it flows from under-mentioned machinery is clear, cold, bright-looking and agreeable, without any peculiar taste, and equal in quality, taste and appearance, to the best river-water as usually supplied for drinking in towns. (See the reports on other side.)

Full instructions for putting together and working will be supplied with the machinery, and, if desired, special arrangements will be made for the machinery to be supplied and erected abroad, and also worked for an agreed time, the consumption of coal and the quantity and quality of the fresh-water produced being guaranteed.

Note A.—Under favorable circumstances, this machinery will produce from 20 *to* 30 *per cent. more water* per 24 hours, than is stated below, and the quantity of fresh-water produced by 1 ton of coal will be increased *by* 10 *to* 15 *per cent.* (*See results of Flushing trial on other side.*) For long continued working, however, the best results will be obtained by working so as not to produce much more than the quantity specified below, as the production per 25 hours.

Each *complete set of machinery* includes one of Normandy's Improved Patent Condensers with filter, suitable steam boiler and steam pumps for supplying sea-water to the condenser and boiler, and for *forcing the fresh-water produced to a great height or distance.* Also *all connecting parts and pipes in between above, the whole being arranged to a suitable plan, ready for putting together on a level surface abroad.* It also includes iron chimneys for the boilers, complete with guy chains, 40 yards of suction pipe from sea to machinery, 20 yards of waste sea-water pipe, and 20 yards of fresh-water delivery pipe. Also a quantity of useful stores and tools, such as spare fire bars, stoking and cleaning tools, spanners for tightening up, oil cans, gauge glasses and sundry useful stores, so that the whole may be readily set to work and kept in order without delay or difficulty. The surface on which the machinery stands should not be more than 8 yards (or 7 metres) above the sea-level.

The condenser tubes are of solid brass, tinned inside and outside. The pumps are of strong and simple construction, and easily adjustable to compensate for wear. The water is drawn and forced by plungers moving through stuffing boxes, easily packed and kept tight by an *external* gland, thus avoiding the troublesome and difficultly repaired leaks, which so frequently stop other kinds of pumps. They *work at a moderate speed*, so as to avoid the excessive wear and knocking about of the valves and other parts, always resulting from quick speed. They have fly-wheels, and have all valves, bearings, plungers and working parts in contact with water, made of *brass or copper, wrought-iron crank shafts, and steel piston-rods.* The *boilers* have furnace plates of *Low Moor or Bowling iron*, and have dampers, Bourdon's pressure gauges, safety valves, *and all necessary fittings.* They are proved to double the working pressure, and the working pressure is from $\frac{1}{6}$ to $\frac{1}{8}$ of the bursting pressure.

Note B.—If delivered in less than the maximum times stated below, then 4 per cent. extra on prices for every 10 per cent. less time.

Number of Estimate.	1	2	3	4	5	6	7	8
Number of complete and independent apparatus included in each estimate	2	1	1					
Type of the apparatus included in each estimate (single, double, or treble distilling)	Treble	do.	do.					
Type of boilers included in each estimate	Lancashire	do.	do.					
Fresh Water produced per 24 hours (See note A above).								
Gallons	12,000	9,000	12,000					
Tons, or cubic metres (1 *cubic metre equals* 1,000 *litres or kilos*)	53·6	40·2	53·6					
Economy of Coal and Wood (See Note A above).								
Wood or coals consumed for producing the quantities of water stated above as the production per 24 hours (weight in tons or 1,000 kilorammes)	Coal 3 Wood 12	Coal 2·15 Wood 8·6	Coal 2·67 Wood 4·9					
Tons of water (or cubic metres) yielded per 1 ton (or 1,000 kilogrammes) of coal	Coal 18 Wood 4·5	Coal 18·8 Wood 4·7	Coal 19·8 Wood 4·9					

(*Continued.*)

Number of Estimate.	1	2	3	4	5	6	7	8
Time required from receipt of order for delivering the machinery in London.								
Days for delivering all the independent apparatus included in above estimates (*See Note B above.*) *or else*	45 *to* 120	40 *to* 100	45 *to* 120	*to*	*to*	*to*	*to*	*to*
,, ,, first ,, ,, ,, ,,	*to*	*to*	*to*	*to*	*to*	*to*	*to*	*to*
,, ,, second ,, ,, ,, ,,	*to*	*to*	*to*	*to*	*to*	*to*	*to*	*to*
,, ,, third ,, ,, ,, ,,	*to*	*to*	*to*	*to*	*to*	*to*	*to*	*to*
,, ,, fourth ,, ,, ,, ,,	*to*	*to*	*to*	*to*	*to*	*to*	*to*	*to*
Prices, delivered packed and free on board in London.								
Prices for all the complete apparatus in each estimate as decribed above .. .. £	4,362	3,052	4,046					
Extras if required.								
Iron roofs supported on iron columns to contain the above machinery .. .. £								
Tanks of galvanized iron to contain the quantities of fresh water stated above as the production per 24 hours .. .. £								

REPORTS on Normandy's Improved Patent Machinery for producing from sea-water, pure, cold, and agreeable fresh-water for drinking purposes.

RESULT of the trial of Normandy's Improved Patent Distilling Machinery erected at Flushing for the Dutch Government, January and February 1877.

This machinery was supplied as suitable for producing 6,000 gallons, or 27 cubic metres, of good, cold, drinking water, per 24 hours, from sea-water.

By the direction of Mr Van Diesen, Chief Engineer of the Waterstaat, in the province of Zealand, Holland, this machinery was carefully tested by being worked under the inspection of officials appointed for the purpose, the result being, that *in* 19 *hours' work* this machinery produced 28,500 litres of fresh-water, and consumed 1,545 kilogrammes of coal. This is equal to 6,270 gallons (or 28 tons) of fresh-water, produced with 1½ tons of coal in 19 *hours' work.*

The fresh-water produced, as it flowed from the machinery, *was bright-looking, clear, cold and agreeable, without any peculiar taste, and, in fact, equal in appearance and taste to the best river or spring water.*

It will be seen, therefore, that this machinery, when worked *for* 19 *hours*, produced 33 *per cent. more water than it was sold to produce* in that time, and yielded 4,100 *gallons* (*or* 18·3 *tons*) *per* 1 *ton of coal* (equal to 18·3 cubic metres per 1,000 kilogrammes of coal); the economy of coal would have been still greater had the machinery been less overworked, as similar machinery at *Aden and Alicante* has yielded over 20 *tons* of water per 1 ton of coal (or 20 cubic metres per 1,000 kilogrammes of coal).

In the above trial, the productive power and consumption of coal were ascertained as follows:—The machinery having been fairly started, *the coals were removed from the furnaces,* and the working was continued, under inspection, with *weighed coals.* After 19 *hours'* working, *the unconsumed coals were removed from the furnaces and weighed,* and their weight was deducted from the quantity of weighed coals put into the furnaces, the difference being taken as the weight consumed. The fresh-water produced from the sea-water was collected in an iron tank and carefully measured. The results were as above stated.

OPINION of DON JOSE SOLER Y SANCHEZ, Licentiate in Pharmacy, Doctor in Sciences, late Professor of Chemistry to the Faculty of Sciences of University of Madrid, Professor of Chemistry and Physics to the Institute of Alicante, &c., &c.

Alicante, 11th September 1879.

I hereby certify that, having analysed in my laboratory a sample of pure fresh-water in order to see if the same was drinkable, and which sample was delivered to me by the Presidente Alcalde (Mayor) of the most illustrious municipality of Alicante, the said sample being drawn, according to his declaration, from Mr. Normandy's Distilling Engine:

This sample of fresh-water was received in the presence of the Notary, Mr. Nereo Albert, in two glass bottles duly sealed and stamped with the letters J.C.B., the result being as follows:—

1st. Its hyrotimetrical degree is 5°.
2nd. A litre of water contains 0·085 grammes of mineral substance.
3rd. Does not contain any organic matter.
4th. Contains 17·64 c c. of air per litre of water.
5th. Does not prevent soap from dissolving.
6th. Is clear, without color, limpid, and transparent.

Therefore, by its character and condition, it is to be considered *a most eminently drinkable water.*

And in order that the interested party make use of this certificate as he may think fit, at his own request I grant the present document attaching my signature thereto.

REPORT of DR. NOAD, Ph.D., F.R.S., Professor of Chemistry at St. George's Hospital, London.

I find the water to be *absolutely free from organic matter*, which all river and well waters contain more or less, and which is acknowledged to be a predisposing cause of disease; it is also bright, colorless, well aerated and agreeable, and it contains an exceedingly small percentage of saline matter, which is the case with all waters derived from the best natural sources.

From a sanitary point of view, I consider this water to be quite equal, and in its absolute freedom from organic matter, superior, to that obtained from the purest natural sources. It is therefore well suited for alimentary purposes.

REPORT of DR. LETHEBY, M.B., M.A., Professor of Chemistry in the Medical College of the London Hospital and Medical Officer of Health for the City of London.

The sample was colorless and well aerated, and it was agreeable to the palate. It contained a very small proportion of saline matter, which I regard as an advantage, as it approximates the quality of the water to that derived from the best natural sources. For dietetical purposes, the proper aeration of the water is essential. *The water was absolutely free from organic matter*, and it is very soft.

I am of opinion, from these results, that the water is very wholesome and is well adapted for all domestic purposes.

KRASNOVODSK, 1st October 1880.

I, the undersigned, Doctor of Medicine, Doctor-in-Chief of the Trans-Caspian Expedition, certify that the water of the Caspian Sea rendered potable by NORMANDY'S DISTILLING APPARATUS has been submitted to me, by being taken as it flowed from the apparatus, and that after an examination of fifteen days I found it to have the following qualities:—

The water was *perfectly pure, free from all organic matters, contained a sufficient quantity of air*, was without any taste of machinery, or of any other unpleasant flavor. I personally used it, and found it suited me well. I consider it *perfectly suitable for alimentation, and for all domestic purposes.*

In consideration of which I have delivered the present certificate.

DR. OSCAR HEYFELDER,
Councillor of State.

All sizes supplied, producing from 100 to 15,000 gallons of water per 24 hours, and yielding up to 20 tons, or 4,480 gallons of water per 1 ton of coal consumed.

Notes and Remarks.

