M.R.O. 1—32,400—22-11-89.

MADRAS RECORD OFFICE.

Government of Madras.

Public Works **DEPARTMENT.**

Irrigation Branch

G.O. No. 603-04-05 Press

Irrigation

Dated 2nd August 1882

Not to be folded or roughly handled

GOVERNMENT OF MADRAS.

PUBLIC WORKS DEPARTMENT.

Irrigation.

No. 13.

READ—the following Note by the Acting Chief Engineer for Irrigation, dated Ootacamund, 24th July 1882, No. 68 I. :—

The accompanying Monograph on the Madras Water-supply and Irrigation Extension Project, compiled by Mr. Vincent, under instructions by Colonel Mullins, has been prepared in compliance with letter No. 159 M., dated 23rd May 1881, from the Assistant Secretary to the Government of India, and is submitted to Government.

(Signed) J. O. HASTED, Colonel, R.E.,
Ag. Chief Engr. for Irrigation.

To the Joint Secretary to Government, Public Works Department, Irrigation Branch.

No. 14.

ORDER—dated 2nd August 1882, No. 603 I., Public Works.

Ordered that the Monograph on the Madras Water-supply and Irrigation Extension Project be forwarded to the Government of India, with reference to their letter No. 159 M., dated 23rd May 1881.

2. Ordered also that a copy of these Proceedings be forwarded for the information of the Secretary of State.

(True Extract.)

(Signed) J. O. HASTED, Colonel, R.E.,
Ag. Joint Secy. to Govt., P.W.D.,
Irrigation Branch.

To the Chief Engineer for Irrigation.
" Superintending Engineer, Fifth Circle.
" Examiner of Public Works Accounts.
" Financial Department.
" Revenue do.
" Board of Revenue.

No. 15.

ENDORSEMENT—dated 2nd August 1882, No. 604 I., Public Works.

Forwarded to the Government of India.

(Signed) J. O. HASTED, Colonel, R.E.,
Ag. Joint Secy. to Govt., P.W.D.,
Irrigation Branch.

Exd. S. T. Austin.
Spare Copies

IRRIGATION.

Govt. of {1882} Madras.

PUBLIC WORKS.

Dated August, 2nd.

Recd. *Encl.*

G.O., 2nd August 1882, No. 604 I.

AUGUST.

Nos. 13—15.

Madras Water-supply.

Monograph on the — and Irrigation Extension Project.

PUBLIC WORKS DEPARTMENT.

LETTER—to

THE MOST HONORABLE THE SECRETARY OF STATE FOR INDIA.

MY LORD MARQUIS,

We have the honor to forward for your Lordship's information a Monograph on the Madras Water-supply and Irrigation Extension Project.

We have the honor to be,
My Lord Marquis,
Your Lordship's most obedient, humble servants,

(Signed) M. E. GRANT DUFF.
(„) FRED. ROBERTS.
(„) DAVID F. CARMICHAEL.
(„) H. E. SULLIVAN.

OOTACAMUND,
2nd August 1882.

Exd. S. T. Austin.

GOVT. OF MADRAS.

PUBLIC WORKS DEPARTMENT.

LETTER to the Most Honorable the Secretary of State for India.

No. $\frac{33}{605}$ I., dated 2nd Aug. 1882.

MONOGRAPH on the Madras Water-supply and Irrigation Extension Project.

MONOGRAPH ON THE MADRAS WATER-SUPPLY AND IRRIGATION EXTENSION PROJECT.

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The following abbreviations have been employed :—

M.W.L. for maximum water level.
F.S.L. „ full supply level.
F.T.L. „ full tank level.
M.S.L. „ mean sea level.

MONOGRAPH ON THE MADRAS WATER-SUPPLY AND IRRIGATION EXTENSION PROJECT. (a)

CHAPTER I.

DESCRIPTION OF THE WORKS AS EXISTING.

MADRAS is supplied with water from a reservoir known as the Red Hills Tank fed by a channel from the river Kortalayár, which passes through a reserve reservoir known as the Cholavaram Tank before it arrives at the Red Hills.

2. The Kortalayár has its origin in the surplus escape of the Kávéripák Tank, which is the principal reservoir fed by the Pálár Anicut. It has a length of about 54 miles above the dam which supplies the Red Hills Reservoir, and of about 22 miles below the dam to its outlet into the sea at Ennore, 7 miles to the north of Madras. The area of drainage basin of the river above the anicut, including that of its principal affluent, the Nagari, which receives the Tirutani, is about 1,105 square miles; but 268 square miles of this area has to be excluded, being that of the drainage basin of the Kortalayár above the Kasavaram dam, which is 30 miles above the Thamarapak Anicut. The water coming down the river is almost all taken off at this point and turned into the Kuam River. This leaves 837 square miles as the area actually drained.* The catchment basin consists chiefly of the hilly country forming the Kárvetnagar Zemindari in the North Arcot District. This country was formerly well wooded, but most of the jungles on the slopes of Nagari Hills have now been cut to furnish firewood for the Madras Railway Company, and as they have not been replanted, the rainfall is said† to have much diminished. The average rainfall on the catchment basin may be taken at about 37‡ inches. The river is in flood during the north-east monsoon, and in an average year runs in full flood for four or five days, then with a flow of about 3 feet for thirty or forty days more, when it subsides to the small summer channel which runs, as a rule, all the year round.

* Mr. Fraser assumed 770 square miles.

† Mr. Fraser's original report.

‡ Averages of five years (1877—81) at the following stations, *vide* sketch map of Catchment Basin :—

Station.	Rainfall. IN.
Tirutani	34·70
Pólúr	37·86
Thamarapakkam	38·25
Kávéripák	33·40
Kasavaram	41·16
General Average ...	37·07

3. The dam is built at a place called Thamarapak, where the normal breadth of the river is about 500 feet. The anicut, however, is 624 feet long, with the crest at 69·86. The foundations consist of two rows of wells, 6 feet outside diameter and about 6 feet deep, on which rests a depth of 4 feet of solid brickwork.

The body wall is 6 feet high, 6 feet broad at the crest, and 7½ feet broad at the level of the top of the foundations, the batter being on the upstream side. On the downstream side there are two aprons; the first, 6 feet below the crest, being 32 feet broad and 4 feet thick; the second at the same level as the first, being 33 feet broad and 2 feet thick. There are eight under-sluices on the south side, each 7 feet × 4 feet, with their sills 6 feet below the crest of the anicut, or at 63·86. The bed-fall of the river averages 3½ feet per mile, and there are embankments on either side upstream and on the south bank downstream. The south embankment above the anicut is 2¾ miles long and the north embankment 2 miles long. In section the banks are 4 feet broad at the top, which is 5 feet above F.S.L. in the river, and have side slopes of 1½ to 1. The bank below the river is of similar section, and is 3,900 feet long.

(a) 1. All levels are in feet and decimals, and are referred to mean sea level, unless the contrary is expressly stated.
2. Volumes are given in cubic feet as a rule, but as until quite lately it was usual to state quantities in cubic yards, these have had to be retained in some cases.

4. The head-sluice to the supply channel has 10 vents, each 5 feet × 5 feet 7 inches, with their sills at the same level as those of the under-sluices. The length of the supply channel from the head-sluice to where it enters the Cholavaram Tank is 8 miles 14* chains. In section it is 30 feet in bottom width, with side slopes of $1\frac{1}{2}$ to 1. The depth of ordinary flow is $2\frac{1}{2}$ feet. The top of the retaining bank on the north side is about $8\frac{1}{2}$ feet above bed-level. The bed-fall of the channel averages 2 feet per mile, and the volume of its discharge at ordinary level is therefore 940† cubic feet per second.

* Of 66 feet.

† Kutter's formulæ.

The number and description of the masonry works between the head-sluice and the Cholavaram Tank are as follow :—

No.	Description.	Distance from Head.	Level above M.S.L.‡
		MS. CHS.	FEET.
1	Inlet, 30 feet long ...	0 20	75·12
2	Bridge (3 vents of 18 feet).	0 55	62·84 (floor)
3	Outlet, Kattankal surplus weir, 147 feet long.	1 60	65·86 (crest) 62·86 (sill)
4	Inlet, $20\frac{3}{4}$ feet long	1 66	67·86
5	Do. 24 do. ...	2 8	67·24
6	Do. 24 do. ...	2 39	65·98
7	Do. 20 do. ...	2 63	64·12
8	Do. 24 do. ...	2 69	63·40
9	Bridge (3 vents of 18 feet).	3 3	58·30 (floor)
10	Inlet, 24 feet long ...	3 26	62·81
11	Do. 20 do. ...	3 44	63·05
12	Do. 24 do. ...	3 68	63·79
14	Old Busikal division ...	4 11	65·23
15	Outlet, Busikal surplus weir, 141 feet long.	4 53	...
16	Rámapuram Bridge ...	4 64	59·69 (crest) 56·69 (sill)
17	Bridge (3 vents of 18 feet).	4 73	56·92
18	Do. (do.)	4 79	54·39
19	Alacheri aqueduct ...	5 55	53·00
		6 12	52·10

‡ These levels are referred to de Haviland's B.M. at Madras, which was taken at 6·83 feet above M.S.L. The correct value is now given as 7·83 feet, but the original level has been retained here for convenience of comparison.

It will be observed that there are ten inlets and two outlets. The Busikal and Kattankal are streams draining 44 square miles and 62 square miles, respectively, and have often breached the supply channel. Estimates for lengthening and improving their outlets have been sanctioned.

5. The total length of the bank of the Cholavaram Tank is 2 miles 22 chains, but the length from where the supply channel enters it to the channel leading to the Red Hills Tank is only 2 miles 5 chains. The top of the bank is 10 feet broad. The inside slope is at 1 to 1 with rough-stone revetment and a parapet wall at the top. The outside slope is at $1\frac{1}{2}$ to 1. The F.T.L. is at 61·68, and the area and contents§ of the tank at this level are respectively 67·21 million square feet and 766·405 million cubic feet. There are two irrigation sluices. The first, called the north sluice, is at 1 mile from the head of the tank, and consists of a vent 3 feet × 4 feet. The head of water over the vent at F.T.L. is 19·85 feet, its level being 41·83. The other sluice is formed by a vent 1 foot × $1\frac{1}{4}$ feet in the body of one of the weirs, 43·84 chains from the head of the tank, with its sill at 52·68 ; there is also a plug 6 inches in diameter at top and 5 inches at bottom.

§ See Chapter IV for fuller details.

There are two weirs. The first is 9 chains from the north end of the tank and 166 feet long, with its crest at 63·62. The second is 43 chains from the same end, 187 feet long, and has its crest at 61·68.

6. The head-sluice to the Red Hills Tank supply channel is, as above stated, at 2 miles 5 chains from the north end, and consists of 10 vents, each 4 feet × 3 feet, with their sills at 45·33 feet. The length of the channel is 2 miles 50 chains to the commencement of the bank of the Red Hills Tank ; the section of the channel is the same as that of the upper supply channel already described. There is a siphon sluice across the channel at 1 mile 25 chains from the head, and a girder bridge of 40 feet span and floor level 39·76, at 2 miles 29 chains.

7. The Red Hills Tank bank begins at the left wing of the north (Mr. Fraser's) weir, and is 3 miles 27 chains long. The section, speaking generally, is the same as that of Cholavaram Tank. The top of the bank is at 52·31, and there is a dry stone wall above this, raising the level to 55·31 along the deeper parts and to 54·31 along those of intermediate depth. The full tank level is at 46·31.* The greatest depth of water against the bank is over the sill of the north sluice, where it is 25·65 feet at F.T.L. There are four irrigation sluices and one sluice for the municipal supply channel in the reservoir.

* Temporarily reduced to 43·31, *vide* paragraph 11, Chapter III.

The following particulars refer to the irrigation sluices :—

No.	Distance from Head of Tank.	Level of Sill.	Description.
	MS. CHS.		
1	15		In surplus weir.
		31·42	One vent 2 feet × 3 feet.
		36·43	Two plugs ; one plug, top diameter $7\frac{3}{4}$ inches, bottom diameter $6\frac{3}{4}$ inches ; other plug, top diameter $8\frac{1}{2}$ inches, bottom diameter $7\frac{1}{2}$ inches.
2	32 34		North sluice.
		20·66	One vent 3 feet × 6 feet.
		30·66	Four plugs, upper diameter 10 inches, lower diameter 9 inches.
		40·66	Four do. do.
3	1 27·07	21·10	Polal sluice.
		30·10	Vent as in No. 2.
		40·10	Four plugs do.
4	3 3·25		Soorapedoo sluice.
		27·31	One vent 3 feet × 4 feet.

† Proceedings of the Madras Government, No. 1038 W., of April 22nd, 1882.

The municipal sluice is at 3 miles 15 chains, and contains six pipes of $2\frac{1}{4}$ diameter each, placed as follows† :—

Three	pipes	with sill at the level of	31·31
One	do.	do.	35·31
One	do.	do.	39·31
One	do.	do.	43·31

The reservoir has one surplus weir at the extreme north end, which is 1401·33 feet long, and has its crest at F.T.L. (46·31). In this weir there is a 10-vented surplus sluice at 21·06 chains, each vent being 6 feet × 6 feet with its sill at 31·31. These sluices, which did not form part of the original design, were deemed‡ necessary as a safeguard owing to the slips which occurred in the bank of the reservoir after it had been raised. The surplus weir is of ample capacity to discharge all the water to be disposed of, but it does not come into action until the water has risen above F.T.L. It was therefore considered to be desirable to provide means for rapidly lowering the water level, should the bank be in danger of giving way, as also to allow of the discharge of surplus without necessitating the rise of the water level in

‡ G.O., No. 2322, of August 11th, 1875.

the reservoir to as great a height above F.T.L. as would be necessary, were all such surplus to be passed over the weir.* The area and contents of the reservoir at F.T.L. are respectively 212·103 million square feet and 2744·8911 million cubic feet. The level of the lowest point of the tank-bed is about 20·00.

* Proceedings, Madras Government, No. 849 I., of December 9th, 1881.

8. The portion of the works outside the Red Hills Reservoir, that is, the Municipal Delivery Channel, are briefly described in Chapter IV, which treats of "The Town Supply of Madras."

CHAPTER II.

IMPORTANT PHASES OF ITS HISTORY.

The question of supplying Madras with an abundance of pure water was one that had occupied the attention of Government for many years before the first definite action was taken on the subject in 1866. Numerous reports and suggestions had been submitted by professional Engineers and others, either under the direct orders of Government, or from having their attention directed to the subject by the constant complaints of the gradually increasing impurity of the water drawn from the wells, which then formed the only source of supply.

The reasons for the deterioration in the quality of the well water were not far to seek. Madras being built on the belt of silicious sand which runs along the Coromandel Coast, it followed as a matter of course that a portion of the filth collected on the surface was, owing to the porous nature of the soil, washed down to the water-bearing strata during every monsoon. The Chemical Examiner to Government, who analysed the water of a very large number of wells, reported that the results showed that, with very few exceptions, the drinking water of Madras was as bad as it possibly could be.

2. The first proposal on the subject was made by Lieutenant (now Major-General) O'Connell, R.E., in 1855, who submitted a scheme estimated to cost Rs. 43,39,476. This provided for an anicut across the Kortalayár at Pushali, some distance above the crossing of the Madras Railway and 3 or 4 miles below the Kasavaram dam, which turns some of the Kortalayár water into the Kuam (or Cooum) River. The supply channel, which was to have been about 28 miles in length, was, in its course to the Red Hills, to supply the following eight tanks: Senji, Pudumavalangai, Kadambatúr, Puttalur, Tannirkulam, Pakkam, Palaveda, and Mittanemali. After supplying these tanks, the surplus water for the supply of Madras was to be stored in the Red Hills Tank, the bank of which was to be raised 9 feet. An open channel was to convey the water from the tank to two basins in Madras, whence it was to be pumped into settling reservoirs, and passed into the mains for distribution. No detailed plans of this scheme were prepared, and there were, according to Mr. Fraser, two vital objections to it—

(1) that virtually, though not admittedly, it made the storing of water for Madras a matter secondary to that of filling the eight irrigation tanks;

(2) that the supply would have been deficient had the channel been taken from the Kortalayár so close to the Kasavaram dam, which is supposed to turn most of the flood and all the summer water of the Kortalayár into the Kuam for the supply of the Chembrumbaukum and other tanks.

No action was taken on Lieutenant O'Connell's proposals, and nothing further was done till October 1861, when the Municipal Commissioners drew attention to and recommended the substantially similar scheme put forward by Mr. Peter Orr, of Madras. Government, in its Proceedings of December 20th, 1861 referred the subject for the consideration of the Public Works Department, and in May 1862 Mr. Roberts, C.E., was appointed to report on the scheme. But with the exception of one trial line of levels Mr. Roberts confined his observations to the ground previously examined by Lieutenant O'Connell. In 1863, however, Mr. Fraser, C.E., suggested† the possibility of improving upon Lieutenant O'Connell's design, and he was forthwith directed to undertake the re-investigation of the whole project.

† Letter No. 1741 of July 2nd, 1863.

3. Mr. Fraser's first report was submitted with his letter, No. 50, of February 26th, 1866, and on 30th April of the same year the Madras Government, when replying to the Budget Orders of the Government of India, intimated* that it was proposed to devote Rs. 1,10,800 "to the project for the storage of water in the Cholavaram and the Red Hills Tank, with a view of increasing the capacity of those reservoirs for irrigation, as well as of providing the city of Madras, its garrison, and public establishments, with an abundant and wholesome supply of water, according to the plans and estimates which have been prepared in full detail by Mr. Fraser, C.E., and have recently received† the approval of this Government."

* Letter No. 1376 of April 30th, 1866.

† In Proceedings, Madras Government, No. 1102, of April 11th, 1866, from which most of the above details have been taken.

4. Mr. Fraser's scheme consisted of—

		Rs.
I.	The construction of a dam across the Kortalayár	30,710
II.	The construction of a channel with head and other sluices, and all requisite works from the anicut to Cholavaram Tank, a distance of 8¼ miles	1,22,055
III.	The enlargement of the capacity of this tank by raising its bank 18 feet	1,38,752
IV.	The construction of a channel with sluices, bridges, &c., from the Cholavaram to the Red Hills Tank, 2¾ miles in length.	65,964
V.	The enlargement of the capacity of this tank by raising its bank 15 feet	1,17,934
VI.	The construction of a channel with its sluices, accommodation bridges, &c., from the Red Hills Tank to the Spur Tank in Madras	28,032
VII.	Sundries, compensation for land and houses, superintendence, &c.	1,33,483
	Total ...	6,36,930

The scheme also contemplated the irrigation of between 8,000 and 9,000 acres of waste land, and it was anticipated that the returns from irrigation alone would suffice to pay a high interest on the estimated outlay.

Sanction to the project was accorded by the Government of India by telegram‡ on July 14th, 1866, and by letter§ on July 19th, 1866, No. 626 C, the total sanction being Rs. 6,11,759, Item VII of Mr. Fraser's estimate being reduced to—

‡ Proceedings, Madras Government, No. 2374, of July 27th, 1866.

§ Proceedings, Madras Government, No. 3298, of October 16th, 1866.

	Rs.
Five per cent. for contingencies	25,172
Compensation for land	83,140
Total ...	1,08,312

5. In the meantime, however, proposals had been sent to the Secretary of State for the carrying out of the works by a private Company, it being considered‖ that the financial prospects were so good that funds would be readily forthcoming. The Secretary of State replied in Despatch No. 22 of 1866, dated November 24th. He considered that the promising nature of the work was rather a reason for not seeking the co-operation of a Financial Company, even had there been any probability, which in the then state of the money market was very doubtful, that any Company would be prepared to co-operate. It appeared to the Secretary of State that if Government took upon itself the irrigation part of the scheme, it could thereby render the mere conveyance of water to a reservoir in Madras

‖ Despatch No. 46 of 1866, dated September 13th.

so profitable a business that it could afford on liberal terms to place the water in the reservoir at the disposal of the Municipality. It would then only remain for the Municipality to construct the distribution works, and if any difficulty were found in raising sufficient funds for that purpose, it appeared that Government would incur little or no risk in advancing the money on the security of water-rates, fixed sufficiently high to be likely to pay off principal and interest within a limited period. The adoption of this plan, besides preventing the water from being made needlessly dear for the profit of strangers, would, the Secretary of State considered, not improbably be beneficial in showing to the Madras Municipality the advantages which they might confer on the town by themselves providing for ordinary municipal requirements.

6. The Government of Madras accordingly recommended* to the Secretary of State that the Government of India should be authorised to raise a loan of 8 lakhs to be applied to the construction of the works comprised in Mr. Fraser's project. In reply it was pointed† out to the Government of Madras that the Government of India had full power to dispose of such questions, and application was therefore made‡ to the Government of India to sanction the loan of 8 lakhs. As, however, the requirements of the project for the year (1867-68) had been stated§ to be not more than 3 lakhs, the Government of India appeared to think‖ that the loan was unnecessary, and that funds could be provided in the ordinary way.

* Despatch to Secretary of State, No. 7 of 1867, dated February 8th.

† Letter from Government of India, No. 40 I., of March 25th, 1867, in Proceedings, Madras Government, No. 1139, of April 13th, 1867; also Despatch from Secretary of State, No. 13, dated April 8th, 1867, in Proceedings, Madras Government, No. 1455, of May 14th, 1867.

‡ No. 967 of March 27th, 1867.

§ Telegram of March 8th, Proceedings, Madras Government, No. 696.

‖ Letter No. 40 I.

7. The Municipality, however, required a loan for the construction of the distribution works. Mr. Standish Lee, the then Municipal Engineer, prepared the scheme for these, which were estimated to cost Rs. 12,80,000, and application was accordingly made¶ to the Government of India for a loan for this amount.

¶ Letter No. 3410 of October 30th, 1868.

The Government of India, in replying to the proposal as regards the loan, suggested** that the Municipality should become joint owners with the Government of the work. The case was stated thus:—

** No. 55 A.I. of March 11th, 1869, in Proceedings, Madras Government, No. 1014, of March 24th, 1869.

"The whole additional supply of water stored is 2,700 millions†† cubic feet; of this 1,431 millions are to be used by the Government and 864 millions by the Municipality, besides 405 millions which are of no use; in all the Municipality has 1,269 million cubic feet stored for its purposes. If, therefore, the cost (8 lakhs) be divided in the proportion of 53 to 47 (1,431 to 1,269), it gives 4¼ lakhs for Government and 3¾ lakhs for the Municipality; it is then proposed that the Municipality shall be considered as joint proprietors of the reservoirs, and be allowed to pay the interest on the above capital, *plus* a proportional share of maintenance charge."

†† Stated in cubic yards in original.

The Municipality declined,‡‡ however, to accept the offer of joint proprietorship, and the loan of Rs. 12,80,000 was sanctioned§§ by the Government of India on the terms originally proposed by the Madras Government, viz., at 6 per cent. per annum, 4 per cent. to be considered as interest for the money and 2 per cent. to be credited to a sinking fund for the liquidation of the debt, the Municipality being further required to pay Rupee 1 per 27,000 cubic feet for the supply of water received from the reservoirs. This latter point was strongly insisted‖‖ on. "The Municipality has elected to be treated as a customer in respect to the water supplied, and it cannot therefore reasonably hope to enjoy more favourable terms than those granted to the public generally. The

‡‡ Proceedings, Madras Government, No. 1622, of May 17th, 1869.

§§ Proceedings, No. 126 A.I., of June 25th, 1869, in Proceedings, Madras Government, No. 2327, of July 17th, 1869.

‖‖ Government of India Resolution, No. 126 A.I., of June 25th, 1869.

Governor-General in Council, moreover, requests that it may be distinctly pointed out to the Municipality that the free use of water from the Government reservoirs must not be looked for."

8. As the works in connection with the storage progressed, it became evident that the original estimate for them would prove wholly insufficient, and a revised estimate, amounting to Rs. 10,42,640, is noticed in Proceedings, Madras Governmont, No. 1100, of April 26th, 1870. This, however, was not forwarded to the Government of India, as doubts had been thrown on the estimated returns from irrigation, and it was considered advisable that a definitive decision should be come to on this point before any revised estimate was submitted for sanction. But as it was not possible to delay the progress of the works, the outlay soon largely exceeded the sanction, and the revised estimates were repeatedly called* for. Not being ready, the Government of India ruled† that all expenditure after January 1st, 1871, should be debited to the Ordinary Agricultural grant instead of to the Extraordinary (Loan Funds) grant, from which the previous expenditure had been met.

* Proceedings, Madras Government, No. 2697, of November 10th, 1870.
Proceedings, Madras Government, No. 2909, of December 2nd, 1870.

† Proceedings, Madras Government, No. 233, of January 26th, 1871.
Proceedings, Madras Government, No. 520, of February 21st, 1871.

9. The Madras Government eventually decided‡ that a Committee should be appointed to report on—

‡ Proceedings, Madras Government, No. 939, of May 29th, 1871.

(1) the complete outlay required in order to place the works in a satisfactory condition;
(2) the total return to be equitably credited to the works;
(3) the charge for maintenance.

The Committee's Report§ is dated July 14th, 1871, and was forwarded to the Government of India with letter No. 2172 of August 23rd, 1871. It is therein stated that the estimated total cost had risen to Rs. 12,25,558 owing to—

§ Proceedings, Madras Government, No. 2171, of August 23rd, 1871.

(1) increased rates;
(2) improvements in design;
(3) additional rates;
(4) increase in land compensation.

The estimated return had also fallen from Rs. 1,12,166, at which it was taken in 1870, to Rs. 49,000. It was suggested that the portion of the expenditure on which this return would pay 6 per cent., or Rs. 8,16,666, should be met from Loan Funds, leaving the balance, Rs. 4,08,892, to be defrayed from Ordinary.

10. The Government of India did not, however, approve of the latter part of this proposal, considering‖ it to be unfair to tax the public in the Madras Presidency generally with one-third of the cost of a project undertaken principally on behalf of the city of Madras, and for which there seemed no doubt the city could well afford to pay. An enhancement of the price to be paid for the water by the Municipality was therefore recommended. It was pointed out that in Calcutta only about 2,440 gallons of water were obtained per rupee, and in Bombay only about 8,000 gallons, against 168,750 gallons per rupee, which would be the rate in Madras. In reply to this the Government of Madras pointed¶ out that a distinct engagement had been made with the Municipality not to charge more than Rs. 32,000 per annum for the water, on which understanding it had declined** to become a joint proprietor, and that, moreover, the cost of supply should be estimated on the volume used, not on that available. In

‖ Letter No. 695 I. of November 10th, 1871, in Proceedings, Madras Government, No. 65, of January 10th, 1872.

32 million cubic yards = 5,400 million gallons for Rs. 32,000.

¶ Letter No. 1015 of April 18th, 1872.

** Letter No. 1015 of April 18th, 1872.

regard to this it was said that the supply was not expected to reach more than 312,000* inhabitants, and even assuming that each person took as much as 20 gallons a day, this would only give a yearly consumption of 2,277 million gallons, or at the rate of 16,824 gallons per rupee.

* Out of a population of 397,000. The Census of 1871 showed that the supposed population of Madras was very much larger than proved to be the case.

11. The Government of India accepted this reasoning, and with letter No. 05 I. of May† 10th, 1872, forwarded a copy of a letter it had addressed to the Secretary of State recommending that the proposal should be adopted that 8 lakhs of the expenditure should be met from Loan Funds, and the balance from the same source in the first instance, but to be repaid by annual instalments of 1 lakh, one-half of each instalment being met from the Ordinary grants to the Madras Government for Agricultural Works, and the other by a reduction of the Provincial Assignments to that extent.

† Proceedings, Madras Government, No. 1452, of June 12th, 1872.

12. The Secretary of State did not, however, approve of this proposal. In his despatch‡ No. 59 of July 10th, 1873, after reviewing the circumstances of the case, he said he regretted he could not concur as to the mode in which the difficulty should be met, it being entirely opposed to the policy under which expenditure on remunerative works was permitted to be undertaken from borrowed money, that any portion of the cost of a work which is shown to be unremunerative should be debited against Loan Funds. It was therefore ordered that no part of the principal or interest of the money laid out should be eventually debited to Extraordinary Funds.

‡ Proceedings, Madras Government, No. 162 B., of January 24th, 1874.

13. The Government of India, in forwarding a copy of this letter from the Secretary of State to the Government of Madras, remarked that the Accountant-General, Public Works Department, had reported that the ultimate expenditure was likely to amount to more than 15 lakhs, instead of Rs. 12,25,558 as reported by the Committee of 1871, owing to no provision having been made in the estimate for establishment and tools and plant charges. The actual outlay to the end of 1872-73, combined with the grant for 1873-74, showed the following results:—

No. 854 I. of December 9th, 1873, in Proceedings, Madras Government, as above.

—	Loan Funds.	Ordinary.	Total.
	RS.	RS.	RS.
Works	8,45,616	3,71,989	12,17,605
Establishment	1,64,231	1,05,045	2,69,276
Tools and Plant ...	7,901	9,123	17,024
Total ...	10,17,748	4,86,157	15,03,905

The refund to be made accordingly amounted to Rs. 10,17,748, and, with a view of affording every assistance in its power to the Government of Madras, the Government of India authorised the Accountant-General, Public Works Department, to debit the Ordinary and credit the Extraordinary grant with Rs. 5,70,000 in the accounts for 1872-73 for the Madras Water Supply Project. This left Rs. 4,47,748 still to be refunded, which it was suggested should be done in the following way: 2 lakhs from Provincial Funds by annual amounts of Rs. 50,000, commencing from 1874-75, and the balance in three instalments from the Ordinary grant under Agricultural. Subsequently all Irrigation works, including Agricultural, were included under Imperial, and the refund had therefore to be made entirely from Provincial. It has been carried out in the following§ way:—

§ Proceedings, Madras Government, No. 849 I., of December 9th, 1881.