The price of the treble distilling arrangement exceeds that of the double, and that of the double exceeds that of the single distilling arrangement, but this *extra first cost is soon repaid by the great saving of coal.*

Applications for prices and further particulars should state size, kind of arrangement preferred, and whether required to convert sea-water into cold fresh-water for drinking, for a land station, or on board ship, or whether to produce hot or cold fresh-water for feeding locomotive boilers, or other manufacturing purposes, such as for saltpetre refining, dyeing works, brightening colors for calico printing, &c.

This machinery will force the fresh-water produced to *any distance* and to a height of 40 yards (or metres) or more if desired, and it may be placed at any convenient distance from the sea; but the surface on which it stands should not be more than 8 yards (or 7·2 metres) above the sea-level, which would necessitate special arrangements according to circumstances.

The attendance of *one man* will suffice to work one or more sets of this machinery, provided that the total quantity of fresh-water produced per 24 hours does not exceed 8,000 gallons if single distilling, 15,000 gallons if double distilling, or 20,000 gallons if treble distilling.

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Full instructions for putting together and working will be supplied with the machinery, and if desired, special arrangements may be made for the machinery to be supplied and erected abroad, *and also worked for an agreed time, the consumption of coal, and the quantity and quality of the fresh-water produced being guaranteed.*

Note A.—Each of these *complete sets of machinery* includes one of Normandy's Improved Patent Condensers with filter, suitable Cornish or Lancashire (double flue Cornish) steam boiler, and steam pumps for supplying sea-water to the condenser and boiler, and for *forcing the fresh-water produced to any distance, and to a height of* 40 *yards (or metres) or more if desired.* Also *all connecting parts and pipes in between above, the whole being arranged to a suitable plan, ready for putting together on a level surface abroad.* It also includes iron chimneys for the boilers, complete with guy chains, 40 yards of suction pipe from sea to machinery, 20 yards of waste sea-water pipe, and 40 yards of fresh-water delivery pipe. Also a quantity of useful stores and tools, such as spare fire bars, stoking and cleaning tools, spanners for tightening up, oil cans, gauge glasses and sundry useful stores, so that the whole may be readily set to work, and kept in order without delay or difficulty. The surface on which the machinery stands, should not be more than 8 yards (or 7·2 metres) above the sea level.

The condenser tubes are of solid brass, tinned inside and outside. The pumps are of strong and simple construction, and easily adjustable to compensate for wear. The water is drawn and forced by plungers moving through stuffing boxes, easily packed and kept tight by an *external* gland, thus avoiding the troublesome and difficultly repaired leaks, which so frequently stop other kinds of pumps. They *work at a moderate speed*, so as to avoid the excessive wear and knocking about of the valves and other parts, always resulting from quick speed. They have fly wheels, and have all valves, bearings, plungers and working parts in contact with water, made of *brass or copper, wrought-iron crank shafts, and steel piston-rods.* The *boilers* have furnace plates of *Low Moor or Bowling iron*, and have dampers, Bourdon's pressure gauges, safety valves, fusible safety plugs in crowns of furnaces, *and all necessary fittings.* They are proved to double the working pressure, and the working pressure is from $\frac{1}{6}$ to $\frac{1}{8}$ of the bursting pressure.

Note B.—Each of these complete sets of machinery includes the same as described under Note A, but the boilers included take up less room, and do not require setting in brickwork, being of the vertical, or return flue, type, and of simple construction so as to avoid difficulty in cleaning and working; they are, however, not so economical of coal, and boilers as described in Note A are generally preferable, especially for the larger sizes, as they are the most economical of coal, and easiest to clean, and keep in good working order, and are easily fixed in brickwork, concrete, cement, stone, &c.

Note C.—Tanks for containing the fresh water produced are supplied as extras. They are best made of galvanized iron, fitted with drawing-off cocks complete. It is convenient to have tanks large enough to contain at least the production per 24 hours, as per list on opposite page. For convenience of shipping, large sizes are made of flat or curved pieces, easily bolted together abroad.

Extra length of sea-water suction pipe, waste sea-water pipe, and fresh-water delivery pipe, including bends and joints to suit various positions, are supplied at per yard as required.

Iron roofs supported on iron columns for containing this machinery for land stations are also supplied as extras if required.

Some of the land stations supplied with various kinds of Normandy's Patent Distilling Machinery.

Aden, Red Sea.	Gibraltar.	Ismalia (Egyptian War).
Flushing, Holland.	Alicante.	Island of Ascension.
Abyssinian Expedition.	Peru.	Krasnovodsk, Caspian Sea.
Malta.	Chili.	Galapagos Islands.
Cape Coast Castle.	Australia.	China Hospital Ships.
West Coast of South America.	Brighton.	Heligoland.
Iquique.	Packam and Co., Croydon.	Fort Moultrie.
St. Vincent, Cape Verds.	Red Sea Lighthouses.	Pure Water Co., London.

Some of the above produce 20 tons or 4,500 gallons of good, cold, drinking water from sea water per 1 ton of coal.

Some of the Ships supplied with Normandy's Patent Distilling Machinery.

British Government.

H.M.S. Nelson	H.M.S. Rifleman	H.M.S. Forester
" Victor Emanuel	" Frolic	" Northampton
" Flying Fish	" Dee	" Foxhound
" Iron Duke	" Goshawk	" Foreward
" Lord Warden	" Swinger	" Emerald
" Lord Clyde	" Ready	" Medina
" Czarewitch	" Serapis	" Medway
" Crocodile	" Jumna	" Sabrina
" Euphrates	" Undine	" Spey
		24

British Government—*cont.*

H.M.S. Audacious
„ Vanguard
„ Swiftsure
„ Encounter
„ Invincible
„ Magicienne
„ Assistance
„ Curacoa
„ Cleopatra
„ Conquest
„ Inflexible
„ Diamond
„ Moorhen
„ Sheldrake
„ Superb
„ Comus
„ Belle Isle
„ Triton
„ Himalaya
„ Sapphire
„ Pioneer
„ Rover
„ Fury
„ Lily
„ Arab
„ Investigator
„ Hecla
„ Hymalaya
„ Express
„ Contest
„ Cygnet
„ Daring
„ Sappho
„ Pegasus
„ Dragon
„ Albatross
„ Modeste
„ Amethyst
„ Shah
„ Fantome
„ Egeria
„ Dromedary
„ Boadicea
„ Bacchante
„ Raleigh
„ Cormorant
„ Gannet
„ Leander
„ Arethusa
„ Phæton
„ Ariel
„ Zephyr
„ Kestrel

H.M.S. Amphion
„ Caroline
„ Imperiuse
„ Malabar
„ Hydra
„ Briton
„ Rupert
„ Sultan
„ Volage
„ Active
„ Hecate
„ Hotspur
„ Mosquito
„ Don
„ Esk
„ Champion
„ Heroine
„ Hyacinth
„ Lark
„ Thetis
„ Barrosa
„ Odin
„ Gorgon
„ Druid
„ Merlin
„ Thalia
„ Glatton
„ Triumph
„ Magdala
„ Foam
„ Coquette
„ Cyclops
„ Decoy
„ Tourmaline
„ Slaney
„ Trent
„ Harrier
„ Raleigh
„ Ready
„ Pylades
„ Tweed
„ Iris
„ Griffin
„ Falcon
„ Firebrand
„ Firefly
„ Carrysfoot
„ Neptune
„ Starling
„ Stork
„ Raven
„ Humber
„ Firm

H.M.S. Tay
„ Tees
„ Osprey
„ Condor
„ Flamingo
„ Temeraire
„ Turquoise
„ Ruby
„ Pelican
„ Penguin
„ Wild Swan
„ Dolphin
„ Wanderer
„ Sphinx
„ Calliope
„ Doterel
„ Mallard
„ Shannon
„ Euryalus
„ Garnet
„ Orion
„ Colossus
„ Conqueror
„ Sea Horse
„ Cordelia
„ Canada
„ Rambler
„ Ranger
„ Niger
„ Algerine
„ Kingfisher
„ Constance
„ Grappler
„ Banterer
„ Wrangler
„ Wasp
„ Espoir
„ Redwing
„ Bullfrog
„ Cockchafer
„ Swift
„ Linnet
„ Flying Fish
„ Agamemnon
„ Phœnix
„ Miranda
„ Satellite
„ Wyvern
„ Edinburgh
„ Majestic
„ Rodney
„ Warspite
„ Collingwood

German Government.

H.M.S. König Wilhelm
„ Krön Prinz
„ Kaiser
„ Ariaden

H.M.S. Medusa
„ Vinetta
„ Albatros
„ Nymphe

H.M.S. Deutschland
„ Leipzig
„ Sedan

Chilian, Danish, Brazilian, Portuguese, Argentine, Turkish, Spanish and Japan Governments.

H.M.S. Foo-so
„ Kongo
„ Hiyei
„ Feyen
„ Independencia
„ Rainha de Portugal

H.M.S. Almirante Cochrane
„ Almirante Brown
„ Riachuelo
„ Mindelho
„ Moyini Zaffer
„ Nictherhoy

H.M.S. Florencia
„ Ingolf
„ Miramar
„ Lotus
„ Gravina
„ Velasco

Royal Mail Steam Packet Company.

S.S. Moselle
„ Atrato
„ Neva
„ Tagus
„ Nile
„ Boyne

S.S. Shannon
„ Esk
„ Rhone
„ Seine
„ Douro
„ Eden

S.S. La Plata
„ Tasmanian
„ Oneida
„ Elbe

Allan Line of Royal Mail Steamers.

S.S. St. Andrew
„ St. George
„ St. David
„ Germany
„ Peruvian
„ Moravian

S.S. Polynesian
„ Pomeranian
„ Norway.
„ Nestorian
„ Circassian
„ Prussian

S.S. Scandinavian
„ Sweden
„ Sardinian
„ Nova Scotian
„ Assyrian
„ Austrian

Messrs. R. and H. Green.

S.S. Sultan
„ Viceroy
„ Shannon
„ Melbourne
Malabar

Roxburg Castle
Carlisle Castle
Newcastle
Clarence
Alnwick Castle

Agamemnon
Windsor Castle
Renown
Nile

Belonging to various Governments and Shipowners.

S.S. Torrington
„ Hampton
„ Harrington
„ Wyberton
„ Durham
„ Macassar
„ Bothnia
„ Synthia
„ Kingston
„ Spartan
„ Madeira
„ Nachimof
„ Serendib
„ Dacia
„ Russia
„ Pavonia
„ Padang
„ Royal Dane
„ Gelderland
„ Nepaul
„ Kate Fawcet
„ Servia
„ Lena
„ Kent
„ Friesland
„ Dreuthe
„ Royal Welsh
„ Black Watch
„ Cephalonia
„ Overyssel

S.S. Samarang
„ Zuid Holland
„ Aurania

Indus
Beaumaris Castle
Light Brigade
Eastern Empire
Southern Ocean
City of Melbourne
Marchesa
Southern Cross
Flying Cloud
Hugoumont
Young Australia
Lightning
Prince of Wales
Blue Jacket
Sir Robert Sale
Lansborough
Montmorency
Himalaya
Burlington
Caroline Coventry
Java
Maryborough
Matilda Atheling
Clairellen
Wambojeeg

Wellesley
Kent
Ellenborough
Harkaway
Atalanta
Aliquis
Canning
Samarang
Norman Morrison
Gresham
Howrah
Mermaid
Maori
Peeress
Lincoln
Zenobia
Canterbury
Gosforth
Avon
Clive
Siam
Zelandia
Wansfell
Philosopher
Thames
Poonah
Clara
Arcot
Dunbar Castle
Theresa

All sizes supplied and guaranteed to produce from sea-water from 100 to 15,000 gallons of best, cold, drinking water per 24 hours, and yielding up to 20 tons, or 4,500 gallons, of water per 1 ton of coal consumed, with the larger sizes.

See Condenser List No. 2 for particulars of Normandy's Improved Patent Double Distilling Condensers for steamships, yachts, and torpedo boats, for working with greasy steam from main boilers supplying the engines so as to produce good, cold, drinking water, and also hot fresh-water for keeping up the full supply of fresh-water in these boilers and prevent scale accumulating therein.

See Condenser List No. 3 for particulars of single Distilling Condensers for producing good cold, drinking water from sea-water when worked with clean steam from boilers fed only with sea-water, these condensers are less economical of coal.

From A. NORMANDY, Esq., for Normandy's Patent Marine Aerated Fresh Water Company (Limited), to General Hyde, India Office, Westminster, S.W., dated Custom House Station, Victoria Dock, London, 21st February 1884.

With reference to Col. J. Mullins' letter to you, dated Bangalore, 17th January 1884, which you were good enough to show me, respecting the water supply at Bangalore, I beg to observe as follows:—

Filtration will not make very foul water reasonably wholesome, and though filters may, at first, somewhat improve the quality of such impure water, they very soon lose this power, and get out of order.

Such impure water as Colonel Mullins describes may, however, be converted into good and agreeable drinking water by distillation with apparatus such as we have supplied for Aden and other places, and which are very economical of fuel.

Ordinary distillation converts salt-water into fresh-water, but such fresh-water is heavy and unwholesome, as well as unpleasant to drink, owing to want of proper æration, and to its being tainted by an extremely small quantity of a very offensive oil.

If 25 gallons of ordinary distilled water be very slowly evaporated at considerably below the boiling point, at the end of several weeks the little platinum dish last used, will be found covered with a film of a most offensive oil, and if this film of oil is re-dissolved in 25 gallons of good drinking water, it will give it the unpleasant taste noticeable in the distilled water from which it was extracted as above.

The above film of oil results from as follows:—

The impure water to be distilled is evaporated in boilers, and the organic matter in such water coming in contact with the heated surfaces of the boiler is decomposed, thus creating a minute quantity of volatile oil, which mixes with the steam and is condensed therewith.

In our apparatus the distilled water, after being properly aerated, is passed through a large mass of prepared animal charcoal, which, without being acted upon itself, has the property of inducing some of oxygen dissolved in the water to oxydize the abovenamed offensive oil, so as to in effect burn it; the product of such oxydation being a minute quantity of water, and carbonic acid gas, and the consequence is, that the distilled water ultimately produced is purified from the above oil, and rendered *quite tasteless* and agreeable to drink as well as wholesome.

The reason why distilled water on board ship is often not palatable is, that the condensers are worked with *greasy* steam, which is good for driving the engines, but unsuitable for condensing into drinking water; but it is sometimes collected separately for washing with our improved for steamers such steam is sometimes so greasy that I have known pipes in our condensers more or less obstructed with a black fatty substance and the filter rendered impervious to water from the same cause. Sometimes this greasy steam yields an oil more or less volatile, and catches fire in the filter if a light is introduced.

With reference to the existing boilers, they are not large enough for distilling, and even if they were, they would not be suitable for obtaining good results as to quality of water and economy of fuel.

We should recommend working the proposed distilling machinery night and day, as they do at Aden, partly because it economises fuel, but principally because it saves 50 per cent of the price of the distilling machinery, as less powerful machinery is then sufficient.

There would be no difficulty in arranging for our boilers to burn wood instead of coal.

We therefore beg to submit the following estimates for consideration:—

No. 1 *Estimate.*—Two complete sets of Normandy's improved patent treble distilling machinery as supplied for Aden, producing together 12,000 gallons of good, cold, drinking water per 24 hours, with a consumption of 3 tons of coal, or 12 tons of wood (assuming 4 of wood equal 1 of coal as in Colonel Mullins' letter) price packed and delivered in London, £4,362.

No. 2 *Estimate.*—One complete set as above to produce 9,000 gallons per 24 hours, with 2·15 tons of coal or 8·6 tons of wood, price packed and delivered in London, £3,052.

No. 3 *Estimate.*—One complete set as above to produce 12,000 gallons per 24 hours, with 2 67 tons of coal or 10·7 tons of wood, price packed and delivered in London, £4,046.

In above estimates each complete set of apparatus includes distilling condenser and filter, steam boiler with iron chimneys, steam pumps for circulating water, and for forcing the distilled water produced wherever desired, and all connecting parts in between so that the whole may be readily erected abroad, also suction and delivery pipes and spare stores, all as described at length in annexed printed estimate form dated this day.

P.S.—In case some other size or kind of our apparatus should be preferred, we send herewith our No. 1 condenser list, giving particulars of all the sizes and kinds we make.

You will observe we only estimate for *treble* distilling arrangements, as the saving in fuel they effect soon repays their extra first cost as compared with the single and double distilling arrangements also described in our No. 1 condenser list herewith.

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From A. NORMANDY, Esq., for Normandy's Patent Marine Aerated Fresh Water Company (Limited), to General Hyde, India Office, Westminster, S.W., dated Custom House Station, Victoria Dock, London, 1st March 1884.

In reply to your letter of the 29th ultimo, as the prepared animal charcoal is not acted upon itself, but acts as explained in paragraph 7 of our letter of the 21st ultimo, it does not require renewing for very many years.

2. What does occur is as follows:—When the machinery is first started, more or less rusty water is produced for a few minutes; this should be run off so as not to pass into the filter. A little rust, however, always finds its way in, and in the course of about a year may accumulate in the upper half-inch thick layer of charcoal; this should then be scraped off, and thrown away, and the rest of the charcoal should be removed from the filter to lighten it (it is apt to become dense by the constant flow of water through it); it is then simply replaced in the filter.

From the Commissary-General, to the Inspector-General of Railway Stores, India Office, Westminster, S.W., dated Bombay, 28th August 1883, No. E-25-5554.

With reference to your letter of 3rd instant, I have the honor to inform you that the two new condensers were tried at Aden in June last with the following results:—

The 6,000 gallons condenser was worked for 24 hours and the water produced during that period was 7,082 gallons with the expenditure of 1½ tons of coal, which gives an outturn of 21 lb. of water to every pound of coal consumed.

The 9,000 gallons condenser was worked for 24 hours and the water produced during that period was 12,110 gallons with the expenditure of 2 tons 11 cwts. of coal, which also gives 21 lb. 3 ozs. of water to every pound of coal consumed.

2. I beg to append a copy of the statement showing the results of the working of these new condensers contrasted with those hitherto in use, and those of private companies, from which it will be observed that the result is very satisfactory.

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CONTRASTED Statement of Water produced by the new and present Condensers belonging to Government and those of private Companies at Aden.

Particulars.	New Condensers.	Present Condensers on Flat Hyderabad.	Messrs. Luke, Thomas and Co.'s Condensers.	Aden Water Co.'s Condensers.	Remarks.
Average outturn of water per 1 lb. of coal consumed .. .. lb.	16	9	8	12	The outturn of water produced by the new condensers on the first trial was found to be 21 lb. of water per lb. of coal consumed, but this cannot be taken as an average of their outturn in future when worked continually; so the average outturn is taken at 16 lb. of water per lb. of coal consumed.
Taking the daily consumption of coal for each condenser at 2 tons, 18 cwts. or 6,496 lb. will produce .. .. lb.	103,936	58,464	51,968	77,952	
At 10 lb. per gallon .. .. lb.	10,393	5,846	5,196	7,795	
Difference in production of new and old condensers per day .. .. gallons.	..	4,547	5,197	2,598	
Profit to Government in using new condensers, per month, taking 26 working days .. gallons.	..	4,547	5,197	2,598	
	..	118,222	135,122	67,548	
Cost at Rs. 1-12-0 per 100 gallons ..	..	2,068-14-2	2,364-10-2	1,182-1-5	

N.B.—Thus it will be seen that the profit to Government per month in using the new condensers as compared with the present condensers on Flat Hyderabad is Rs. 2,068-14-2 as compared with Messrs. Luke, Thomas and Company's condensers, Rs. 2,364-10-2, and with the Aden Water Company, Rs. 1,182-1-5.

COMMISSARIAT OFFICE, ADEN,
31st July 1883.

Lieut.-Colonel,
Acting Commissary-General.

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APPENDIX No. 26-A.

STANDARDS of Impurity of Water.

		Pure and wholesome water yields an analysis figures which do not exceed the following limits.	Usable water gives figures which do not exceed the following limits.	Suspicious water gives figures which do not exceed the following limits.	Bad water gives figures which exceed the following limits.
Total solids ..	Grms. per litre	0·114	0·428	0·714	0·714
Volatile solids ..	Do.	0·014	0·043	0·071	0·071
Chlorine ..	Do.	0·014	0·043	0 086	0·086
Total hardness ..	Clark's scale	..	..	..	..
Permanent hardness	Do.	2°	4°	6°	6°
Free ammonia ..	Mlgrms. per litre ..	0·02	0·05	0·1	0·1
Albumenoid ammonia	Do. ..	0·08	0·1	0·15	0·15
Nitric acid ..	Do. ..	..	..	..	..