	RS.
By transfer in 1876-77	50,000
Do. in 1878-79	50,000
Do. in 1879-80	1,00,000
Do. in 1880-81	1,00,000
Do. in 1881-82	1,00,000
Do. in 1882-83	* 47,748
Total ...	4,47,748

* Entry in Budget for 1882-83.

14. But this does not constitute the whole refund. The estimate, amounting to Rs. 12,25,558, sanctioned in Government of India letter, No. 695 I, of November 10th, 1871, only included works and petty establishment charges, the regular establishment charges, and those for tools and plant having been omitted, as well as all indirect charges. It was found also that several of the component works required extension or modification, so that an additional provision under works was necessary, and a revised estimate to include all these additions was called for. Great delay occurred in submitting it, and it was not till the 9th of December 1881 that the revised estimate was forwarded for the sanction of the Government of India. It amounted to Rs. 18,54,463, divided thus:—

Proceedings, Madras Government, No. 849 I.

	RS.
1. Anicut and Head Works	95,839
2. Cholavaram Tank Supply Channel	2,45,670
3. Cholavaram Tank	2,67,367
4. Red Hills Tank Supply Channel	1,32,882
5. Red Hills Tank	2,98,609
6. Distribution	27,201
7. Land other than for the Madras Municipality	1,45,079
8. Miscellaneous	58,596
9. Items chargeable to Provincial	96,573
	13,67,816
Deduct amount charged to Works, which belongs to Establishment	24,866
Total, Works ...	13,42,950
Establishment	2,19,255
Tools and Plant	8,201
	15,70,406
Less Receipts on Capital Account	1,167
Total, Direct Charges ...	15,69,239
Capitalised Abatement of Land Revenue	2,13,320
Interest	71,904
Grand Total, Direct and Indirect ...	18,54,463

The total of this estimate is divided as follows:—

	RS.
Imperial	9,82,105
Provincial	8,72,358

so that the whole of the charges having been originally met from Imperial, and only Rs. 4,47,748, as above stated, added to Rs. 23,214 originally met from Provincial, having been refunded of the Provincial share, there is still a refund of Rs. 4,01,396 to be made. This, it has been ordered,* is to be carried out in the Civil Accounts, by continuing to refund one lakh year by year, including 1882-83, until the whole debt has been paid.

* Letter from Government of India, No. 228 A-G, of June 5th, 1882.

CHAPTER III.

ACCOUNT OF THE ENGINEERING DIFFICULTIES ENCOUNTERED, AND OF THE MANNER IN WHICH THEY WERE OVERCOME.

THE project has suffered from its commencement to quite an unusual extent, both from the accidents owing to floods of unexpected severity to which every irrigation work is liable, and also from mistakes made in the original method of execution, the two reservoirs comprised in the project being formed by additions to old works, and requiring therefore exceptionally careful treatment, which unfortunately they did not receive, to ensure homogenity between the old work and the new. The difficulties arising from these two causes will be taken separately.

I. DAMAGES FROM FLOODS.

2. In October 1870 a very heavy flood came down the Kortalayár, the water rising to 16 feet above the sluice sill, or 10 feet above the crest of the anicut, and 4 feet above the flood-level as originally estimated. The anicut was but slightly damaged, but the upstream wings of the head-sluice were carried away, and a large breach was formed behind them. The roadway of the head-sluice, being only 15 feet above the level of the sluice sills, was 1 foot under water. The supply channel from the river was also breached in several places by the land drainage brought into the channel by the two streams called the Kattankal and Busikal, the existing works being insufficient to pass the discharge across the channel.*

* Proceedings, Madras Government, No. 2774, of November 18th, 1870.

3. In November 1882 a still higher flood occurred, the water rising to 13 feet above the crest of the anicut, and also over the banks on both sides of the river Kortalayár. The flood turned the north wing of the anicut, and breached extensively the south flood-bank above it, causing, in consequence, considerable damage to the supply channel. The anicut itself sustained no injury, but a small portion of the wing-wall which was turned was carried away. The breaching of the south flood-bank let a large volume of water into the country beyond, which found its way into the Kattankal and Busikal, thence into the supply channel, which was breached, and so back to the Kortalayár. The additional works which the flood showed to be necessary consisted of —

† Proceedings, Madras Government, No. 2132, of August 26th, 1873. The actual cost was Rs. 23,437.

(1.) Lengthening the anicut by 150 feet, making it 624 feet long. The estimate for this amounted to Rs. 25,000.†

(2.) A further raising of the roadway of the head-sluice to the supply channel, which had only been 6 inches above the flood of November 1872. The necessary raising was recommended,‡ to be effected by closing the spaces between the piers which carry the shutter gear, and by raising the earthworks at either end to the level of the tops of the parapets of the wings.

‡ Proceedings, Madras Government, No. 2132, of August 26th, 1873.

(3.) Raising the flood-banks on each side above the anicut and on the south side below it. The banks above were raised to 5 feet above the level of the 1872 flood, that on the south side having its terminus on the Veliyur Tank bank, and that on the north side on a village boundary mark. Below the anicut on the south bank there was a flood embankment extending three-fourths of a mile to comparatively high ground, but the upper part of this bank was much too low. The flood-level below the anicut reached 80·83, or 2·03 feet below that above the dam. At 10,300 feet, or rather less than 2 miles, its level was 76·96, so that the surface fall was 1·97 feet per mile, and to the proposed terminus of this bank, a length of 3,900 feet, the fall would be 1·46 feet, making the flood-level here 79·37. The ground here was at 81·32, giving a margin of 1·51

* Proceedings, Madras Government, No. 1222, of May 7th, 1874.

† Proceedings, Madras Government, No. 2132, of August 26th, 1873.

feet, but on the whole it was considered* safer to make the bank here 3 feet higher or, say, 84·31. This high ground had to be connected with the left bank of the supply channel, as in 1872† the water in the Kortalayár had risen considerably above the level of the crests of the then existing weirs. The level of the top of this connecting bank was also fixed at 84·31 feet. The estimates for these banks were—

		Rs.
Flood-bank north of Kortalayár above anicut	...	5,550
Do. south do. above and below do.	...	6,800

and were sanctioned in G.O., No. 1222, of May 7th, 1874.

‡ Proceedings, Madras Government, No. 2011, of July 15th, 1875.

4. In October 1874 a higher flood even than that of 1872, occurred in the Kortalayár, the levels of the water in each case being given‡ as —

	1872.	1874.	Difference.
At 1 mile 1,293 yards above anicut	87·32	90·85	3·53
Anicut	82·86	84·20	1·34

The embankments above the anicut were not much damaged, only three small breaches, which perhaps were intentionally caused by the villagers, having been made in the south bank, but it was discovered that the terminus of this bank did not fulfil its purpose, as it proved capable of being turned. Estimates amounting to Rs. 2,558 for completing the right flood-bank, and to Rs. 4,900 for extending it, were sanctioned in G.O., No. 368 I., of October 3rd, 1877. The anicut suffered more than the embankment, but principally from local scour. The foundations of the crest wall were undermined for a length of about 120 feet, the front row of wells disappearing almost entirely, and the second row settling considerably. The crest wall went out of the upright, parts of it also being carried away, and a crack appeared in the rear apron. The remedy proposed§ besides the restoration of the damaged portion, was to lay an apron of rough stone 21 feet wide and 2 feet thick at a gentle slope on the upstream side of the crest. The supply channel was also damaged, owing to the impossibility of discharging through it, when the Kortalayár is in high flood, all the land drainage coming into it. The drainage basin of the Kattankal is estimated at 62‖ square miles and that of the Busikal at 44 square miles, and it was calculated that, allowing M.W.L. in the channel to be 10½ feet above the bed or 4½ feet above F.S.L., weirs of 280 feet and 216 feet in length, respectively, would be required to discharge the drainages. This was supposing the weirs to have flush crests, but by adopting self-acting revolving shutters for the vents the lengths were reduced to 144 feet and 135 feet, respectively, and estimates for these improvements, amounting to Rs. 18,400,¶ for the Kattankal escape and to Rs. 16,900** for the Busikal escape were sanctioned in G.O., No. 2785, of October 17th, 1876. Their execution had, however, to be deferred pending the sanction of the revised estimates. The proposed arrangements, even when carried out, do not promise to be wholly satisfactory, but it is impossible to devise adequate arrangements at a reasonable cost. Should the river be in extreme fresh when the local rainfall approaches a maximum, the discharge of the drainages cannot be disposed of without exceeding the proposed M.W.L. in the channel, and on the rare occasions when these unfavourable circumstances may combine, the left bank of the channel will probably breach at points which will be left exceptionally low so as to fix the site of the breaches.††

§ Proceedings, Madras Government, No. 2011, of July 15th, 1875.

‖ Proceedings, Madras Government, No. 2785, of October 17th, 1876.

¶ Subsequently increased to Rs. 19,000.

** Do. do. Rs. 17,400.

†† Proceedings, Madras Government, No. 849 I., of December 9th, 1881.

5. An estimate, amounting to Rs. 2,135, for raising the connecting bank between the flood-bank of the Kortalayár below the anicut and the bank of the supply channel,

the necessity for which had been shown by the same floods of 1874, was sanctioned in G.O., No. 368 I., of October 3rd, 1877. The condition of the river embankments, of the anicut, and of the supply channel was generally satisfactory on the occasion of the inspection of the works by the Chief Engineer for Irrigation in November 1881.

II. Damages to the Reservoirs.

(1.) *Red Hills Tank.*

6. In February 1870 leakage was first noticed in the bank of the Red Hills Tank near the north end, when only $4\frac{1}{4}$ feet depth of water above the old calingulah crest had been admitted to the tank out of the additional depth of 15 feet which it was designed to hold. The leakage was considerable for a length of 867 feet, and for an additional length of 4,596 feet the water passed through or under the bank in smaller quantity. The new earthwork which had been placed on the top of the old bank had, it was supposed, been rendered impermeable by means of a puddle wall, but it appears to have been taken for granted that the old earthwork below this puddle wall would also be impermeable even under the pressure due to the increased depth of water. In those portions which were composed of clay soil no leakage took place, but under certain portions of the embankment laterite gravel and rock crops up, and there the water found its way through. The remedies proposed and carried out were—

(1.) At 5 or 6 feet from the foot of the revetment a trench from 8 to 9 feet wide was carried down to a little below the original ground surface and filled in with puddle. The soil between this puddle and the revetment was then removed to a depth of 4 feet in short lengths at a time, and also filled in with puddle, the whole of the excavated earth being then placed over the puddle, well watered and rammed. The cost of this was estimated at Rs. 14,595.

(2.) Low retaining walls were built at the foot of the rear slope where the leakage was heavy to prevent slips. The cost of this was Rs. 1,905.

Proceedings, Madras Government, No. 1959, of Aug. 17th, 1870.

7. In November 1871 about 178 feet of the bank of the Red Hills Tank settled slightly, owing, it was supposed, to heavy rain having sunk down to the new earth in the rear of the puddle wall. The settlement was slight and no danger was apprehended.

Proceedings, Madras Government, No. 72, of January 11th, 1872.

8. In October 1872 another settlement occurred* in precisely the same spot, the maximum subsidence being 0·95 of a foot. Exaggerated reports as to the subsidence were current in Madras and excited some alarm, but the Chief Engineer for Irrigation reported (1) that the tank was in no danger of breaching, and that (2) even did it breach, the water would not inundate Madras, but would find its way into the Ennore backwater, some 5 miles to the north of the city. Certain remedial measures were proposed, but before they could be completely carried out very heavy rain again fell and the bank again slipped on October 14th to 18th in the same place. This time the slip was more serious, and the sinking consequently greater. A length of 437 feet was disturbed, the depression being greatest at the two ends, where it was 2·11 feet and 1·41 feet on the north and south sides respectively. The slip was attributed to the use of clay with a large admixture of inferior yellow soapy soil for the bank, together with the absence of a gravel backing that should have been provided to the revetment. A searching inquiry was ordered in Proceedings, Madras Government, No. 3014, of December 18th, 1872, the results of which are given in Proceedings, Madras Government, No. 1926, of August 1st, 1873. A note by Major Scott, R.E., who had been in charge of the works for many years during their construction, is printed therein, which throws much valuable light on the causes of failure. The new work having been raised on the old bank, obviously hung on an inclined plane represented by the back slope of the old bank, so that when the new work settled on being permeated by water under pressure, the old work did not participate in the movement, and dislocation therefore took place,

* Proceedings, Madras Government, No. 2466, of October 19th, 1872.

the line of fracture being along the back slope of the old bank. The failures were favoured by the slippery blue clay which formed the lower part of the backing, as the water would naturally have a tendency to travel along the line of junction of the old and new works, especially if assisted in its passage by the remains of roots of trees, grass, or vegetable soil. Dislocation having once taken place in this way it is easy to see that the addition of earth to make up the bank to its proper level would, by adding to the weight of the mass in a state of unstable equilibrium, tend to renew the slide downwards. This is what actually occurred, the bank continuing to sink as fast as earth was added. The slips were due partly to an error in design and partly to errors in execution. It would have been preferable to provide for the additions to the bank being made on the inner instead of on the outer slope, as the pressure of water would then have held the new earthwork against the old bank. But even if this were not done, as in the case of the work as executed, failure might have been guarded against had the old bank been thoroughly cleared and broken up to ensure junction with the soil added.

9. On December 2nd, 1873, another and very extensive slip occurred,* 1,600 feet north of the Polal sluice, or about half way between it and the slips of the previous year, very heavy rain having fallen during the previous few days and saturated the bank. A quantity of what was described as "utter boggy stuff," which had been covered by sound earth, was exposed. The remedial measures adopted were similar to those previously ordered, viz., the drainage of the fallen mass so as to form a sort of retaining bank, and the reformation of the bank with sound earth.

* Proceedings, Madras Government, No. 238, of February 2nd, 1874.

10. The bank stood well during the heavy rains of October 1874, and was not subjected to any further severe test till 1877, when, on November 17th, a slip again occurred, due† to the saturation of the lower part of the rear of the bund, resulting from the porous laterite subsoil. The drainage of the bank where the slip took place was again ordered.

† Proceedings, Madras Government, No. 38 I., of January 14th, 1878.