APPENDIX No. 26-B.

ANALYSIS of Samples of Water received from the Engineer in charge of Ulsoor Water Works with his letter, dated 9th May 1883.

		Sample of water taken direct from the Ulsoor tank.	Sample of water taken direct after passing through the filter bed.	Sample of water taken direct from the dhobies' wells.
		1	2	3
Total solids		0·27	0·26	0·23
Volatile solids ..	Grms. per litre	0·12	0·06	0·09
Chlorine ..	Do.	0·081	0·078	0·053
Total hardness ..	Clark's scale	3°·5	2°·8	3°·86
Permanent hardness ..	Do.	2°·45	1°·75	3°·15
Free ammonia ..	Mlgrms. per litre	0·4	0·48	0·08
Albumenoid ammonia	Do.	0·56	0·48	0·8
Nitric acid ..	Do.	3·0	3·0	3·3
Apparent quality of the water as inferred from the results obtained on examination.		Bad.	Bad.	Bad.

REMARKS—No. 1. Deposit abundant and composed of vegetable debris.
,, 2. Deposit scanty and composed of vegetable debris and argillaneous matter.
,, 3. Deposit scanty and composed of vegetable debris.
All three samples contain a very large amount of organic impurity.

MADRAS,
24th May 1883.

(True Copy.)
(Signed) T. K. ROGERS, M.B., F.R.C.S.,
Chemical Examiner.

APPENDIX No. 26-C.

N.B.—Nos. 1 to 4 from below Bund of New (Ooparhalli) Reservoir.

		No. 1. Spring water below Sappers' well.	No. 2. Dhobies' well.	No. 3. Sappers' well.	No. 4. Spring directly below bund in centre of valley.	No. 5. Miller's No. 4. Reservoir
Total solids ..	Grms. per litre ..	0·3	0·15	0·19	0·32	0·25
Volatile solids ..	Do. ..	0·11	0·08	0·08	0·10	0·08
Chlorine ..	Do. ..	0·028	0·22	0·21	0·019	0·039
Total hardness ..	Clark's scale ..	5°·95	2°·45	1°·75	7°·7	3°·15
Permanent hardness	Do. ..	3°·5	1°·75	1°·05	1°·4	1°·75
Free ammonia ..	Mlgrms. per litre ..	0·16	0·08	0·06	0·88	0·2
Albumenoid ammonia	Do. ..	0·120	0·592	0·16	0·24	0·4
Nitric acid ..	Mlgrms. per litre (as ammonia) ..	1·950	1·950	1·8	2·4	2·1
Apparent quality of the samples as inferred from the results obtained on examination.		Usable.	Bad.	Usable.	Bad.	Usable.

These waters have been previously analysed and the results reported in the office docket, No. 1030, dated 13th June 1883, addressed to the Deputy Assistant Quartermaster-General, Bangalore, from whom the samples appeared to have been received.

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APPENDIX No. 26-D.

			Agram tank water.
Totals solids	Grms. per litre		0·25
Volatile solids	Do.		0·10
Chlorine	Do.		0·043
Total hardness	Clark's scale		4°·2
Permanent hardness	Do.		1°·75
Free ammonia	Mlgrms. per litre		0·12
Albumenoid ammonia	Do.		0·16
Nitric acid	Do.	(as ammonia)	3·0

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

Remarks.—An abundant deposit, composed chiefly of vegetable debris.

APPENDIX No. 26-E.

			Agram tank water.	Well water N.W. of Agram tank weir.
Total solids	Grms. per litre		0·25	0·78
Volatile solids	Do.		0·10	0·32
Chlorine	Do.		0·043	0·284
Total hardness	Clark's scale		4°·55	19°·25
Permanent hardness	Do.		1°·4	14°·0
Free ammonia	Mlgrms. per litre		0·096	0·04
Albumenoid ammonia	Do.		0·16	0·12
Nitric acid	Do.	(as ammonia)	3·0	4·8
Apparent quality of the water as inferred from the results obtained on examination.			Usable.	Bad.

Remarks.—Both samples gave an abundant deposit chiefly composed of vegetable debris.

APPENDIX No. 26-F.

Analysis of Water in accordance with Deputy Surgeon-General's Memorandum, No. 930-E, of 14th March 1884.

	Source and date of supply.	Physical character.	Qualitative tests. Nitrous acid.	Nitric acid.	Sulphuric acid.	Hardness, Clark's scale. Total degrees.	Fixed.	Total oxidisable matter.	Chlorine, grs. per gallon.	Remarks.
	No. 2 well water to south of Cavalry Hospital, 12th March 1884.	A transparent water without sediment, taste or smell.	Nil.	Nil.	Nil.	2°·30	·94	·8	1·24	Usable water.
West side of Agram tank.	No. 1 well water, 12th March 1884.	Do. do.	Nil.	Nil.	3 grains.	19°·95	16·8	2·80	29·26	According to the extent of present analysis these waters come under the hygienic sub-division of "impure."
	No. 2 do. do.	Slight sediment.	Nil.	Nil.	1½ do.	11°·20	8·2	1·6	6·94	
	No. 3 do. do.	No do.	Nil.	Nil.	Traces.	10°·85	6·9	1·4	4·96	
	No. 4 do. do.	No do.	Nil.	Nil.	Nil.	9°·80	6·2	1·	4 21	

Bangalore,
17th March 1884.

(Signed) H. J. McLAUGHLIN, M.B.,
Surgeon, A.M.D.

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APPENDIX No. 26-G.

Qualitative Analysis of Water.

Source and date of supply.	Physical characters.	Chlorine.	Nitrates.	Nitrites.	Ammonia.	Sulphates.	Oxidisable matter by gold chloride.	Remarks.
No. I. Pool water under Agram tank, 26th March 1884.	A turbid water, odourless.	Slight.	Nil.	Nil.	Nil.	Nil.	Nil.	Apparently a pure water.
No. II. Pool water near sugar field under Agram tank, 26th March 1884.	Turbid, yellowish, probably from suspended clay. Sediment of clay.	Slight.	Nil.	Nil.	Nil.	Nil.	Nil.	Apparently a good water after filtration.

Bangalore,
27th March 1884.

(Signed) H. J. McLAUGHLIN, M.B.,
Surgeon, A.M.D.

APPENDIX No. 27.

Explanatory Memorandum regarding the Levels connected with Bangalore Water-supply *Investigations.*

There are at Bangalore three sets of levels referred to mean sea level, the one based upon the Madras Railway levels and their connection with De Havilland's bench-mark at Fort St. George; the second on the G.T.S. levels brought up from Karwar on the west coast, while the third were determined trigonometrically from Madras. The first and third each need an addition of 1 foot for the corrected level of De Havilland's bench-mark.

Apart from this the Madras Railway levels were said to be 8·06, and the trigonometrically determined levels 4·40 higher than the spirit levelling from Karwar. The revised differences would be 9·06 and 5·40, respectively. On sheet No. 42 of the topographical survey, issued in 1881, the difference between the G.T.S. spirit levelling from Karwar and the trigonometrical determination is shown to be 4·74, which would apparently be raised to 5·74 by the correction of De Havilland's bench-mark.

Memorandum of G.T.S. bench-marks, copy appended.

2. The value of the crest of the waste weir of the Halsur lower tank has been taken to be 2,929·97 above mean sea level at Karwar, as noted on a survey of the upper tank, dated 22nd November 1880, and signed F. J. Romilly, Lieutenant, R.E., Assistant Engineer. That this value is referred to Karwar is indicated by a list * of levels, dated 27th June 1879, by Overseer Patten, the reduction of which to that datum is given and afterwards the above value for the waste weir. That it is about right has been proved by the connections made with the G.T.S. B.M. on the step of the gunta at Subadar's chattram, the value of which is 2,996·29. As the Halsur waste weir crest is irregular, it has been thought best to take the zero of the gauge opposite the engine-house as F.T.L. corresponding to the reduced level 2,929·97 above mentioned, and a B.M. 11·95 feet above that zero has been cut on the offset at base of the south wall of the engine-house. The value of this B.M. is therefore 2,941·92.

* Office records, Executive Engineer, Presidency Division.

3. The waste weirs of the Bangalore water-supply reservoir (Ooparhalli) are nominally 104·00 feet above the Halsur tank weir. The west weir is slightly (0·10) the higher of the two. Their values as deduced from connection with the Subadar's chattram G.T.S. bench-mark, and by adding 104 to the Halsur waste weir value, are 2,929·97 + 104·00 = 3,033·97.

2,996·29 + 37·55 = 3,033·84 west weir.
2,996·29 + 37·45 = 3,033·74 east do.

4. The following levels have been taken by Mr. Simmons, Surveyor, and will be found in the same order in his level book, which is indexed: —

1. Levels to, and a contour of, a small hill S. by W. of Subadar's chattram; not checked.
2. Levels from the east waste weir of the Bangalore water-supply (Ooparhalli) reservoir to 6¾ miles on the Yelabanka road.
3. Levels from the above point to and round the hill to the west.
4. Levels from same point to Yelabanka tank.
5. Levels from a point, ⊙123 of the contour in No. 3, to and round Bettahalli hill.
6. Levels from a point, ⊙47 on this contour in No. 5, to Subadar's chattram.

APPENDIX No. 26-D.

		Agram tank water.
Totals solids	Grms. per litre	0·25
Volatile solids	Do.	0·10
Chlorine	Do.	0·043
Total hardness	Clark's scale	4°·2
Permanent hardness	Do.	1°·75
Free ammonia	Mlgrms. per litre	0·12
Albumenoid ammonia	Do.	0·16
Nitric acid	Do.	3·0
	(as ammonia)	

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

Remarks.—An abundant deposit, composed chiefly of vegetable debris.

APPENDIX No. 26-E.

		Agram tank water.	Well water N.W. of Agram tank weir.
Total solids	Grms. per litre	0·25	0·78
Volatile solids	Do.	0·10	0·32
Chlorine	Do.	0·043	0·284
Total hardness	Clark's scale	4°·55	19°·25
Permanent hardness	Do.	1°·4	14°·0
Free ammonia	Mlgrms. per litre	0·096	0·04
Albumenoid ammonia	Do.	0·16	0·12
Nitric acid	Do.	3·0	4·8
	(as ammonia)		
Apparent quality of the water as inferred from the results obtained on examination.		Usable.	Bad.

Remarks.—Both samples gave an abundant deposit chiefly composed of vegetable debris.

APPENDIX No. 26-F.

Analysis of Water in accordance with Deputy Surgeon-General's Memorandum, No. 930-E, of 14th March 1884.

Source and date of supply.	Physical character.	Qualitative tests. Nitrous acid.	Nitric acid.	Sulphuric acid.	Hardness, Clark's scale. Total degrees.	Fixed.	Total oxidisable matter.	Chlorine, grs. per gallon.	Remarks.
No. 2 well water to south of Cavalry Hospital, 12th March 1884.	A transparent water without sediment, taste or smell.	Nil.	Nil.	Nil.	2°·30	·94	·8	1·24	Usable water.
West side of Agram tank. No. 1 well water, 12th March 1884.	Do. do.	Nil.	Nil.	3 grains.	12°·95	16·8	2·56	29·26	According to the extent of present analysis these waters come under the hygienic sub-division of "impure."
No. 2 do. do.	Slight sediment.	Nil.	Nil.	1½ do.	11°·20	8·2	1·6	6·94	
No. 3 do. do.	No do.	Nil.	Nil.	Traces.	10°·85	6·9	1·4	4·96	
No. 4 do. do.	No do.	Nil.	Nil.	Nil.	9°·80	6·2	1·	4 21	

Bangalore,
17th March 1884.

(Signed) H. J. McLAUGHLIN, M.B.,
Surgeon, A.M.D.

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APPENDIX No. 26-G.

Qualitative Analysis of Water.

Source and date of supply.	Physical characters.	Chlorine.	Nitrates.	Nitrites.	Ammonia.	Sulphates.	Oxidisable matter by gold chloride.	Remarks.
No. I. Pool water under Agram tank, 26th March 1884.	A turbid water, odourless.	Slight.	Nil.	Nil.	Nil.	Nil.	Nil.	Apparently a pure water.
No. II. Pool water near sugar field under Agram tank, 26th March 1884.	Turbid, yellowish, probably from suspended clay. Sediment of clay.	Slight.	Nil.	Nil.	Nil.	Nil.	Nil.	Apparently a good water after filtration.

Bangalore,
27th March 1884.

(Signed) H. J. McLAUGHLIN, M.B.,
Surgeon, A.M.D.

APPENDIX No. 27.

Explanatory Memorandum regarding the Levels connected with Bangalore Water-supply *Investigations.*

There are at Bangalore three sets of levels referred to mean sea level, the one based upon the Madras Railway levels and their connection with De Havilland's bench-mark at Fort St. George; the second on the G.T.S. levels brought up from Karwar on the west coast, while the third were determined trigonometrically from Madras. The first and third each need an addition of 1 foot for the corrected level of De Havilland's bench-mark.

Apart from this the Madras Railway levels were said to be 8·06, and the trigonometrically determined levels 4·40 higher than the spirit levelling from Karwar. The revised differences would be 9·06 and 5·40, respectively. On sheet No. 42 of the topographical survey, issued in 1881, the difference between the G.T.S. spirit levelling from Karwar and the trigonometrical determination is shown to be 4·74, which would apparently be raised to 5·74 by the correction of De Havilland's bench-mark.

Memorandum of G.T.S. bench-marks, copy appended.

2. The value of the crest of the waste weir of the Halsur lower tank has been taken to be 2,929·97 above mean sea level at Karwar, as noted on a survey of the upper tank, dated 22nd November 1880, and signed F. J. Romilly, Lieutenant, R.E., Assistant Engineer. That this value is referred to Karwar is indicated by a list* of levels, dated 27th June 1879, by Overseer Patten, the reduction of which to that datum is given and afterwards the above value for the waste weir. That it is about right has been proved by the connections made with the G.T.S. B.M. on the step of the gunta at Subadar's chattram, the value of which is 2,996·29. As the Halsur waste weir crest is irregular, it has been thought best to take the zero of the gauge opposite the engine-house as F.T.L. corresponding to the reduced level 2,929·97 above mentioned, and a B.M. 11·95 feet above that zero has been cut on the offset at base of the south wall of the engine-house. The value of this B.M. is therefore 2,941·92.

* Office records, Executive Engineer, Presidency Division.

3. The waste weirs of the Bangalore water-supply reservoir (Ooparhalli) are nominally 104·00 feet above the Halsur tank weir. The west weir is slightly (0·10) the higher of the two. Their values as deduced from connection with the Subadar's chattram G.T.S. bench-mark, and by adding 104 to the Halsur waste weir value, are 2,929·97 + 104·00 = 3,033·97.

2,996·29 + 37·55 = 3,033·84 west weir.
2,996·29 + 37·45 = 3,033·74 east do.

4. The following levels have been taken by Mr. Simmons, Surveyor, and will be found in the same order in his level book, which is indexed: —

1. Levels to, and a contour of, a small hill S. by W. of Subadar's chattram; not checked.
2. Levels from the east waste weir of the Bangalore water-supply (Ooparhalli) reservoir to 6⅞ miles on the Yelabanka road.
3. Levels from the above point to and round the hill to the west.
4. Levels from same point to Yelabanka tank.
5. Levels from a point, ⊙123 of the contour in No. 3, to and round Bettahalli hill.
6. Levels from a point, ⊙47 on this contour in No. 5, to Subadar's chattram.

57

59

With regard to the series of levels Nos. 2 to 6, the first point made was the mantapam on the hill to the north of the weir. There is a recorded G.T.S. value 3,116·90 for the floor, but no B.M. being distinguishable, it is uncertain whether Mr. Simmon's levels are to the same point.

His value is 3,117·65 or just 0·75 difference. At the Yelabanka tank the topographical survey shows a value 2,940, but no B.M. could be traced. These values are shown, by a footnote on the survey, to require a reduction of 4·74 feet to refer them to M.S.L. Karwar. Consequently the reduced value would be 2,935·26. Mr. Simmon's level of the waste weir at the south end of the tank is 2,939·75.

On closing at Subadar's chattram the apparent error was 4·37 feet, which is reduced by the corrected level of the reservoir east weir, his starting point, to 4·14.

For the purpose for which the levels were taken, viz., to see what ground, on a sufficiently high level to drain into the reservoir, could be found, they are sufficiently accurate. There are two field books connected with Mr. Simmon's levels.

5. The rest of the levelling work has been done by Mr. Andrews, surveyor. The levels are in two books and the surveys therewith connected in three field books. The following is the order in which the levels are recorded in the books:—

Book A—

1. Levels from Miller's tank No. 1 to Halsur (lower) tank weir.
2. Levels between Halsur (lower) tank weir and the B.M. on rock engine-house; between this last and the zero of tank gauge, and between the latter and crest of upper tank weir.
3. Levels from Halsur lower tank for a supply channel to the eastward with check levels between third and fifth milestones of road.
4. Levels from the end of contour for channel up water-shed northwards, and then along water-shed westwards to junction with eastern water-shed of Halsur tanks.
5. Levels along northern water-shed of Halsur tanks.
6. Levels of Miller's tanks Nos. 1 to 4.
7. Levels from South Station Hospital along water-course to southward, on water-shed of the valley, and to Agram tank waste weir.
8. Levels across the greater bends of the contour for eastern supply channel—Halsur tank.
9. Contour levels of the Agram tank, with levels of wells, &c., near thereto.
10. Levels from Subadar's chattram northward along the water-shed between the Pinakini and Arkavatti rivers.

Book B—

11. Continuation of do.
12. Levels from Melekote tank to a B.M. on the above, No. 11.
13. Check levels from Agram tank to the B.M. on South Station Hospital.
14. Cross sections of Agram tank bund.
15. Check levels from South Station Hospital to Halsur tank and back to hospital.
16. Check levels from B.M. at Subadar's chattram to west and east waste weirs of the Ooparhalli reservoir, and thence to P.W.D. B.M., 10, opposite railway station.

6. The levels of the first set are wrong. They make the weir of Miller's No. 1 tank to be 69·58 feet above the Halsur lower tank weir, and by set 6 the level of the former weir is 27·31 feet below the Public Works Department bench-mark, 10, opposite the cantonment railway station.

The resulting reduced value would be 96·89 + (2929·97 — 0·09) = 96·89 + 2929·88 = 3026·77

The G.T.S. value of the B.M., 10, Public Works Department, is .. .. .. 3021·30

Difference .. 5·47

In the Mysore Public Works office the value of Miller's No. 1 tank weir is 63·21 + 2929·97, to which adding 27·31 the Public Works Department B.M., 10, would be 3020·49, or 0·81 lower than the G.T.S. value.

It may therefore be concluded that Miller's No. 1 tank weir is 3021·30 — 27·31 = say, 2994·00, and that No. 1 set of levels is valueless.

In the levels, set 16, which connect the G.T.S. bench-mark at Subadar's chattram with the weirs of the new (Ooparhalli) reservoir and the Public Works Department B.M., 10, the value of the latter is shown as 3020·68, or 0·62 lower than the G.T.S. value of this B.M. This confirms the general correctness of the levels. The levels of the weirs have already been referred to in paragraph 3 above.

7. No. 2 set needs no explanation.

The value of the zero of the Halsur lower tank gauge is .. .. 2929·97

and that of the B.M. on the rock engine-house .. .. 2941·92

8. The levels of No. 3 set have been checked in two ways — first by a line between the third and fifth milestones of the road and, secondly, by a junction line along the east water-shed of the Halsur tanks to the upper tank weir.

2438

68·21	
50·00 *dd*	
18·21	
2929·97	
2948·18	

The channel contour levels to B.M. on the fifth milestone made the value of the latter .. .. 2948·18

the check levels do. .. .. .. 2948·73

a difference of 0·55 feet, which in nearly 9 miles is unimportant.

The continuation to Halsur upper tank weir showed a difference of only—0·16 feet, the start being from the higher value of the fifth milestone above given. The fourth set are included in the above.