The new sluices in the waste weir failed‡ on the same occasion, owing to water working under the covering stones of the vents and forcing them up by hydrostatic pressure. The insertion of these sluices for the purpose noticed in the 7th paragraph of Chapter I had been sanctioned in Proceedings, Madras Government, No. 2322, of August 11th, 1875, at an estimated cost of Rs. 17,100. It was discovered in 1877 that the concrete foundations on which the piers of the vents stood had to a great extent been washed out, having been made of bad material. When the floods had subsided a coffer-dam of earth was put round the sluice-vents pending the preparation of the estimate for all the repairs the tank was held to require.

‡ Proceedings, Madras Government, No. 38 I., of January 14th, 1878.

11. In May 1879, however, a cyclonic storm passed over Madras, the fall of rain being very heavy, with the result that a portion of the coffer-dam was washed away. The breach was with difficulty closed. In passing orders on the papers reporting this occurrence, Government signified a desire§ to have complete information on the following points before deciding what further work should be undertaken for the security of the reservoir:—

§ Proceedings, Madras Government, No. 374 I., of July 1st, 1879.

(1.) The cost of draining the rear portion of the bank which had been reported by the Chief Engineer for Irrigation in September 1878 to be still saturated with moisture for a considerable distance.

(2.) The cost of raising the parapet wall of the tank. The top of the bank referred to M.S.L. is 52·31, but there was a dwarf parapet wall of laterite stone at the top of the revetment which made the margin above F.T.L. nearly 7 feet. It was considered that it would add considerably to the safety of the reservoir to raise this parapet to 55·31 along the deeper parts of the tank, and to 54·31 along those parts which are of intermediate depth.

(3.) The cost of repairing the surplus sluices in the waste weir of the tank.

(4.) The cost of rendering the tank bank completely secure from the right wing of the surplus weir to the end of the apparent leakage a short distance south of the Polal sluice by the insertion of a puddle core wall in the bank with a longitudinal drain at the back of the puddle wall, and cross drains to the rear toe of the bund at interval of from 50 to 75 feet according to the amount of leakage manifested.

Until this information had been furnished it was directed that the surplus sluices should be left unrepaired and the surplus weir kept at its then level of 43·31,* water being retained as near to the F.T.L. of 46·31 as circumstances might indicate to be prudent by means of temporary arrangements, as had been done since the first failure of the sluices in 1877.

* The crest of the weir had been lowered temporarily to 43·31 in November 1877.

12. The preparation of the estimates required by Government as mentioned above involved borings being made in the bank, and these confirmed the previous evidence of the very mixed character of the material used in the formation of the embankment, and showed moreover that the old as well as the new portion was constructed in a very unreliable manner. In two of the borings water was met with at 22 feet from the top of the bank or at 14 and 12 feet, respectively, below the actual water level, and in one bore hole the water rose to about 6 inches below the water level, indicating a very unsafe freedom of communication between the water in the tank, and the interior of the bank.† This proved very conclusively that a puddle core wall could not be inserted in the bank without first lowering the water level in the tank considerably. Nor did it appear at all certain that the insertion of a puddle wall would be sufficient to stop the leakage. Its effect would be to cut off all but subsoil leakage from the bank behind it, and such leakage might, it was evident, be disposed of by means of drains. But the front part of the bank would still remain in its then condition, *i.e.*, in some parts of the consistency of butter, and settlements might therefore take place at any time which would involve the rupture of the puddle wall and admit water to the rear part of the bank. It seemed, therefore, that nothing less than the formation of a properly constructed bank inside the existing bank at the places where the latter was rotten could render the tank secure, and to carry this out it would have been necessary to empty the tank and to keep it empty for many months. But to do so, and by so doing to cut off the supply of water to the city of Madras, was out of the question, even had the necessary supply of material been forthcoming, which was not at all certain.

† Proceedings, Madras Government, No. 406 I., of June 24th, 1880.

Whatever remedial measures might be ultimately adopted, it was certain, however, that transverse drains under the unstable portion of the bank would have to be inserted, and in view of the above-mentioned difficulties it seemed advisable to see first what would be the effect of these. It was considered possible that they would so far induce consolidation of the bank as to allow of a connecting longitudinal dry stone wall being inserted on the line of the inner ends of the drains, which would have the effect of securing freedom from water to all the rear part of the bank, and to ensure its stability. The result would then be a front part of the bank not much, if at all, altered in condition, and a rear part so arranged as to afford the front part adequate support; between this support in rear and the water pressure in front practical stability might be found to exist.

13. In accordance with the above recommendations the following estimates were sanctioned in Proceedings, Madras Government, No. 406 I., of June 24th, 1880 :—

		Rs.
(1.)	Parallel drain in rear of south part of bank	90
(2.)	Fifty transverse drains in bank	6,000
(3.)	Longitudinal drain and dry stone wall	8,200
(4.)	Channel to lower the water level of pool in rear of bank to 21·00.	300
	Total ...	14,590

14. The following is a copy of the specification for carrying out the above works :—

"*Transverse drains.*—These drains will start at the level of 21·00, at which level the sole of the drains at their outfall will throughout be fixed at all places at which there is a pool or lower ground in rear of the bund. Where the ground level is higher than 21·00 a drain parallel to the bund will be cut along low ground not less than 30 feet from the toe of the rear slope with a fall of 1 foot* in 10 chains starting with the level of 21·00 at the lower end. The head of this drain to have a width of bottom of 1 foot and side slopes of 1 to 1. The bottom width to increase by 6 inches at the end of every 10 chains, *i.e.*, at 10 chains from the head it will be 1½ feet wide, at 20 chains 2 feet wide, and so on. The soles of the transverse drains at their outfall will be 0·50 foot above the bottom of the parallel drain. All open transverse drains to have a fall of 1 in 330.

* 8 feet a mile.

"All drains filled with stone to have a fall of 1 in 30. The transverse drains under the bund to be run into a line 22½ feet from the rear face of the bund parapet. As the lengths and starting levels of these drains will vary, so will the sole level at the inner end.

"2. *Excavations for transverse drains.*—These drains outside the toe of the bund to be 1½ feet wide at bottom with side slopes of 1 to 1.

"The cuttings into the bund to be at right angles to its alignment and to be 3 feet wide. Taking the rear slope as on the average 2 to 1, the cutting will be about 3 feet deep at 6 feet deep from its commencement, and, so far, the sides may be left unsupported. All the cutting beyond this to be supported by close planking with struts or distance pieces at 6 feet apart horizontally or in the direction of the length of the plank, and vertically according to circumstances.

"The simplest arrangement will be to lay the planks parallel to the sole of the drain. As soon as about 30 feet in length of the cutting for a drain has been completed down to sole level, the stone for the drain should be laid in and handpacked. This stone should be in irregular roundish lumps, 4 to 6 inches in diameter. Turf sods should be laid vertically at the sides, with the grass next the stone, and on removing the planks the space left vacant should be filled in with good soil well tamped. The stone to be covered in with turf sods, grass downwards, and the bund reformed to section, the planks being removed one by one as the filling in progresses; the soil to be carefully tamped in 3 or 4 inch layers. The stone at the end of each length of drain thus formed to be protected from being obstructed by the earth by a plank placed vertically against the stone and edge of turf; this plank will be removed when the next length of stone is about to be laid down.

"Should much water be met with as the cutting progresses, the drain should be laid in with stone, and the bund reformed over it in shorter lengths, say of 10 feet, so as not to leave any greater length open at one time than can be quickly closed and completed, should the adjacent soil show signs of being washed out by the water. The width of the cutting being only 3 feet it is probable that the face of the bund at its end, which may be cut at a slope of ¼ to 1, will stand without support, but preparations must be made for supporting it by short pieces of plank, with cleats fastened to the side planking if necessary. All the planks will be 2 inches thick, so these planks for the face should be 2 feet 7½ inches long, and wedges should be driven between the ends and the side planking to hold the short planks until the cleats have been fixed.

"3. *Longitudinal dry stone wall.*—On the completion of cutting for a transverse drain, it will be seen what the nature of the bund at this point is, as also whether water finds its way through only at the bottom or at points above the level of the drain. It will then be determined whether a longitudinal dry stone wall is to be inserted or not. If this be ordered the excavations for it will be made in lengths of 10 or 12 feet at a time, on either side of the head of the transverse drain, commencing from the top of the bund, with a lining of close planking on either side of the trench and struts. The trench to be 3 feet wide down to the level of the surface of the natural soil or ground level, below which a width of 2 feet will suffice. The bottom of the wall to be laid at 23·00, except where original ground level is reached at a higher level, in which case it will be not less than 2 feet below ground level, the exact depth being determined from the nature the soil which, if porous, will necessitate excavation being carried lower. The wall will be in some cases founded lower than the head of the transverse drain. The dry stone wall will not be a necessity where the bund above the level of the transverse drain is water-tight and its height may be according to circumstances, viz., to the level at which the bund is good and water-tight. It may therefore be anything from the 2 feet of a simple longitudinal drain to that which would approximate to F.T.L. Generally it may be considered unlikely that it will need to be carried much above the surface of the old bund, but in all cases it should cut off from the bund in rear all water passages, so that the rear of the bund may be left dry and stable.

"4. *Order of execution of work.*—The longitudinal open drain in rear of the bund must be completed before the transverse drains having an outfall thereinto are commenced. The transverse drains into the bund must be formed before a longitudinal drain or a longitudinal dry stone wall is put in because the transverse drains are required to carry off all water tapped or met with in excavating for the L drain or dry stone wall. The excavations for these latter are to be so arranged as to afford uninterrupted drainage to the transverse drains on either side. Care to be taken that the heads of the transverse drains are not choked by silt from the excavations.

"5. *Drainage of pool in rear of bund.*—Arrangements are to be made by an outfall channel to keep the water level down to 21·00 as a maximum, and to this end the sole of the outfall channel at its head must not be higher than 20·50 and it may have to be lower. On the plan (tracing), dated 2nd September 1879, of the tank there is a drainage from the pool marked, but there is nothing to indicate that it is effective, and it is not shown as running into any channel which would carry the water away."

15. A report regarding the works as executed is contained in Proceedings, Madras Government, No. 307 I., of May 10th, 1881. From these it appears that 50 transverse drains and about 1,000 running feet of longitudinal drain had been completed, but that the 2,000 running feet of dry stone wall allowed for in the original estimate had not been found necessary, the longitudinal drain being found on examination of the interior of the bund to fulfil the required purpose. The cost of the works was therefore reduced to Rs. 9,800.*

* Proceedings, Madras Government, No. 498 I., of August 6th, 1881.

The parapet wall, the raising of which had been recommended as stated in paragraph 11, had been completed at a cost of Rs. 2,384. The Chief Engineer for Irrigation, who inspected the tank in November 1881, remarked that: "the transverse drains which have been inserted in the bank have acted well, but until the water has risen to somewhat above F.T.L., their sufficiency must not be taken for granted." The weir crest was then only at 43·31 or 3 feet below F.T.L., being so maintained as a measure of precaution pending the completion of the surplus sluices. Provision for this has been included in the revised estimate for the project printed in Proceedings, Madras Government, No. 849 I., of December 9th, 1881.

16. The dangers to which the Red Hills Tank has been exposed, and the difficulties that have been experienced in meeting them as summarised above, afford a very valuable precedent to Engineers engaged on similar works, and it may be well to point out briefly the causes of the difficulties that have arisen and the precautions that should have been originally taken.† Unfortunately the mistakes of the past are hardly capable of being entirely remedied in the present. The slips that have occurred at several points were undoubtedly due to water getting into the bank, whether at points above ground surface or through sub-soil leakage has not been very clearly ascertained, but probably both. The origin of the leakage is to be found in the omission to provide—(1) an adequate puddle wall in the first instance, (2) for the freedom from soakage of the base of the rear slope, while (3) the widening of the bank was made on both sides instead of only on the tank side, and (4) the puddle wall was placed in rear of the revetment and its backing, but was carried down only into the foreshore of the old bank instead of below original ground level; its thickness and height were likewise inadequate. Seeing that much of the old bank was founded on porous laterite, it is probable that no puddle wall placed as above mentioned would have been fully effective, for water would have been liable to pass through the sub-soil and to come to the ground surface under the bank The proper arrangements would therefore have been—

† Inspection Notes of the Chief Engineer for Irrigation, dated September 30th, 1878.

(1.) To have aligned the enlarged bank so that all, or nearly all the necessary widening should have been on the tank side of the old bank.

(2.) To have placed the puddle wall on about the centre line of the new bank with its foundations 4 or 5 feet as a minimum below original ground level.

(3.) To have constructed a longitudinal drain at ground level immediately in rear of the puddle wall, with cross drains at intervals, to carry leakage away to the rear of the bank. These precautions, if carried out at the time, would not have added much to the cost, and so arranged the bank would have been perfectly stable.

(2.) *Cholavaram Tank.*

17. The circumstances as regards the Cholavaram Tank have been very similar to those of the Red Hills, though in a minor degree. The bank of the Cholavaram Tank slipped badly for a length of 80 feet and to a less extent for a length of 112 feet more near the south end, commencing at a point about 900 feet north of the head-sluice to the delivery channel, after the heavy rains of October 1870.

No water was found in the bank, and it was therefore considered* probable that the slip was not due to any percolation of tank water, but to the rain having found its way down the cracks to the lower part of the new bank, which in settling might have been pushed outwards by the rear slope of the old bank. The remedies consisted in—

* Proceedings, Madras Government, No. 2774, of November 18th, 1870.

(1.) Making transverse cuts 3 feet wide down to 3 feet below the level of the water in the rear of the bank, and filling these in with large lumps of laterite;

(2.) Cutting a longitudinal trench from end to end of the slip in rear of the bund, also to a depth of 3 feet below the water level, and in this building a dry stone wall 6 feet high, with width of base 6 feet, and of top 3 feet, the batter being towards the rear of the bank. The face of this wall at the original ground level was on a line with the toe of the rear slope of the bank where undisturbed. The soil below this wall was well consolidated, that over the transverse cuts being also carefully filled in, so as to give additional support to the wall.

(3.) The earth of the slip was consolidated by means of rammers, and stepped so as to give a firm base for the new earth required to bring the bank to section.

(4.) The bank was raised to the height at which it stood before the slip occurred, the new† earthwork being removed from the back to the front of the old bank, and the rear slope brought to section. The cost of these repairs, charged as new work, was Rs. 30,675.

† Paragraph 5 of Major Scott's Memorandum in Proceedings, Madras Government, No. 1926, of August 1st, 1873.

These precautions proved successful, and during the monsoon of 1871 no further signs of failure were apparent.

18. But during the rains of 1872, when as stated in paragraph 3 the Red Hills bank slipped, the Cholavaram bank also slipped at a point a short distance to the north of the slip of 1870. The portion then repaired continued to stand well, and the new slip was considered‡ to be due to the nature of the soil, a light-colored clay of the regur class, of which the new bank was composed at that point. The portion that had slipped was cleared away, and new soil was in process of being added when the continuation of the slip was announced§ and a full report on the preventive measures to be adopted was called for. Slight slips occurred at the same spot in 1873, but these were not of much importance and were considered‖ to be due rather to the evaporation of the water used in remaking the bank than to leakage through the bank. It was eventually decided¶ to reform that portion of the bank which had slipped by advancing it 33 feet in the same way as had been done by Major Scott for the first slip of 1870. The estimate for this re-formation amounted to Rs. 30,675** and was sanctioned in Proceedings, Madras Government, No. 271, of February 4th, 1874.