9. In the fifth set the levels ended at the mantapam near the G.T.S. base line station (book, page 33) with a value of .. 238·74

or R.L. .. .. 3118·71

238·74	
50·00 *dd*	
188·74	
2929·97	
3118·71	

The G.T.S. value of the floor of the mantapam is .. .. 3116·90

Difference .. 1·81

There is no G.T. bench-mark discoverable on the floor, so it is doubtful whether the levels are to the same point. The error if it be as shown is not of importance, as all the material levels have been determined.

10. The sixth set of levels are not needed in connection with any of the proposals for the supply of Bangalore.

The weir of Miller's No. 1 tank is as before mentioned	2994·00
" " 2 tank	2991·35
" " 3 tank	No weir.
" " 4 tank (lowest)	2975·59

11. The seventh set of levels makes the difference between the B.M. on the south corner of cavalry part of South Station Hospital and the waste weir of Agram tank 77·13 feet.

Also sets 13 and 15.
2948·85 — 2871·72.
2949·02 — 2871·72.
* Set 15.

The check levels, set 13, make this difference 77·30 feet.

The check levels* from South Station Hospital to Halsur tank weir B.M. show the difference of level to be 20·52 feet, or to zero of gauge 20·43 feet.

2948·85 — 2928·33.

The return levels, from the B.M. on rock engine-house, make the difference 20·51 feet.

2950·48 — 2929·97.

The B.M. on South Station Hospital was originally taken, by mistake, to be at Lieutenant Romilly's value for the floor of the hospital on which, however, it is not situated, but is 0·96 feet above the floor.

The reduced value of the B.M. on the hospital is now taken to be 2950·48, and this raises the value of the Agram tank weir to 2873·35. Lieutenant Romilly's levels for this hospital floor appear to be wrong by (2950·48 — 0·96) — (30·38 — 11·50 + 2929·97) = 2949·52 — 2948·85 = 0·67, but the particular part of the floor referred to in his section is not known.

12. The levels, set 8, deal only with a detail, and in laying out the channel the alignment would be made as desired.

13. The levels of set 9 have not been connected or checked. The orders were to contour the tank and connect the two ends by levels along the bund. The water in the tank was but little below full tank level, as the levels were taken on the 4th February, and on the 29th January the water was 0·20 below full tank level, which is taken at 0·10 foot above the lowest part of the crest of the weir, which latter is higher at the ends than in the middle.

14. *Levels, sets* 10 *and* 11.—The levels along the water-shed to Nandidrug, southern spur, have not been checked. There are many levels along this line shown on the topographical survey, and as Mr. Andrews took levels to many stones bearing numbers it was hoped that these were the stones to which the levels shown on the survey referred.

As far as can be ascertained Mr. Andrews' levels have no connection with any of the topographical levels shown against a △, and in only two cases does it seem probable that with the latter levels placed against a dot has a connection been made.

These latter are B.Ms. on stones marked—

Feet.	Mr. Andrews' values.	Topographical Survey.
37		
85 at 68,451	3071·71	3,068
43		
64 at 89,262	3079·16	3,083

53

and it will be seen that the difference is *plus* in the one case and *minus* in the other. The two sets of levels should probably differ by 4·74 feet—*vide* note at foot of sheet 42 of the survey.

If the idea of bringing water from Nandidrug should be entertained, check levels will be essential, and there are numerous B.Ms. which will admit of check being effected mile by mile.

MEMORANDUM of G.T. Survey bench-marks at or near Bangalore as determined by spirit levelling brought from approximate sea level * at Karwar (North Canara) in 1875 and previously.

	Height in feet above sea level.
1. Uyal-dinne Observatory, 25 yards north-west of the old mantapam about 2¼ miles out, on the Nandidrug and Bellary roads; brass (⊙) mark 5 inches below the stone floor (see G.T.S. of India, spirit levelled heights, No. 2 S.G.)	3113·26
NOTE.—The lower (⊙) mark defining the S.W. end of the Bangalore base line (measured in 1868) is 3 feet plump below this ..	
2. Plinth outside doorway of above, north side, about ground level.	3113·63
3. Floor of the mantapam on top of the mound	3116·9
4. Lowest step at base of the Chief Commissioner's flag-staff (350 yards N.N.W. of public offices) about ground level. (A new flag-staff has been set up since)	3042
5. St. Andrew's Church, top step of central entrance under the tower (which is 80 feet high)	3006·42
6. Cistern of barometer 2·8 feet above floor of meteorological room at the (Bowring) Civil Hospital	2980·9
7. Flooring of the covered well under the new market clock tower of 1863 in the cantonment bazaar (just outside the parapet wall)	2955·5
8. Public Works Department bench-mark No. 10 $\left(\frac{\text{B.M.}}{10.}\right)$ at the (cantonment) railway station, across the road and opposite the Central or Booking office	3021·3
9. Madras Railway B.M. on coping stone at east end of south or arrival platform (cantonment station)	3025·91

* Mean sea level at Karwar was determined by a series of observations, but is still called "approximate" until the results obtained from the record of a self-registering tide gauge have been reduced. It is probably within a few inches of the true value.

NOTE.—The Madras Railway levelled value of this last point, as derived by spirit levelling from the D.P.W. B.M. in ditch at N. gate of Fort St. George, Madras (giving Colonel De Havilland's value of mean sea level) = 3033·97 feet or 8·06 feet higher than above given.

The G.T. Survey preliminary trigonometrical values are 4·4 feet greater than the spirit levelled heights given above.

(Signed) B. R. BRANFILL, Lt.-Col.,
Dy. Supt., Survey of India, in charge
Madras Party.

Sheet no 57
B/Cant Sheet
Reserve

2438

GOVERNMENT OF MADRAS.

PUBLIC WORKS DEPARTMENT.

Buildings and Roads.
Military Works.

READ—the following papers:—

Report on the Bangalore Water Supply by Colonel J. Mullins, R.E., Chief Engineer, on Special Duty, dated 31st March 1884.

Note by Chief Engineer, Public Works Department.

In this complete report, Colonel Mullins disposes conclusively of the various matters referred to him for investigation in connection with the water-supply of Bangalore.

2. The results are summed in paragraph 51 of the report, and may be briefly stated as follows:—

(1) The Ooparhalli project is incapable of supplying the station or the troops.
(2) The Halsur tanks are not capable of being made a satisfactory source of supply for the troops.
(3) Wells may be sunk which would yield a sufficient supply for the troops for drinking and cooking purposes, but the quality of the water must remain doubtful.
(4) The Agaram tank offers a new source of supply of suitable water, having an ample and sufficiently clean catchment basin.
(5) Water of unexceptionable quality is probably obtainable at Bangalore only by distillation.

3. Allusion is also made in the report to the possibility of supplying Bangalore by gravitation from a reservoir to be constructed near Nundidroog; but the expense would probably be prohibitive, being roughly estimated at from 25 to 29 lakhs of rupees.

The conclusions arrived at on these points may, I think, be accepted.

4. With respect to the Ooparhalli project, Colonel Mullins has apparently not noticed General Sankey's proposal to supplement the supply by sinking a line of wells below the bund of the reservoir, by means of which the leakage from the reservoir and the sub-soil drainage would be caught and pumped, to be distributed by gravitation. The omission may prove to be of importance with respect to the civil station, but not with respect to the troops; for Colonel Mullins' investigations have placed beyond doubt that the troops could not be properly supplied from the tail end of the Ooparhalli source, however enlarged and improved.

5. The proposed supply of the troops from the Agaram tank, the water from which is reported by the Chemical Examiner to be "usable," is estimated to cost Rs. 2,20,000 if the water is drawn direct from the tank, and Rs. 1,88,000 if water is taken from a well within the influence of the tank; but Rs. 13,000 should be added to the last-named sum, as enlargement of the tank is apparently advocated even if the supply is pumped from the well.

6. These amounts do not include compensation. It is not clear whether any would be necessary.

57

7. This source of supply seems to offer the most promising, if not the only practicable solution of the difficult question of water-supply to the Bangalore garrison; and I am of opinion that it would be well to appoint a qualified officer for the special duty of elaborating the scheme in the necessary detail and of preparing plans and estimates. This would, of course, have to be done in communication with the Mysore Government.

8. In paragraph 46 of his report, Colonel Mullins remarks that, to avoid the expense and complication of artificial filtration, "in any case it would be desirable to have an experimental well sunk in the bed of the tank to test, through the water therefrom drawn, the character of the soil through which the water has filtered, and its effect upon the potable qualities of the supply." This should be done; although I greatly doubt the possibility of dispensing with artificial filtration in the case of the Agaram tank water.

OOTACAMUND,
23rd May 1884.

(Signed) J. SHAW-STEWART, Col., R.E.,
Chief Engineer, P.W.D.

ORDER—dated 13th June 1884, No. 1473 W., Public Works.

His Excellency the Governor in Council concurs in the opinion that the Agaram tank scheme offers the most promising solution of the question of water-supply to the Bangalore garrison, which has been so exhaustively treated in the report by Colonel Mullins recorded above. A qualified officer will therefore be appointed to elaborate the scheme and prepare the requisite plans and estimates.

2. Captain Romilly, R.E., at present employed in the B Project division, has been recommended by the Chief Engineer for the duty, and he will accordingly be directed by the Superintending Engineer, IV Circle, to proceed to Bangalore as early as practicable, and to make the requisite preliminary arrangements in communication with the officers of the Mysore Government.

3. The suggestion in paragraph 46 of Colonel Mullins' report, for sinking an experimental well in the tank-bed in order to test the character of the soil and its effect upon the potable qualities of the supply, should receive proper attention.

4. His Excellency the Governor in Council desires to place upon record his appreciation of the thorough manner in which Colonel Mullins has so ably discharged the duty intrusted to him, forming a fitting termination to his long and arduous labors in the service of the State in the Public Works Department of this presidency.

5. The Mysore Government will be furnished with a copy of these proceedings, and they will be requested to facilitate the proposed inquiry.

(Here enter No. 1474 W., dated 13th June 1884.)

(True Extract.)

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

To the Superintending Engineer, V Circle.
" " " IV Circle, with plans, &c., and a copy of Colonel Mullins' report to be handed to Captain Romilly.
" Military Department.
To Colonel Mullins, R.E.
To the Examiner, Public Works Accounts.