‡ Proceedings, Madras Government, No. 1926, of August 1st, 1873.

§ Proceedings, Madras Government, No. 3014, of December 18th, 1872.

‖ Proceedings, Madras Government, No. 1045, of April 23rd, 1874.

¶ Proceedings, Madras Government, No. 2876, of November 27th, 1873.

** Actual cost Rs. 29,832.

19. The Cholavaram Tank bank stood very well during the heavy rains and floods of October 1874, only a small general settlement occurring§ where the bank had been turned over, and as it has given no further cause for anxiety since that date it may now be considered as stable. When inspected by the Chief Engineer for Irrigation in November 1881, although reported as "by no means in good order," this referred solely to the general condition of the bank, which ordinary repairs would suffice to put right, and not in any way to the sinking of or leakage through the bank, both of which have now quite ceased.

†† Proceedings, Madras Government, No. 2011, of July 15th, 1875.

CHAPTER IV.

THE TOWN SUPPLY OF MADRAS.

THE town supply and the principal phases of the history of the project are naturally so intimately connected that a good deal concerning the former has inevitably been stated in Chapter II. The circumstances with regard to it may now be amplified and completed so far as the records of the Irrigation Office render possible, but it must be premised that as the Public Works Department has nothing to do with the supply when once it has left the Red Hills Tank, the account must necessarily be confined to statements of the volumes supplied, the price paid, and so on, and cannot go into the details of distribution.

2. In Mr. Fraser's original scheme 40 million cubic yards* constituted the Municipal share of the assumed total additional supply of 100 million cubic yards.† The population of Madras was then supposed to be 470,000,‡ and assuming it to be half-a-million, and allowing 20 gallons a day per head, which he stated to be a very liberal allowance, Mr. Fraser found that the required supply was 585,686,295 cubic feet. The difference was to make up for waste, loss by evaporation, special cases of consumption, &c.

* 1,080 million cubic feet.

† 2,700 million cubic feet.

‡ Paragraph 10 of report, but see paragraph 10 of Chapter II, and Note.

3. In preparing its distribution scheme, however, the Municipality preferred to adopt the principle of distribution by gravitation in order to escape the expenditure entailed by the use of steam-power in raising the water and delivering it under artificial pressure. This advantage was necessarily gained by a sacrifice of quantity, the water having, in consequence, to be drawn off from the Red Hills Reservoir at a level 6 feet above that that originally contemplated. The supply available was thereby reduced to 864 million cubic feet, and the question of municipal supply was also affected in another way. There is no doubt that it was not contemplated originally to make any charge for the water supplied, and it was not till the raising of the level§ of delivery of the water, and the consequent loss of 418½ million cubic feet of storage, that the question of payment for water actually delivered arose. This change in level reduced the estimated returns from irrigation under the works to Rs. 53,000, and it was considered that they could not be deemed remunerative unless 7 per cent., or Rs. 56,000, was realised on the then estimated expenditure of 8 lakhs. There was thus a deficit of Rs. 3,000, and it was proposed that this should be met by charging the Municipality the same price as that estimated to be yielded by irrigation, or at the rate of Rs. 7 per 189,000 cubic feet, or 7,000 cubic yards, which was the volume said to be required for the irrigation of one acre. The Government in affirming the proposed charge said that it recognised a prior claim on behalf of the Municipality to 864 million cubic feet per annum.‖ The charge to be made was finally confirmed in G.O., No. 2327, of July 17th, 1869, on letter from the Government of India, No. 126-A.I., of June 25th, 1869, in which it was said that the price would be at the rate of Re. 1 per 1,000 cubic yards or 27,000 cubic feet. No doubt a great mistake was made,¶ from a Public Works point of view, in the wording of G.O., No. 3409, of October 30th, 1868, for it would only have been equitable that the Municipality should have paid for the whole of the 864 million cubic feet (32 million cubic yards) which were reserved for it. But there is also no doubt it was then supposed that the whole volume would be utilised every year, for in all the many calculations of profit that were made at and after this time, Rs. 32,000 were invariably entered among the probable receipts. The population to

§ Paragraph 2 of G.O., No. 2981, of October 21st, 1875.

‖ Proceedings, Madras Government, No. 4309, of October 30th, 1868.

¶ Proceedings, Madras Government, No. 1287, of May 5th, 1875.

be supplied had been shown by the Census returns of 1871 as not likely to exceed 312,000,* the higher number that had been assumed by Mr. Fraser being attributable to the erroneous ideas held as to the number of inhabitants of Madras in 1866.† The 864 million cubic feet were held to be quite sufficient for the wants of 312,000 people, though why that exact volume was fixed upon is not very clear. It appears to have been purely arbitrary, and the reduced supply required might more properly have been assumed at 675 million cubic feet or 25 million‡ cubic yards, which would have allowed an ample margin even for the development of Mr. Clarke's Drainage Scheme, which was prepared in 1875, but which has not yet been, nor is at present likely to be carried out, owing to the inability of the Municipality to provide the necessary funds. Under these circumstances even the reserve of 675 million cubic feet was clearly excessive. In the letter of the President of the Municipality, No. 271 G., of July 21st, 1875, printed in Proceedings, Madras Government, No. 2981, of October 21st, 1875, it is stated that the Commissioners hope by the extension of pipe-laying to reach ultimately a consumption of 20 gallons per head per day for a population of 312,000, or a total of 364·5 million cubic feet per annum, but, it is added, they neither desire nor expect to exceed that consumption to any considerable extent. In the same letter it is stated that the actual consumption was then 9 gallons per head per day for 280,000 consumers. In the report of the President, printed in Proceedings, Madras Government, No 620, of April 4th, 1876, the consumption is said to amount to 920,376 cubic feet (34,088 cubic yards) per diem, equivalent to 20 gallons per head for a population of 280,000 or 12½ million cubic yards per annum. The reason for this sudden increase in consumption is not stated, and there is probably some discrepancy in one of the returns, but at the present time it may be said that the actual consumption is not likely to exceed 12 million§ cubic yards annually, and by G.O., No. 598-A.I., of October 10th, 1879, it was settled that no more water than at present would need to be reserved for municipal use.

* *Vide inter alia* Proceedings, Madras Government, No. 1287, of May 5th, 1875.

† Proceedings, Madras Government, No. 2981, of October 21st, 1875.

‡ Proceedings, Madras Government, No. 2981, of October 21st, 1875.

§ Paragraph 2 of G.O., No. 492 I., of August 5th, 1881.

4. The following table shows the consumption year by year up to end of 1881. Water was first supplied to the Municipality from the reservoir during May to September 1872, but no record of the volume used is extant :—‖

‖ Proceedings, Madras Government, No. 1287, of May 5th, 1875.

Periods.	Quantity in Million Cubic Yards.	Quantity in Million Cubic Feet.
From January 1873 to December 1873 ...	5·25	141·75
From „ 1874 to „ 1874 ...	5·36	144·72
From „ 1875 to March 1875 ...	1·36	36·72
From April 1875 to „ 1876 ...	11·986	323·622
From „ 1876 to „ 1877 ...	5·698	153·846
From „ 1877 to „ 1878 ...	3·428	92·556
From „ 1878 to „ 1879 ...	5·693	153·711
From „ 1879 to „ 1880 ...	5·07	136·89
From „ 1880 to „ 1881 ...	6·006	162·162
From „ 1881 to December 1881 ..	3·835	103·545

5. It was stated in the last paragraph of Chapter II that the total cost of the project has been divided in certain proportions between Imperial and Provincial Funds, and the reasons that led to this division, the proportions adopted, and how they were obtained may now be explained. A brief recapitulation of paragraphs 12 and 13 of Chapter II is necessary as a preliminary. When, in 1873, it was found that the

actual expenditure amounted to Rs. 12,25,558, Rs. 10,17,748 of which had been met from Loan Funds, it was proposed by the Government of India in a despatch to the Secretary of State, No. 27, of February 21st, 1873, to charge only 8 lakhs, the amount of the original estimate, finally against Loan Funds, and to recover the balance from the Ordinary Agricultural and Provincial assignments. This proposal, however, did not meet with the approval of the Secretary of State, who directed in his despatch No. 59, of July 10th, 1873, that no part of either principal or interest of the money laid out on the scheme should be eventually debited to Extraordinary Funds. The Government of India in giving effect to these instructions informed the Government of Madras in letter, No. 854 I., of December 9th, 1873, that it was considered that 2 lakhs of the outlay from Loan Funds should be made good from Provincial Funds, leaving the balance, which then amounted to Rs. 8,17,748, to be met from the Ordinary Imperial grant. The theory, that Provincial Funds should bear the share of the total cost represented by the proportion of the volume reserved for the use of the Municipality to the total volume stored, appears to have been first stated in paragraph 17 of the Note of the Chief Engineer for Irrigation, printed in Proceedings, Madras Government, No. 1548, of June 2nd, 1875. It is there said: "with the town supply Agricultural Funds have properly nothing to do, and Provincial Funds appear to be the only other source from which this share of the cost can be defrayed." The principle being admitted, it only remained to determine the volume of water that had to be reserved for the Municipality.

* Proceedings, Madras Government, No. 21, of January 5th, 1876.

6. The necessary calculation was made in 1876. The total capacity of the two tanks was stated* to be as follows:—

	Millions of Cubic Yards.	Millions of Cubic Feet.
Cholavaram Tank	28·47	768·69
Red Hills do.	101·98	2,753·46
Total ...	130·45	3,522·15

† Proceedings, Madras Government, No. 21, of January 5th, 1876.

and the capacity of the tanks before the commencement of the project having been†—

	Millions of Cubic Yards.	Millions of Cubic Feet.
Cholavaram	3·36	90·72
Red Hills	20·48	552·96
Total ...	23·84	643·68

the additional storage provided amounted to 106·61 million cubic yards or 2,878·47 million cubic feet. One-fifth of the total capacity was assumed as the extra supply during the year, making the total amount stored 156·54 million cubic yards, or 4,226·58 million cubic feet, and the additional amount stored 132·7 million cubic yards, or 3,582·9 million cubic feet. The sill of the lowest municipal pipe being at 31·31, or 15 feet below F.T.L., there remained 20·48 million cubic yards, or 552·96‡ million cubic feet, below this, which in any case would have to be reserved to keep up the town supply. Further, it was found that a head of not less than 3 feet§ above this sill was required to ensure a proper flow down the municipal channel, rendering a further reserve of 11·06 million cubic yards, or 298·62 million cubic feet, necessary. Finally, from certain calculations that had been made of the issues and receipts of water,

‡ 547·917 million cubic feet, according to Col. O'Connell's table given in Appendix A.

§ A head of 6 feet had been decided on as necessary in G.O., No. 2981, of October 21st, 1875, and no authority is quoted for the reduction.

combined with the contents of the tanks at different dates, it appeared that the proportion of issues to consumption averaged 1 to $2\frac{1}{2}$,* so that 12 million cubic yards, or 324 million cubic feet, being the estimated yearly supply required by the Municipality, $12 \times 2\frac{1}{2} = 30$ million cubic yards, or 810 million cubic feet, would have to be reserved for it. Thus altogether 20·48 + 11·06 + 30 = 61·54 million cubic yards, or 1,661·58 million cubic feet of the additional storage was the total estimated amount required to be reserved for the town, leaving 71·2 million cubic yards, or 1,922·4 million cubic feet, as the average annual amount available for irrigation.†

* The necessity for allowing for evaporation had been strangely lost sight of in all previous calculations. The proportion assumed is very nearly correct—*vide* paragraph 4 of Chapter VI.

† Proceedings, Madras Government, No. 1090, of May 1st, 1876.

7. The total additional supply provided by the works being, as above stated, estimated at 132·7 million cubic yards, the portions reserved for the purposes of municipal supply and irrigation were respectively $\frac{61·5}{132·7}$ and $\frac{71·2}{132·7}$, or in round numbers 46 and 54 per cent. This therefore became the proportion in which the shares of Capital and Revenue expenditure had to be divided.‡

‡ It will be shown in Chapter VI, paragraph 6, that the assumption that one-fifth more than the full capacity is received annually is incorrect, and that the additional amount stored is therefore less than 132·7 million cubic yards. The municipal share of the expenditure should properly, therefore, be higher than 46 per cent.

Of the total of the revised estimate, printed in Proceedings, Madras Government, No. 849 I., of December 9th, 1881, amounting to Rs. 18,54,463, the Provincial share is thus Rs. 8,72,358, divided into—

	Rs.
Direct charges	7,36,295
Indirect do.	1,36,063

§ Proceedings, Madras Government, No. 849 I., of December 9th, 1881.

The share of the annual maintenance charges debitable to Provincial is Rs. 3,342,§ so that the charges against Revenue amount to—

	Rs.
Interest on Rs. 7,36,295 at $4\frac{1}{2}$‖ per cent.	33,133
Maintenance charges	3,342
Total ...	36,475

‖ Under recent orders the charge for interest will be reduced to 4 per cent.

Against this the receipts from the Municipality are not likely to exceed ultimately Rs. 12,000, so that the Government contribution to the water-supply of Madras will be but little under Rs. 24,500 a year, and at the present time it is considerably more.

8. The following is a brief description of the arrangements for the conveyance of the town supply from the Red Hills Reservoir to within municipal limits. Mr. Fraser's original proposal was to take the municipal supply channel from the reservoir to the Spur Tank in Madras, and thence through properly prepared filter beds into a covered-in water basin. From this basin, which was to have held three or four days supply, the water was to pass to the pump well, placed at some central point, whence it might have been raised into an elevated cistern, and so distributed to various parts of the city.¶ The area of land to be taken up by the supply channel of this design was 56·2 acres.

¶ Proceedings, Madras Government, No. 1102, of April 11th, 1866.

But this arrangement did not suit the Municipality, which wished to have the water delivered at a higher level, so as to be able to distribute it by gravitation throughout the town, and thus avoid all the expense of pumping. A new line was therefore chosen, which however took up an area of 160·28** acres, and increased the land compensation from Rs. 15,887 †† to Rs. 42,270.‡‡

** 156·98 acres actually taken (Proceedings, Madras Government, No. 849 I., of December 9th, 1881).

‖ Proceedings, Madras Government, No. 492 I., of August 5th, 1881.

¶ Proceedings, Madras Government, No. 849 I., of December 9th, 1881.

9. The water on issuing from the municipal sluice in the Red Hills Tank is discharged into a basin 80 feet in diameter, which is divided by two parallel walls 6 feet apart. The space between was intended to be filled with charcoal, and thus act as a filter, but as this horizontal filtration proved to have no effect whatever on the water, the filtering medium was removed. The water in this basin is usually at a depth of $2\frac{1}{2}$ feet. From the basin the water falls over an ordinary shutter weir into the municipal supply channel. In section, this channel, which is not however very regular, is 6 feet broad at bottom, with side slopes of 2 to 1. The depth from the level of the top of the banks is $7\frac{1}{2}$ feet, so that the extreme breadth between the banks is 36 feet. The depth of flow is $3\frac{1}{2}$ feet. The outside slopes of the retaining banks are $1\frac{1}{2}$ to 1, whether in cutting or embankment. The length of the channel is 6 miles $33\frac{1}{3}$ chains, and the fall being at the rate of 3 inches per mile,* the level of the bed of the channel where it ends is 29·61.†

* The observed velocity is 58 feet per minute.

† The level of the sill of the municipal sluice is 31·31.

The water from the channel is delivered into a circular well 22 feet in diameter, called the masonry shaft. From this well, which is within municipal limits, the distribution takes place. The head available is 29·61 feet, the level of the bed of the channel, *plus* $3\frac{1}{2}$ feet, the depth of water in it, or a total of 33·11 feet above mean sea level. The main pipe from the masonry shaft is 42 inches in diameter and 1,485 yards in length. It there divides into two pipes of 36 and 30 inches diameter, respectively, from which minor offtakes proceed.

10. Large numbers of the inhabitants whose houses are situated in the vicinity of mains have the water brought into their houses. These house services, which are paid for by the house-owners, cost from Rs. 50 to Rs. 200 each, and in some cases as much as Rs. 700. Their adoption is developing, the figures being—

	No.
Up to April 1878	240
To end of April 1878	292
„ of „ 1879	428
„ of September 1880	574

In some cases people have joined together and paid the total cost of the main in their street as well as for the separate house services. The amounts so paid have been as high as Rs. 4,000. The water-tax is at the rate of 4 per cent. on the rental, and the amount allowed is 1,000 gallons for each 4 annas paid, but there is practically no measurement. For public use, cisterns, wall taps, and pillar fountains are employed, the numbers of each being 42, 84, and 113. The cisterns do not answer.

Water for non-domestic purposes is charged 2 annas per 1,000 gallons, and from Rs. 1,200 to Rs. 1,500 yearly is collected from this source.

11. The actual cost of the municipal distribution works has been Rs. 14,30,000 against the original estimate of Rs. 12,80,000—*vide* paragraph 14 of Chapter II. It is universally admitted however that the works need to be improved. An offtake from the Red Hills Reservoir at a lower level, a closed pipe to Madras, and pumping and filtering works, would seem to be what are most required, but the Municipality is scarcely in a position to devote the necessary funds to these objects. A scheme for the improvement of the work[illegible] prepared by the Municipal Engineer in 1877, at an estimated cost of Rs. 13,[illegible] but no action regarding it has yet been taken.

This account of the municipal works is from the Municipal Engineer's (J. A. Jones, Esq.,) report, printed in Proceedings, Madras Government, No. 1038 W., of April 22nd, 1881.

CHAPTER V.

THE IRRIGATION UNDER THE WORKS.

THE only point that need be noticed with regard to the irrigation under the project is the various estimates that have been formed from time to time of the area that might be irrigated. The point is one that has always been of the highest importance in connection with the works, for on account of the small demand for water made by the Municipality, and the extremely low price at which the supply has been given, the project has always virtually depended on the returns from irrigation to cover the charges for maintenance. Nevertheless, as the project was primarily undertaken for the supply of water to the city of Madras, the volume available for irrigation has of necessity been directly dependent on that which has had to be reserved for municipal consumption.

2. In Mr. Fraser's original estimate 60 million cubic yards* were said to be available for irrigation. This at 7,000† cubic yards per acre, which was Sir Arthur Cotton's allowance, would suffice for 8,57[illegible] res, on which the increased assessment, assumed at Rs. 7 per acre, would amount to nearly Rs. 60,000 a year. The raising of the sill of the municipal sluice in the Red Hills Tank 6 feet (from 25·31 to 31·31), noticed in the last chapter, involved however the sacrifice of $15\frac{1}{2}$ million cubic yards‡ available for irrigation. On the assumptions, that about 53§ million cubic yards would thus be left for use, and that the irrigating duty and water-rate remained as above stated, the probable return was thus reduced to Rs. 53,000.‖

* 1,620 million cubic feet.

† [illegible]9,000 cubic feet.

‡ $418\frac{1}{2}$ million cubic feet.

§ 1,431 million cubic feet.

‖ Minute by His Excellency the President in Council (Lord Napier), dated October 1868.

3. The Committee appointed in 1871, (G.O., No. 1518, of June 5th,) to report on the estimates for and the probable return from the works, arrived at a very different calculation of profit. Major Ryves, then Acting Chief Engineer for Irrigation, took¶ 160 million cubic yards as the average quantity of water stored by the tanks in one year, from which he deducted 45 million cubic yards for loss by evaporation, and 32 million cubic yards as the reserve for the town supply, leaving 83 million cubic yards available for irrigation, or enough for about 11,000 acres. The then estimated average area of old wet cultivation was 4,980 acres, so that about 6,000 acres of additional area were expected to be cultivated. The average increased assessment was now however reduced to Rs. $3\frac{2}{3}$, so that the net profit became only Rs. 18,000, thus:—

¶ Proceedings, Madras Government, No. 2171, of August 23rd, 1871.

	Rs.
6,000 acres at Rs. $3\frac{2}{3}$	22,000
Add average remission saved on old wet	7,500
	29,500
Deduct for maintenance ...	11,500
Net profit ...	18,000

4. In 1876 more reliable calculations as regards the amount of water available for irrigation were made, as was stated in the last chapter. The volume that could be depended upon amounted, it appeared, to 71·2 million cubic yards, or 1,922·4 million cubic feet. The former average area of irrigation was now assumed as 3,284 acres, though it is not very clear whence these figures were derived, and on the assumption that the increased water-supply available for irrigation would suffice for an area

NOTE.—The figures in this chapter, so far as regards acreage and revenue, refer to the project as a whole.

proportionate to that irrigated by the volume contained by the tanks when unimproved, the total area of irrigation was taken at 9,852 acres, giving an increased area of 6,568 acres, which would yield a gross revenue of Rs. 26,272.

The net return thus became :—

	Rs.
Irrigation revenue	26,272
Add average remission	7,500
	33,772
Deduct for maintenance ...	11,500
Total ...	22,272

5. It was not however till the revised estimates were submitted in 1881* that the correct return was calculated. The irrigable area is therein taken at 9,852 acres as above, but the average old cultivation is increased to 3,829 acres, leaving 6,023 as the ultimate increased irrigated area. Of this it is estimated that 4,926 acres will be double cropped, and the ultimate gross receipts are taken at Rs. 24,741. From this maintenance and collection charges have to be deducted. The average maintenance charges from 1870-71 to 1879-80 have been Rs. 8,969, excluding 1871-72 and 1873-74, in which years the outlay was abnormal. From this amount the assumed cost of maintenance of the old tanks, Rs. 1,704,† has to be deducted, leaving Rs. 7,265. This again has to be divided into the proportions of 54 per cent. chargeable to Irrigation or Imperial, and 46 per cent. chargeable to Provincial, for reasons that were explained in the last chapter. The irrigation share is thus Rs. 3,923. To this has to be added the charge for collection at 7·2 per cent. on revenue, or Rs. 1,781, making the total ultimate charge against revenue account Rs. 5,704, and the net ultimate earnings due to irrigation Rs. 19,037. The revised estimate amounts to Rs. 18,54,463, and the Imperial share of this in the above-mentioned proportion of 54 per cent. is Rs. 9,82,105, divided into—

* Proceedings, Madras Government, No. 849 I., of December 9th, 1881.

	Rs.
† Works, at 10 per cent. on average old revenue	1,311
Establishment, &c., at 30 per cent. on works	393
Total ...	1,704

Proceedings, Madras Government, No. 2650, of October 2nd, 1876.

	Rs.
Direct charges	8,32,944
Indirect charges	1,49,161

The estimated return from irrigation therefore amounts to 2·28 per cent. on Direct charges, and to 1·9 per cent. on Direct and Indirect charges.

6. The last year for which actual figures are available is 1879-80, and then the irrigated area under first crop was 2,648 acres, and under second crop was 2,769 acres. The gross receipts were Rs. 12,149, the maintenance charges were Rs. 3,441, and the collection charges Rs. 875, total Rs. 4,316, leaving Rs. 7,833 as the net receipts.

7. A description of the irrigation sluices has been given in Chapter I. The following is the description and cost of the conservancy establishment maintained for the works :—

		Rs.
1	Superintendent	25
1	Do.	15
4	Lascars at 7 rupees	28
2	Do. at 6 "	12
4	Do. at 5 "	20
	Total per month ...	100
	Total per year ...	1,200

CHAPTER VI.

HYDRAULIC DETAILS.

It will be sufficient to confine the hydraulic information to be given in this chapter to that which concerns the Red Hills Tank, which is by far the largest and most important of the two reservoirs. Colonel O'Connell's tables of area and contents at ½ foot intervals for the Cholavaram Tank are however given in Appendix C, as well as the corresponding information for the Red Hills Tank in Appendix B.

In addition to these tables the Monthly Statements of Receipts and Issues have been abstracted for the last five years in Appendix A, and after having first briefly explained how the abstract has been prepared, the conclusions to be drawn from it will then be summarised.

2. Colonel O'Connell's tables for the Red Hills (Appendix B) only show the difference of area and contents at each half-foot, but for the purposes of Appendix A it has been assumed that for each half-foot the differences between each 0·1 of a foot proceed in arithmetical progression. On this basis the contents at the levels shown in column 2 for the beginning of each month and in column 8 for the end of each month have been calculated and are therefore approximately correct to 0·05 of a foot. The method adopted does not give absolutely correct results, but is accurate enough for all practical purposes.

Similarly columns 16 and 17 show the areas corresponding to the contents in columns 3 and 9. Columns 4 and 5 show respectively the receipts through the supply channel and by means of rainfall. The former are obtained by direct measurement of the depth of water passing over the sill of the head-sluice in Cholavaram Tank; the latter by deducting these from the total receipts as calculated by the differences of water level. Column 6 shows the total receipts, and column 7 the sum of these receipts and of the volume in the tank at the beginning of the month.

Column 10 shows the loss during the month, *i.e.*, the difference between the above sum and the volume in the tank at the end of the month.

Columns 11 and 12 show the issues during each month to Irrigation and to the Municipality respectively by direct measurement.

Column 13 shows the total of these, and

Column 14 the difference between this and the total loss, which is therefore the loss due to evaporation and overflow.

Column 15 gives the proportion that the total volume lost bears to the total volume issued.

Column 18 gives the *mean* area of the tank during the month.

Column 19 shows the total depth over the mean area lost by evaporation during the month, and lastly

Column 20 shows the average depth evaporated daily.

3. The figures entered as above stated show discrepancies here and there; as for instance in June 1877 when the total at the end of the month is more than the sum of the receipts and of the volume in the reservoir at the beginning of the month; or as in December 1879, when the difference between the beginning and the end of the month is less than the consumption. But in a long series of somewhat elaborate measurements which cannot be constantly checked by a responsible officer, it is inevitable that some such discrepancies should occur, and they are not numerous enough to prejudice the general accuracy of the results.

Again, as the discharge over the weir and through the weir vents has not been gauged, no calculation has been made as regards the amount of evaporation for those months in which surplus is discharged. This removes to a certain extent the monsoon months—October, November, and December—from the calculations, to which may be added September, when heavy rain often falls.

The general result obtained is however as follows.

That in the five years the average daily evaporation is 0·28 of an inch, and as the average mean area is 149·5026 million square feet, it would result that the average daily loss by evaporation is 3·4884 million cubic feet.*

* But see next paragraph.

The average result month by month is as follows :—

How obtained.	Average daily evaporation. INCHES.
From four Januarys	0·24
„ two Februarys	0·24
„ five Marchs	0·26
„ five Aprils	0·3
„ five Mays	0·37
„ four Junes	0·3
„ four Julys	0·33
„ five Augusts	0·32
„ one September	0·38
„ two Octobers	0·27
„ one November	0·27
„ two Decembers	0·13

Taken as a whole these results accord very fairly with what might be expected, the evaporation increasing gradually up to the hot months and then gradually subsiding. The figures for September, for which it has been possible to make only one calculation, are undoubtedly too high.

4. The statement further shows that the proportion the average volume lost bears to the average volume used is as high as 5·8 to 1, but this includes 1877 when the issues to irrigation were stopped for some months and those to the Municipality were very limited owing to the low level of water in the reservoir, and when therefore the issues in each case were very much below the average (see below). Excluding 1877 this proportion that the volume lost bears to the volume used is 2·888 to 1.

The average receipts during the five years were :—

	Million Cubic Feet.
From Supply Channel	889·2994
Rainfall	627·7973
Total ...	1,517·0967

The average issues were—

	Million Cubic Feet.
To Irrigation	405·591
„ Municipality	131·8222
Total ...	557·4132

The proportion of average issues to average receipts is thus 1 to 2·82, which shows a very close agreement with what is practically the same proportion last given. The proportion issued to the Municipality to that used for Irrigation is as 1 to 3·07.

The difference between the receipts and issues *should* represent the loss by evaporation *plus* the discharge over the weir. This difference is on the average 979·6835 million cubic feet a year, while the average evaporation obtained from column 14 of Appendix A is 913·4078 million cubic feet. This leaves 66·2757 million cubic feet as the average yearly surplus discharge. The average yearly evaporation as last given represents a daily evaporation of 0·208 of an inch as against 0·28 of an inch as given previously. From this the general conclusion may be derived that the daily loss of depth due to evaporation is over 0·2 of an inch and under 0·3. Probably one-quarter of an inch might be assumed with fair accuracy.

5. The following figures show the quantity of water draining into the tank after a heavy fall of rain. They are obtained from Colonel O'Connell's report on the cyclone of May 1877, printed in Proceedings, Madras Government, No. 38 I., of January 14th, 1878. This is the only occasion on which observations have been made on

this interesting point, and though results of a like nature might be deduced from the figures given in Appendix A, it is not considered that the conclusions so derived would be sufficiently reliable to be of value. In calculations of this sort, a somewhat near approach to accuracy is essential, and this can scarcely be considered as attained, unless observations have been specially taken with reference to the object in view.

The rainfall at the Red Hills Tank during the cyclone of May 1877 was :—

	INCHES.
On May 17th	1·00
Do. 18th	12·03
Do. 19th	4·88
Total ...	17·91

The rise in the surface of the water during this cyclone was entirely due to the drainage from the catchment basin of 23 square miles, which includes the area of the reservoir itself.