Exd. E. Fernandez.
Spare Copies

BUILDINGS AND ROADS.
MILITARY WORKS.

Govt. of {1884} Madras.

PUBLIC WORKS.

Dated June, 13th.

Read. *Encl.*

G.O., 13th June 1884, No. 1473 W.

JUNE.

Bangalore Water Supply

Orders on Colonel J. Mullins' report on the —.

2438

GOVERNMENT OF MADRAS.

PUBLIC WORKS DEPARTMENT.

Buildings and Roads.
Military Works.

Read—the following paper:—

Note by the Chief Engineer, Public Works Department, dated 22nd July 1884.

Order—dated 25th July 1884, No. 1814 W., Public Works.

In continuation of the instructions conveyed in G.O., dated 13th June 1884, No. 1473 W., Captain Romilly will now be directed to include in his investigations the alternative scheme suggested by Colonel Mullins in paragraph 50 of his report, namely, for condensing a supply of water from the dhobies' wells sufficient to meet the requirements of the troops for all drinking and cooking purposes; leaving the water required for all other purposes to be pumped from the Halsur tank.

2. In connection with this alternative scheme Captain Romilly will also be directed to investigate the suggestions made in paragraph 34 of Colonel Mullins' report, for taking in an area of additional gathering ground to the eastward of the Halsur tank. The amount of compensation which would be rendered necessary should be carefully calculated and entered in the estimate of cost.

3. The estimate for the Agaram tank scheme should not only include compensation for the land which must be swamped by raising the tank level 3 feet, as proposed by Colonel Mullins, but should also include compensation for all the land at present irrigated under the tank, as it appears probable that all such cultivation would have to be stopped in the event of the Agaram tank scheme being adopted.

4. It appears to be beyond doubt that any water supplied from the Agaram tank would require to be purified by artificial filtration, and the sinking of an experimental well, referred to in paragraph 3 of G.O., dated 13th June 1884, No. 1473 W., may therefore be omitted.

(True Extract.)

Major, R.E.,
Under Secy. to Govt., P.W.D.

To the Superintending Engineer, V Circle.
„ Military Department.

Exd. E. Fernandez.
Spare Copies

BUILDINGS AND ROADS.
MILITARY WORKS.

Govt. of [1884] Madras.

PUBLIC WORKS.

Dated July, 25th.

Recd.

Encl.

G.O., 25th July 1884, No. 1814 W.

JULY.

Bangalore Water Supply

Further instructions issued to Captain Romilly, R.E., in connection with the schemes for the —.

1814 W

2438

W

I have addressed the accompanying G.O. to the S.E.V Circle as Capt^n Romilly is now at Bangalore.

Ed

23/7/84

Noted

Secretary

P.W. Department

2438

Note

my recent visit to Bangalore,
the existing arrangements
ply to the troops, and in=
the various schemes for im=
ich have been suggested
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to the conclusion that the
,000, at which Colonel
oximately estimated the
garam tank scheme, must
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ensate the holders of the
ould be swamped by raising
6 3 feet, as proposed. Besides
w level at which the water
was standing on the date
ou, raised the question
uld not be necessary to
all cultivation below
which case another large

Copy of this should go to Captain Romilly (through S.E. IV) in continuation of G.O. dated 25.7.84 W. 1814 W, and for careful consideration of the objections urged by the Mil: Authorities to the alternative scheme for condensation at the Ghokies' wells.

2438 W.

15.4.84

75A.

C/91/80

P.W. Department

2438

Note

...g my recent visit to Bangalore, ...the existing arrangements ...pply to the troops, and in= ...the various schemes for im= ...which have been suggested ...ullins.

...to the conclusion that the ...20,000, at which Colonel ...proximately estimated the ...agaram tank scheme, must ...bility be largely added to in ...pensate the holders of the ...would be swamped by raising ...vel 3 feet, as proposed. Besides ...low level at which the water ...was standing on the date ...tion, raised the question ...would not be necessary to ...to all cultivation below ...in which case another large

P.W. Department

2438

Note

During my recent visit to Bangalore, I inspected the existing arrangements for water-supply to the troops, and investigated the various schemes for improving it which have been suggested by Colonel Mullins.

I came to the conclusion that the sum of Rs 2,20,000, at which Colonel Mullins approximately estimated the cost of the Agaram tank scheme, must in all probability be largely added to in order to compensate the holders of the land which would be swamped by raising the water level 3 feet, as proposed. Besides which, the low level at which the water in the tank was standing on the date of my inspection, raised the question whether it would not be necessary to put a stop to all cultivation below the tank, in which case another large

sum would have to be added to the estimates, to represent the further compensation necessary.

After careful consideration of the general question I came to the con= =clusion that it would be desirable for Captain Romilly to include in his investigations the alternative scheme suggested in para 50 of Colonel Mullins's report, namely, for condensing a supply from the Dholies' wells sufficient to meet the requirements of the troops for drinking and cooking purposes; leaving water for all other purposes to be pumped from the Halsur tank.

Colonel Mullins has remarked that water of unexceptionable quality is pro= =bably obtainable at Bangalore only by distillation; and it appears not impossible that such supply could be provided at a cost not in excess of that which the Agaram tank scheme will involve. In any case it is desirable that the Government should be in a position to compare the merits of the two schemes.

2438

The inspection which I was able to make placed it beyond doubt that, if the Agaram tank scheme be accepted, it will be necessary to have recourse to artificial filtration; and the sinking of the experimental well, suggested by Col: Mullins in para 46 of his report, may therefore be omitted.

V. Maistland

Col. RE.

Ootacamund
25 July 1884

Chief Engineer P.W.D

67/67

9

1814 W.

I W Dept

No 6734 d/ 15/9/84

2438

Endorsement on the Military Department
No. 4497 d/ 12th September 1884. on letter
from the Quarter Master General No. 7650
d/ 20th August 1884.

Copy forwarded to Captain
Romilly RE, through the Superintending
Engineer V Circle, in continuation of Go
d/ 25th July 1884 No 1814 W.

The objections urged by the
Military authorities to the alternative
scheme for condensation at the Dholies'
wells should be carefully considered,
and dealt with in the report under
preparation

(Sd) J. Shaw Stewart Colonel
RE
Secy to Govt. I W D.

To Captain F. J Romilly. RE. 79
Thro. The Superintending Engineer
V Circle

Dept 15/9/84 69
63

Water supply
Bangalore

Quarter Master General's Office
Ootacamund
20th August 1884

No. 768-C 2438

From The Quarter Master General
To The Secretary to Government
Military Department

Sir

The Commander-in-Chief has perused order of Government No. 1814 70 Public Works, dated 25th July 1884, relating to the Bangalore water supply, which was communicated to His Excellency with G.O No. 3012 dated 7th August 1884, and which provides for consideration of the alternative scheme suggested by Colonel Mullins R. E. for condensing a supply of water from the Dhobies' wells at Bangalore, sufficient to meet the requirements of the troops for all drinking and cooking purposes.

2. The Commander-in-Chief cannot too

too strongly deprecate the entertainment of any measure which would tend to perpetuate the use of the waters of the Ulsoor Sank, and His Excellency desires me to say he hopes the Government will support him in the opinion he has already expressed that the Ulsoor Sank should be entirely abandoned as a source of supply of water.

3. I am herewith to forward for the perusal of Government, a letter on this subject (Nº and date as per margin), re {Nº 190 dated 10th August 1870} from the Surgeon General Her Majesty's Forces, and to express the Commander-in-Chief's entire concurrence in the views therein contained

4. However pure the water may become after condensation, it must be remembered that the water drawn from the Ulsoor Sank for all purposes besides that of cooking and drinking must reach the Barracks by the same means, and

and through the same pipes as the pure water, and the difficulties of preventing men and families from using the impure water would, in His Excellency's opinion, be insurmountable. 2438

5. It would, moreover, be extremely dangerous to rely on a single condensing apparatus for supplying pure water, there being no source to fall back upon in case of accident, except that which has been universally condemned.

6. This question of water supply at Bangalore has been for many years under discussion, and it has at last arrived at a stage at which a solution seems possible - An experienced Officer has reported on the feasibility of a scheme which is calculated to afford a pure supply of water, and His Excellency trusts Government will concur with him in thinking it exceedingly [illegible] impolitic

impolitic to consider any scheme which contains the retention of the Lesser Sank as a source of supply.

I have the honor to be &c

(Signed) R. C. Stewart. Brigr: Genl:
Quarter Master General

2438

69/60 78

15 SEP 84
PUBLIC WORKS DEPARTMENT

No 4497 Transferred to the Public Works Dept for consideration & orders.

[illegible] orders

A. Kennedy Lieut
Offg: Secy to Govt
12 Sept 1884.

OLS 52/9

Buildings & Roads
Irrig. P.W. Dept

A

No 1814 W

Proceedings of the Madras Govt

2438

Under date the 25th July 84.

Read the following

Letter from the Chief Engr P.W. Dept dt July 22nd 1884

In continuation of the instructions conveyed in G.O. dated 13th June 1884, No 1473 W, Capt Romilly will now be directed to include in his investigations the alternative scheme suggested by Col: Mullins in paragraph 50 of his report, namely, for condensing a supply of water from the Dhobies' Well sufficient to meet the requirements of the troops for all drinking and cooking purposes; leaving the water required for all other purposes to be pumped

omitted.

Urgent

22-7-84

Copy in mail to go today to S.E. Div

Despd in mail 25.7.84

Secret

Supply Engr Corps
Army Depts

3

2438

7069 63

Govt. of [1884] Madras.

PUBLIC WORKS.

Dated

Rec'd

Encl.

G.O., 25 July 1884, No. 1814 W

Daily Return wanted
Supply

Further instructions
issued to Captain
Romelly RE in Connection
with the Schemes
for the

C.E. 20
G.O. 6-9-84.

3

Surgeon General's Office,
Her Mo Forces,
Head Qrs, Ootacamund,
18th August 1884

No 1810
O

From,
The Surgeon General,
Her Mo Forces.

2438

To,
The Quarter Master General,
Ootacamund.

Sir,

I have the honor, with reference to GO No 1814 W dated 25th July, 1884, to remark as follows for the information of His Excellency the Commander-in-Chief.

2. In para 1 of the above, the alternative scheme is alluded to; viz, that for supplying drinking water from the Shobies' Wells by condensation, while for ablution purposes, water is to be drawn from the Ulsoor Tank. With reference to this, I beg to point out to His Excellency, that the dual supply here proposed for the use of the men, is in my opinion objectionable. It will be very difficult, if not impossible, to prevent men from making use of the impure ablution water

for

for drinking purposes. Enteric fever has been very prevalent amongst the Cavalry and artillery during the present year, and since the occurrence of rain, there has been a renewed outbreak of the disease in the Infantry regiment, there being at the present time as many as thirteen cases under treatment in the Worth Station Hospital

3. In connection with this matter, I beg to remark that as regards the Dhobies' Wells' supply, I do not consider that the large Natural filtration of this water through the Laterite Bank, is any safeguard against such subtle impurities as the germs of Typhoid, or any other contagious fever. It is well known that the enteric fever poison has passed from village to village in England by means of water, which has filtered naturally through long distances of solid earth, and I allude to the subject, particularly, at the present time to show that, in the event of the condensing apparatus breaking down hereafter

hereafter, the garrison would be dependent for its water upon the Dhobies' Wells, a supply which would be dangerous to health.

2438

4. I therefore beg to represent the great need for a supply of pure water being provided for the garrison of Bangalore; and this end can, I believe, be best attained by the abandonment of the Ulsoor Tank altogether and the adoption of the Agaram Tank scheme.

I have the honor to be,
Sir
Your most obedt Servt
C.D. Madden
Surgeon General & Mt Officer

75
22
71

Water Supply
Bangalore.—
Forwards following letter—

Recommends the
abandonment of the
Ulsoor Tank & adoption
of the 2 alternative schemes
Sprague Tank Scheme for
preference under the
circumstances of Bangalore.

28 Sept 1884 No 2438 Pol

QUARTERMASTER-GENERAL'S OFFICE

Ootacamund,

18th September 1884.

No. 981. C

2438

From

THE QUARTERMASTER-GENERAL,

To

THE Secretary to Government
Military Department.

SIR,

I have the honor by order to submit for the consideration of Government letter No: 349, dated 30th August 1884, from the General Officer Commanding Bangalore Division requesting the publication of the analysis of 3 samples of water taken on the 21st August 1883, from the sources as per margin and to state that His Excellency the Commander-in-Chief sees no objection to the analysis being published.—

I. Direct from Ulsoor Tank
II. After passing thro' the filter bed.
III. Dhoby's Wells.

I have the honor to be
Sir
Your obedient Servant

[signature]
Brigr. General
Quarter Master General.

Bangalore

S.H.

23/9/2

M.D.A.2-82-785

C.6.9.84.

GENERAL LIBRARY
OF THE
UNIVERSITY OF CALIFORNIA

Flh

PG 30 June/84 Nos. 472-475 &c.
Rc 673 E dy 15-9-84
Go. 1814 W dy 25-7-84
" 1473 W dy 13-6-84

p 8

No. 4665 Transferred to the Public Works Dept.
(Reporter)
A. Kennedy Herbert Lt. R.E.
Offg. Secy. to Govt.
19 Sept 1884.

Military 1884, Deptt

No 4871

From The Q. M. General
To The Secy to Govt
M.D.

Dated 18
Rec'd 19 September

No 981. C.

Forwarding for publication an analysis of 3 Samples of water from the Ulsoor Tank & Dhobys Wells.

Analysis. Forwarded. 8/p 2
Drinking Water

Head Quarters, Bangalore Division.

BANGALORE 30th August 1884.

No 349.

2436

From

MAJOR-GENERAL HUGH ROWLANDS, V.C. C.B.

Commanding Bangalore Division.

To

The Quartermaster General

Cotacamund.

Sir,

I have the honor to forward letter No: 202, dated August 27, 1884, from the Engineer in charge Kolar Water Works with copies of analysis of 3 samples of water, taken on May 9, 1883, and on August 24, 1883.

2. The analysis of the water taken on Rea[illegible] 6, appears in the report on the water supply of Bangalore, by the Chief Engineer on special duty, dated March 31, 1884, as shown in appendix No: 26 B. p. 95 of that report; The three different Samples of this water are re-ported as "bad".

PG. No 1473 W. 3 16 Aug 84.

3. But the three Samples of water taken

Taken on 24th August 1883, from the
Same Sources, is reported by the Che-
-mical Examiner to be Nos: I "bad"
Nos: II and III "usable"; this analysis
does not appear in the Report alluded
to-

I have, therefore, the honor to so- 4.
-licit the publication of the analysis
of the water taken on August 24, 1883-

I have the honor to be,
Sir,
Your obedient Servant,
Hugh Rowland
Surgeon Genl:
Commanding Bengal Dn.

2438

88
78 26 75

From
The Major General
Comdg. Bang. Divn
Bangalore

To
The D.A.G.
Ootacamund

No 249

Dated 2nd
Rec'd } August 1883

Copies of Analysis of
3 Samples of Water
taken on 9th May 1883
and 23rd August 1883

OFFICE OF THE MAJOR GENERAL'S OFFICE
RECEIVED 4 SEP 83
DIV. No. 225

No 54871/83

Ulsoor Water Works Off
Bangalore 27th August 1883

No. 202.

To.
The Asst. Dy. Mr. General
Bangalore Division

2438

Sir,

I have the honor to enclose for your information, a copy of the Analysis of 3 samples of water taken on the 9th May 1883. and shown in Appendix No. 26B of the report on the water supply of Bangalore, by the Chief Engineer on Special duty, dated 31st March 1884.

It will be seen from this Analysis that the water is stated to be bad. This was probably owing to the long drought which prevailed at that time, only 1/2 an inch of water having been received into the Tank for upwards of 4 months before these samples were taken, as also to the water in the Tank being very low, Viz 5 feet 11/4 inches below the

the level of the waste weir, and to the large quantity of water being used at that time, Viz 72,249 gallons per diem.

I also beg to enclose a copy of the Analysis of 3 samples of water, taken from the same places, as those above alluded to, on the 24th. Augt. 1883. or 3½ months later, and after the Tank had received 18⅜ inches of fresh water, which shows that the water taken after passing through the Filter bed, No. 3. and that taken from the Dholys' No. 2. Wells was usable. The quantity of water used at this time being 52,144 gallons per diem.

As this Analysis does not appear in the report above alluded to. I would respectfully submit that in fairness to [illegible]eral quality of this water, the Analysis of the samples of Water taken on the 24th. Augt. 1883. should be made as well known, as the Analysis of the samples of water taken on the 9th. of May 1883. and published in the Chief Engineer's report of 31st. March 1884.

I have the honor to be
Sir
Your Most obedt. Servt.
J. Smith
Engineer in charge
Ulsoor Water Works.

2438.

	1	2	3	
	Sample of water taken direct from the Ellsore Tank.	Sample of water taken direct after passing through the filter bed.	Sample of water taken direct from the Whobjs Wells.	
Total solids ---------- Grms per litre ----------	0.27.	0.26	0.23	
Volatile solids ---------- do do ----------	0.12	0.06	0.09.	
Chlorine ---------- do do ----------	0.081	0.078	0.053	
Total hardness ---------- Clark's scale ----------	3°.5	2°.8	3°.86	
Permanent hardness ---------- do do ----------	2°.45	1°.75	3°.15	
Free ammonia ---------- Mlgrms per litre ----------	0.4	0.48	0.08	
Albumenoid ammonia ---------- do do ----------	0.56	0.48	0.8	
Nitric acid ---------- do do ----------	3.0	3.0	3.3	
Remarks. Apparent quality of the water as inferred from the results obtained on examination	bad	bad	bad	

Remarks.

Taken 9th May 1883

No. 1. Deposit abundant, and composed of vegetable debris.

No. 2. Deposit, scanty and composed of vegetable debris and Argillaceous matter

No. 3. Deposit scanty and composed of vegetable debris

All three samples contain a very large amount of Organic impurity.

(True Copy)

L. H. Eyre Lieut Col.

Offg Dy Dr. Mr. General.

	№ I	№ II	№ III	Remarks.
Total Solids — Grms. per litre	0·27	0·25	0·31	№ I — A sample of water taken
Volatile Solids — do — do	0·08	0·07	0·08	direct from the (Ulsoor) Tank at 4 P.M.
Chlorine — do — do	0·085	0·042	0·089	on the 24th August 1883.
Total hardness — Clarks Scale	2°8	2°45	3°5	№ II — A sample of water taken
Permanent hardness — do — do	1°4	1°75	1°75	direct from the Dhobys Wells.
Free ammonia — Mlgrms per litre	0·12	0·24	0·48	on the 24th Augt 1883.
Albumenoid ammonia — do — do	1·92	0·4	0·48	№ III — A Sample of water
Nitric acid — do — do-(as ammonia)	0·75	2·4	2·4	taken direct from the Ulsoor
				Tank water after passing thro'
				the filter bed on the 24-8-83.
Apparent quality of the water as inferred from the results obtained on examination	Bad	Usable	Usable	

Remarks № I — A very abundant deposit composed of vegetable debris.
— " — № II — A scanty deposit composed of vegetable debris and sand.
— " — № III — A very scanty deposit composed of vegetable debris & Argillaceous matter.
— " — № II — is the best Sample.

(True Copy) J. Smith

1884

From

The Chem.r Exr.
Madras

No. 2084
5th August 1884.

To

The Engr. in ch=
Ulsoor Water Works
Bangalore

Your Letter N169 of
4th August 1884.

Subject

Has the honor to for=
ward copy of Analysis
of 3 samples of water received
on the 25th September 1883.
with the Asst. Dr. Mr. Genl's
letter No. 2849 dy 24th Sept. 182.

Sig. Chris J. McNally
Dr. D.
Chemical Examiner

PUBLIC WORKS DEPARTMENT.

PROCEEDINGS OF THE MADRAS GOVERNMENT.

UNDER date the

READ the following

From

The Quarter Master Genl. (M.G. No. 981 C of 18th Sept. 1884)

Endorsement in the Military Dept. (— 4665 of 19th ——)

Recorded, in continuation of Go. 1473 W of 13th June 1884.

Supg. Engineer V Circle
Military Dept.

2438/81

R233

Govt. of (1884) Madras.

PUBLIC WORKS.

81

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G.O., 2 Oct 1884 No. 24

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Engineer

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Estimate

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