The rise and the corresponding drainage are shown in the following table :—

Date.	Level of water surface at 6 A.M.	Corresponding volume in million cubic feet.	Daily difference of level of water surface in feet.	Additional volume entering reservoir. Per day in million cubic feet.	Additional volume entering reservoir. Cubic feet per second.	Drainage in inches over catchment of 23 square miles, which includes reservoir, represented by column 5.
1	2	3	4	5	6	7
May 17th	27·30	253·6886	...	...	..	...
Do. 18th	30·95	517·0018	3·65	263·3132	3,047	4·92
Do. 19th	34·25	838·0862	3·30	321·0844	3,766	6·009
Do. 20th	34·79	921·3674	0·74	83·2812	964	1·56

The quantity draining off in the three days amounts to a total of 12·489 inches. Water continued to run slowly off the catchment basin for nearly a week after the rain had ceased to fall, but the total quantity thus run off did not exceed one-third of an inch, so that the total quantity run off fell short of 13 inches. Taking each day separately the figures in column 7 for the 18th and 19th of May give coefficients of discharge of 377 and 466 respectively for Ryves' formula

$$D = CM^{\frac{2}{3}}$$

and co-efficients of 290 and 359 respectively for Dickens' formula

$$D = CM^{\frac{3}{4}}$$

It is more than probable however that these co-efficients are too small to represent the maximum discharge, which, especially in the case of cyclonic rain, would doubtless considerably exceed the average discharge from which they are obtained.

The table shows that the average rate at which the rain was discharged from the drainage basin between the 18th and 19th of May was 6·009 inches per diem.

The figures given above furnish the nearest reply possible to the information asked for in paragraph IV (V) of Circular No. XXX, dated September 24th, 1880, from the Government of India. The percentage which the volume stored bears to the volume falling on the catchment area, excluding that of the reservoir, after certain recorded falls of rain is there referred to. But accurate information on this point is almost impossible to obtain except in the case of a very small catchment. In the case of a large area no reliance could be placed on the results unless the rainfall were registered at several stations. In the instance given it has been supposed that the whole of the rain that fell was stored, but if the registered rainfall at the reservoir of 17·91 inches was taken over the whole catchment, the percentage stored would be 69.

6. The following figures comparing the average consumption for irrigation and municipal use with the storage reserved will be of interest.

The capacity of the reservoir when full is 2,744·8911 million cubic feet, of which 2,191·9311 are increased capacity due to the improvements. This increase divided in the proportions of 54 and 46 as explained in Chapter IV gives 1,183·6428 million cubic feet as reserved for irrigation, and 1,008·2883 for municipal use. The average annual consumption in each case given in paragraph 4 above is therefore 34·2 per cent. and 13 per cent. of the reserve respectively.

But it is to be observed that the proportions in which the whole volume is divided do not appear to be correct. It was assumed in making the calculation, as explained in paragraph 6 Chapter IV, that $\frac{1}{3}$ more than the whole contents of the reservoirs was annually stored, but from paragraph 4 above it appears that the average annual volume stored in the Red Hills Reservoir, which may be taken as representative, is only 1,517·0967 million cubic feet, or 69 per cent. of the whole capacity of the reservoir. As, however, the level of the water is never supposed to fall below 34·31, it would be sufficient to assume the full reservoir as the volume annually available, and the average amount actually reserved for Municipal use would then be :—

	Million. Cubic Feet.
Volume below *34·31 ... ... =	851·58
†2·888 times average consumption	380·70
Total ...	1,232·28

† Paragraph 4 above. * *Vide* paragraph 6 of Chapter IV.

which is rather more than 56 per cent. of the increased capacity. This therefore leaves only 44 per cent. of the storage available for irrigation, and the proportion of volume used to volume reserved becomes 42 per cent. for irrigation and 10·7 per cent. for municipal use.

7. This Monograph is followed by three Appendices—

APPENDIX A.—Statement of Receipts and Issues of the Red Hills Reservoir from 1877 to 1881.

„ B.—Colonel O'Connell's Tables of Area Contents at Half-foot intervals for Red Hills Reservoir.

„ C.—Colonel O'Connell's Tables of Area Contents at Half-foot intervals for Cholavaram Reservoir.

Also by two plates—

PLATE I.—Catchment Basin of System.

„ II.—Component Works of System.

(Signed) C. VINCENT,
for Chief Engineer for Irrigation.

June 1882.

APPENDIX A.

Statement of Receipts and Issues of the Red Hills Reservoir Month by Month during 1877 to 1881 inclusive, showing the Volume of Water lost by Evaporation.

N.B.—All volumes are stated in Million Cubic Feet.
Areas ... ... Square Feet.
Levels are referred to Mean Sea Level.

Month.	Water Level in Reservoir at beginning of Month.	Corresponding Volume.	Receipts during Month. Supply Channel.	Rainfall.	Total.	Total Columns 3 and 6.	Water Level in Reservoir at end of Month.	Corresponding Volume.	Difference, Columns 7 and 9.	Issues during Month. To Irrigation.	To Municipality.	Total.	Loss by Evaporation, difference between Columns 10 and 13.	Proportion to unity of Volume used (Column 12) to Volume lost (Column 10).	Area of Reservoir at beginning of Month.	Area of Reservoir at end of Month.	Mean Area.	Evaporation in Inches over Mean Area during Month, Column 14 ÷ Column 18.	Average Daily Evaporation in Inches.	Remarks.
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
1877.									The *plus* figures are excluded from the Totals in this Column.											
January ..	30·65	488·571	..	..	..	488·571	29·83	424·8108	— 63·7602	9·856	[illegible]387	13·6447	50·1155	4·6729	82·8986	76·888	79·8933	7·52	0·24	The discharge over the weir and through the weir vents not having been gauged, and the weir moreover having been breached in November 1877, the figures for those months in which surplus water was discharged are valueless. The fact of discharge is noticed in each case when recorded.
February ..	29·81	424·8108	..	..	..	424·8108	29·05	366·1727	— 68·6381	5·681	3·315	8·996	59·6421	7·6298	76·888	72·1242	74·5061	9·6	0·34	
March	29·02	366·1727	..	..	..	366·1727	28·36	318·1683	— 48·0044	0·599	3·6229	4·2219	43·7825	11·3703	72·1242	66·246	69·1851	7·59	0·24	
April	28·35	318·1683	..	..	..	318·1683	27·52	266·8321	— 51·3362	0·355	3·4916	3·8466	47·4896	13·3458	66·246	62·4686	64·3573	8·85	0·29	
May	27·49	266·8321	119·583	705·1617	824·7447	1,091·5768	35·16	935·1865	—156·3903	0·58	1·7112	2·2912	154·0991	68·2569	62·4686	117·595	90·0318	20·53	0·66	Cyclone. { Rainfall on 17th 1 inch. Do. 18th 12·03 inches. Do. 19th 4·88 do.
June	36·33	1,083·267	221·1	..	221·1	1,304·367	38·1	1,327·943	+ 23·576	..	[illegible]981	9·981	Discrepancy shown in Column 10 not explained.		128·038	142·7882	135·4131	..	..	
July	38·07	1,327·943	..	..	..	1,327·943	37·07	1,188·8481	— 139·0949	..	[illegible]574	7·574	131·5209	18·3648	142·7822	135·2624	139·0223	11·35	0·36	
August	37·07	1,188·8481	..	..	..	1,188·8481	36·42	1,096·295	— 92·5531	..	[illegible]3094	7·3094	85·2437	12·6622	135·2624	128·9352	132·0988	7·74	0·25	
September ..	36·4	1,096·295	18·1696	..	18·1696	1,114·4646	38·17	1,342·1912	+ 227·7266	..	8·2124	8·2124	See remark for June.		128·9352	143·4996	136·2174	..	..	
October ..	38·26	1,342·1912	26·65	..	26·65	1,368·8412	42·6	2,040·3403	+ 671·4991	14·685	[illegible]7837	22·2687	Do.		143·4996	169·336	156·4178	..	..	
November ..	42·6	2,040·3403	756	54	810·	2,850·3403	42·73	2,057·5175	— 792·8228	..	7·887	7·887	Discharge over weir.		169·336	172·8472	171·0916	..	..	The waste weir was breached.
December ..	42·84	2,074·6947	..	165·916	165·916	2,240·6107	43·31	2,162·054	— 78·5567	16·882	[illegible]782	23·664	54·8927	3·3196	173·434	176·394	174·914	3·76	0·12	
Totals ..	416·89	12,018·1342	1,141·5026	925·0777	2,066·5803	14,084·7145	428·25	13,526·3595	1,491·1567	48·638	[illegible]·389	119·8969	626·7861	139·6223	..	..	1,423·1486	76·94	2·51	
Averages ..	34·74	1,001·5111	..	..	..	..	..	..	..	6·948	5·9382	..	..	17·4529	..	..	118·5957	9·62	0·31	
1878.																				
January ..	43·28	2,162·054	..	..	..	2,162·054	42·34	1,988·8088	— 173·2452	40·022	[illegible]·068	49·12	124·1252	3·5269	176·394	170·5	173·447	8·58	0·27	
February ..	42·31	1,988·8088	9·311	..	9·311	1,998·1198	42·8	2,074·6947	+ 76·5749	39·679	[illegible]492	49·971	Discrepancy in Column 10 not explained.		170·5	173·434	171·967	..	..	
March	42·78	2,074·6947	..	..	..	2,074·6947	41·8	1,904·3838	— 170·3109	66·388	[illegible]772	78·56	91·7509	2·1679	173·434	167·59	170·512	6·45	0·2	
April	41·77	1,904·3838	..	..	..	1,904·3838	40·4	1,675·7727	— 228·6111	74·733	[illegible]·69	89·423	139·1881	2·5565	167·59	159·979	163·784	10·19	0·34	
May	40·36	1,675·7727	..	10·687	10·687	1,686·4597	39·43	1,519·7741	— 166·6856	58·831	[illegible]·976	73·807	92·8786	2·2584	159·979	152·2682	156·1236	7·13	0·23	
June	39·39	1,519·7741	..	..	..	1,519·7741	37·99	1,313·7947	— 205·9794	80·337	[illegible]·412	94·749	111·2304	2·1739	152·2682	142·0648	147·1665	9·07	0·3	
July	38·08	1,327·943	..	114·036	114·036	1,441·979	37·49	1,243·5927	— 198·3863	39·756	[illegible]·871	52·627	145·7593	2·7697	142 7822	138·5048	140·6435	12·43	0·4	
August	37·46	1,243·5927	..	103·836	103·836	1,347·5287	37·04	1,175·3677	— 172·161	20·016	[illegible]·290	32·306	139·855	5·3290	138·5048	134·3496	136·4272	12·30	0·39	
September ..	37·04	1,175·3677	605·197	322·844	928·041	2,103·4087	41·89	1,921·2688	— 182·1399	27·18	[illegible]·318	38·498	143·6419	4·7309	134·3496	168·172	151·2608	11·38	0·38	
October	41·89	1,921·2688	127·27	161·263	288·533	2,209·8018	42·68	2,057·5175	— 152·2843	30·863	[illegible]·137	42·99	109·2943	3·5423	168·172	172·8472	170·5096	7·69	0·25	
November ..	42·66	2,057·5175	208·656	..	208·656	2,266·1735	42·88	2,092·1666	— 174·0069	41·056	[illegible]·513	53·369	120·6379	3·2604	172·8472	174·026	173·4366	8·34	0·27	
December ..	42·88	2,092·1666	..	..	..	2,092·1666	42·25	1,971·9238	— 120·2428	44·879	[illegible]·209	57·088	63·1548	2·1062	174·026	169·918	171·972	4·40	0·14	
Totals ..	489·9	21,143·3444	950·4340	712·666	1,663·1000	22,806·4444	488·99	20,939·0659	1,944·0434	563·74	[illegible]·768	712·508	1,181·5164	34·4221	..	..	1,927·2498	97·96	3·17	
Averages ..	40·82	1,761·9453	..	..	..	..	..	..	..	46·9783	[illegible]·397	..	..	3·1293	..	..	160·6041	8·91	0·29	
1879.																				
January ..	42·22	1,971·9238	..	17·935	17·935	1,999·8588	41·56	1,854·5978	— 145·261	21·686	[illegible]·13	34·399	110·862	4·2228	169·918	165·8596	167·8888	7·92	0·25	
February ..	41·54	1,854·5978	..	..	..	1,854·5978	40·91	1,756·1746	— 98·4032	37·34	[illegible]·38	48·378	50·0252	2·0340	165·8596	162·4188	164·1392	3·65	0·13	
March	40·89	1,756·1746	219·033	19·57	238·603	1,994·7776	41·4	1,838·0025	— 156·7751	47·777	[illegible]·59	60·536	96·2391	2·5897	162·4188	165·2828	163·8508	7·04	0·22	
April	41·36	1,838·0025	..	..	..	1,838·0025	40·29	1,659·7492	— 178·2533	82·677	[illegible]·14	93·681	84·5723	1·9017	165·2828	159·012	162·1474	6·25	0·21	Cyclone; rainfall on 20th, 8·75 inches. Do. on 21st, 0·5 do.
May	40·26	1,659·7492	..	115·923	115·923	1,775·6722	39·98	1,612·5915	— 163·0807	52·322	[illegible]·68	64·55	98·5307	2·5264	159·012	156·7518	157·8819	7·48	0·24	
June ..	39·96	1,612·5915	..	..	..	1,612·5915	39·09	1,474·48	— 138·1115	36·9	[illegible]·63	48·638	89·4735	2·8396	156·7518	150·0536	153·4027	6·99	0·23	
July ..	39·06	1,474·48	..	73·046	73·046	1,547·526	38·52	1,385·7281	— 161·7979	46·241	[illegible]·97	60·748	101·0499	2·6634	150·0536	145·6694	147·8615	8·2	0·27	
August ..	38·49	1,385·7281	12·15	34·984	47·134	1,432·8621	38·28	1,356·5096	— 76·3525	28·437	[illegible]·26	42·389	33·9635	1·8019	145·6694	144·217	144·9432	2·81	0·09	
September ..	38·38	1,371·1188	6·917	..	6·917	1,378·0358	41·69	1,887·7885	+ 509·7527	61·871	[illegible]·74	76·046	Discrepancy in Column 10 not explained.		144·9432	167·0132	155·9782	..	..	
October ..	41·66	1,887·7885	..	260	260	2,147·7885	43·4	2,179·9788	+ 52·1903	11·055	[illegible]·36	23·141	Do.	do.	167·0132	177·5386	172·2759	..	..	Surplus over weir on 31st.
November ..	43·45	2,179·9788	..	852·719	852·719	3,032·6978	43·22	2,144·5821	— 888·1157	..	[illegible]·2	9·892	..	..	177·5386	175·802	176·6703	..	..	Do. almost throughout the month.
December ..	43·16	2,144·5821	..	..	..	2,144·5821	43·04	2,109·6384	— 34·9437	30·466	[illegible]·687	39·153	Difference (Column 10) less than consumption. Discrepancy not explained.		175·802	174·618	175·210	..	..	
Totals ..	490·43	20,136·7157	238·100	1,374·177	1,612·277	21,748·9927	491·38	21,259·8211	2,041·0946	456·772	[illegible]·778	601·551	664·7162	20·5795	..	..	1,942·2499	50·34	1·64	
Averages ..	40·87	1,678·0596	..	..	..	..	..	..	..	41·525	[illegible]·34	..	..	2·5724	..	..	161·8542	6·29	0·205	
1880.																				
January ..	43·02	2,109·6384	..	27·446	27·446	2,137·0844	42·4	2,005·986	— 131·0984	[illegible]	[illegible]	43·231	87·8174	3·0290	174·618	171·0868	172·8524	5·98	0·19	Evaporation for this month evidently incorrect, so omitted from averages.
February ..	42·39	2,005·986	..	..	..	2,005·986	42·07	1,955·0388	— 50·9472	[illegible]	[illegible]	16·5	8·7842	..	171·0868	169·336	170·2114	..	..	
March	42·06	1,955·0388	..	..	..	1,955·0388	41·11	1,788·7909	— 166·2479	[illegible]	[illegible]	[illegible]	[illegible]	1·7608	169·336	163·5624	166·4492	5·11	0·16	
April	41·06	1,788·7909	..	..	..	1,550·2636	39	1,525·7647	238·5273	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	163·5624	163·5624	163·5624	0·56	0·33	
May	39·58	1,550·2636	..	..	..	1,299·5465	36·06	1,058·1006	— 241·4459	[illegible]	[illegible]	[illegible]	140·6179	2·4639	153·7096	2·0648	147·9164	11·4	0·39	
June	37·93	1,299·5465	..	..	..	1,058·1006	36·33	1,083·267	+ 25·1664	31·[illegible]	[illegible]	[illegible]	153·3199	2·7398	141·3474	126·2744	133·8109	13·74	0·45	
July	36·09	1,058·1006	..	..	..	Discrepancy in Column 10 not explained.							Discrepancy in Column 10 not explained.		126·2744	128·038	127·1562	..	..	
August	36·39	1,096·295	..	..	..	1,096·295	35·66	996·0587	—100·2363	23·343	[illegible]·9	40·185	60·0513	2·4943	128·9352	121·8962	125·4157	5·74	0·18	The loss by evaporation is so high that the figures are evidently wrong, and the averages are therefore not taken.
September ..	35·65	996·0587	690·62	24·32	714·94	1,710·9987	37·09	1,188·8481	—522·1506	15·966	[illegible]·0	35·425	486·7256	..	121·8962	135·2624	128·5793	..	..	
October	37·11	1,188·8481	..	8·3	8·3	1,197·1481	36·93	1,161·8872	— 35·2609	21·223	2·[illegible]0	44·873	..	..	135·2624	133·4368	134·3496	..	..	Difference (Column 10) less than consumption. Discrepancy not explained.
November ..	36·96	1,161·8872	947·194	54	1,001·194	1,263·0812	44·14	2,307·1827	+ 144·1015	..	1·322	10·322	See remark for July.		133·4368	185·606	159·5214	..	..	Surplus over weir on 28th, 29th, and 30th.
December ..	44·24	2,325·6845	144·866	..	144·866	2,470·5505	43·68	2,233·7531	— 236·7974	5·889	[illegible]·698	13·587	..	..	186·1875	180·9724	183·5799	..	..	Surplus over weir on several days.
Totals ..	472·51	18,536·3383	1,782·68	114·066	1,896·746	20,433·0843	473·12	18,643·1714	1,959·1808	499·154	16·743	662·897	1,139·5615	14·6962	..	..	1,808·4962	51·83	1·67	
Averages ..	39·37	1,544·6948	..	..	..	..	..	..	..	45·378	1·[illegible]45	..	..	2·4494	..	..	150·708	8·64	0·28	
1881.																				
January ..	43·8	2,251·6779	..	..	..	2,251·6779	43·76	2,233·7531	— 17·9248	27·575	[illegible]·07	35·645	Difference (Column 10) less than consumption. Discrepancy not explained.		182·117	180·9274	181·5222	..	..	Surplus over weir throughout the month.
February ..	43·74	2,233·7531	..	..	..	2,233·7531	43·19	2,144·5821	— 89·1710	20·814	[illegible]·14	28·928	..	..	180·9274	175·802	178·3647	..	..	Surplus over weir on several days.
March	43·17	2,144·5821	..	..	..	2,144·5821	42·21	1,971·9238	— 172·6583	37·795	[illegible]·43	48·738	123·9203	3·5426	175·802	169·918	172·860	8·59	0·27	
April	42·18	1,971·9238	..	..	..	1,971·9238	40·92	1,756·1746	— 215·7492	59·896	[illegible]·81	72·877	142·8722	2·9604	169·918	162·4188	166·1684	10·31	0·34	
May	40·87	1,756·1746	..	..	..	1,756·1746	39·4	1,519·7741	— 236·4005	65·001	[illegible]·6	81·061	155·3395	2·9162	162·4188	152·2682	157·3435	11·85	0·38	
June	39·34	1,504·4294	..	..	..	1,504·4294	38·22	1,342·1912	— 162·2382	70·424	[illegible]·99	84·923	77·3152	1·9104	151·524	143·4996	147·5118	6·28	0·21	
July	38·2	1,342·1912	..	..	..	1,342·1912	37·04	1,175·3677	— 166·8235	49·482	[illegible]·56	59·638	107·1855	2·7972	143·4996	134·3496	138·9246	9·25	0·29	
August	37·01	1,175·3677	217·617	..	217·617	1,392·9847	36·48	1,109·3229	— 283·6618	31·547	[illegible]·27	41·174	242·4878	6·8893	134·3496	129·8324	132·0910	22·02	0·71	
September ..	36·46	1,109·3229	97·2	..	97·2	1,206·5229	37·88	1,299·5465	+ 93·0236	12·298	[illegible]·36	21·034	Discrepancy in Column 10 not explained.		129·8324	141·3474	135·5899	..	..	
October ..	37·86	1,299·5465	..	..	..	1,299·5465	36·71	1,135·3788	— 164·1677	48·033	[illegible]·96	58·829	105·3387	2·7906	141·3474	131·6268	136·4871	9·26	0·29	
November ..	36·67	1,135·3788	18·954	13	31·954	1,167·3328	42·45	2,005·986	+ 838·6532	23·906	[illegible]·4	24·446	See remark for September.		131·6268	171·0868	151·3568	..	..	
December ..	42·42	2,005·986	..	..	..	2,005·986	42·27	1,988·8088	— 17·1772	12·881	[illegible]·4	23·021	See remark for January.		171·0868	170·5	170·7934	..	..	
Totals ..	481·72	19,930·3340	333·771	13	346·771	20,277·1050	480·93	19,682·8096	1,525·9722	459·652	13·662	590·314	954·4592	23·8067	..	..	1,869·0134	77·56	2·49	
Averages ..	40·14	1,660·8611	..	..	..	..	..	..	..	38·304	1·[illegible]88	..	..	3·4009	..	..	155·7511	11·08	0·35	

APPENDIX B.

RED HILLS TANK.

TABLE showing Water Surface, Areas, and Cubical Contents at half foot vertical intervals up t crest of new Calingulah.

Height above Mean Sea Level.	Difference of Area for each half foot.	Area at Level in Column 1.	Difference of Cubical Contents at each half foot.	Contents at Level in Column 1.
1	2	3	4	5
FEET.	MILLION SQ. FT.	MILLION SQ. FT.	MILLION C. FT.	MILLION C. FT.
22·31		25·503		25·5015
	3·847		13·6970	
22·81		29·350		39·1985
	4·117		15·6873	
23·31		33·467		54·8858
	4·387		17·8125	
23·81		37·854		72·6983
	4·657		20·0729	
24·31		42·511		92·7712
	4·927		22·4682	
24·81		47·438		115·2394
	5·197		24·9987	
25·31		52·635		140·2381
	2·160		26·8557	
25·81		54·795		167·0938
	2·203		27·9465	
26·31		56·998		195·0403
	2·247		29·0590	
26·81		59·245		224·0993
	2·290		30·1932	
27·31		61·535		254·2925
	2·334		31·3491	
27·81		63·869		285·6416
	2·377		32·5267	
28·31		66·246		318·1683
	3·459		33·7912	
28·81		69·705		351·9595
	3·548		35·5329	
29·31		73·253		387·4924
	3·635		37·3184	
29·81		76·888		424·8108
	3·723		39·1477	
30·31		80·611		463·9585
	3·811		41·0208	
30·81		84·422		504·9793
	3·899		42·9377	
31·31		88·321		547·9170
	3·580		45·0528	
31·81		91·901		592·9698
	3·651		46·7604	
32·31		95·552		639·7302
	3·722		48·5036	
32·81		99·274		688·2338
	3·792		50·2824	
33·31		103·066		738·5162
	3·864		52·0968	
33·81		106·930		790·6130
	3·935		53·9468	
34·31		110·865		844·5598
	4·177		56·4762	
34·81		115·042		901·0360
	4·255		58·5842	
35·31		119·297		959·6202

Table showing Water Surface, Areas, and Cubical Contents at half foot vertical intervals up to crest of new Calingulah—*cont.*

Height above Mean Sea Level.	Difference of Area for each half foot.	Area at Level in Column 1.	Difference of Cubical Contents at each half foot.	Contents at Level in Column 1.
1	2	3	4	5
FEET.	MILLION SQ. FT.	MILLION SQ. FT.	MILLION C. FT.	MILLION C. FT.
35·81	4·332	123·629	60·7308	1,020·3510
36·31	4·409	128·038	62·9160	1,083·2670
36·81	4·486	132·524	65·1398	1,148·4068
37·31	4·564	137·088	67·4022	1,215·8090
37·81	3·542	140·630	69·4592	1,285·2682
38·31	3·587	144·217	71·2414	1,356·5096
38·81	3·631	147·848	73·0462	1,429·5558
39·31	3·676	151·524	74·8736	1,504·4294
39·81	3·721	155·245	76·7236	1,581·1530
40·31	3·767	159·012	78·5962	1,659·7492
40·81	2·835	161·847	80·1173	1,739·8665
41·31	2·859	164·706	81·5407	1,821·4072
41·81	2·884	167·590	82·9766	1,904·3838
42·31	2·910	170·500	84·4250	1,988·8088
42·81	2·934	173·434	85·8859	2,074·6947
43·31	2·960	176·394	87·3593	2,162·0540
43·81	5·723	182·117	89·6239	2,251·6779
44·31	5·815	187·932	92·5083	2,344·1862
44·81	5·906	193·838	95·4841	2,439·6703
45·31	5·997	199·835	98·5513	2,538·2216
45·81	6·088	205·923	101·7098	2,639·9314
46·31	6·180	212·103	104·9597	2,744·8911

APPENDIX C.
CHOLAVARAM TANK.

TABLE showing Water Surface, Areas, and Cubical Contents at half foot vertical intervals up to crest of new Calingulah.

Height above Mean Sea Level.	Difference of Area for each half foot.	Area at Level in Column 1.	Difference of Cubical Contents at each half foot.	Contents at Level in Column 1.
1	2	3	4	5
FEET.	MILLION SQ. FT.	MILLION SQ. FT.	MILLION C. FT.	MILLION C. FT.
43·68		17·415		26·123
	1·147		9·000	
44·18		18·562		35·123
	1·183		9·583	
44·68		19·745		44·706
	1·221		10·184	
45·18		20·966		54·890
	1·257		10·803	
45·68		22·223		65·693
	1·293		11·441	
46·18		23·516		77·134
	1·331		12·096	
46·68		24·847		89·230
	1·284		12·743	
47·18		26·131		101·973
	1·317		13·394	
47·68		27·448		115·367
	1·349		14·060	
48·18		28·797		129·427
	1·382		14·743	
48·68		30·179		144·170
	1·414		15·442	
49·18		31·593		159·612
	1·447		16·157	
49·68		33·040		175·769
	1·241		16·829	
50·18		34·281		192·598
	1·263		17·455	
50·68		35·544		210·053
	1·286		18·092	
51·18		36·830		228·145
	1·309		18·741	
51·68		38·139		246·886
	1·332		19·401	
52·18		39·471		266·287
	1·354		20·073	
52·68		40·825		286·360
	1·194		20·710	
53·18		42·019		307·070
	1·211		21·311	
53·68		43·230		328·381
	1·228		21·920	
54·18		44·458		350·301
	1·245		22·538	
54·68		45·703		372·839
	1·262		23·165	
55·18		46·965		396·005
	1·279		23·800	
55·68		48·244		419·804
	1·532		24·502	
56·18		49·776		444·306
	1·556		25·273	
56·68		51·332		469·579

Table showing Water Surface, Areas, and Cubical Contents at half foot vertical, &c.—*cont.*

Height above Mean Sea Level.	Difference of Area for each half foot.	Area at Level in Column 1.	Difference of Cubical Contents at each half foot.	Contents at Level in Column 1.
1	2	3	4	5
FEET.	MILLION SQ. FT.	MILLION SQ. FT.	MILLION C. FT.	MILLION C. FT.
	1·580		26·058	
57·18		52·912		495·637
	1·604		26·854	
57·68		54·516		522·491
	1·628		27·661	
58·18		56·144		550·152
	1·651		28·481	
58·68		57·795		578·633
	1·520		29·277	
59·18		59·315		607·910
	1·539		30·071	
59·68		60·854		637·981
	1·559		30·875	
60·18		62·413		668·856
	1·579		31·689	
60·68		63·992		700·545
	1·599		32·513	
61·18		65·591		733·058
	1·619		33·347	
61·68		67·210		766·405

PLATE. 1.

SKETCH MAP

SHOWING CATCHMENT BASINS OF

MADRAS WATER SUPPLY AND IRRIGATION EXTENSION PROJECT.

SCALE - 4 - MILES TO AN INCH.

5 0 5 10 15 20 MILES

TRANSFER BY T. CUTHANDAPANY AND LITHO BY R. J. BALDREY, BOYS' LITHO PRESS CHEPAUK MADRAS AUGUST 1882.

KARVETNAGAR

MAKISDRUG

NAGARI

NAGARI RIVER

PUDUR

RAJAPALLIUM

NOCHILEY

RAMAKISTNARAJAPETTAH.

PUMBADU

AREA 837 SQS MLS

TIRUTANI (34.70)

TIRUTANI RIVER

NORTH WESTERN RAILWAY LINE

SHOLINGHUR

KODAKAL

POLUR (37.86)

POLIPAKKAM

ARKONAM

KUTTAMBAKKAM

AREA 258 SQS MLS

KAVERIPAK TANK.

KAVERIPAK (33.40)

ARCOT

ANICUT

SUPPLY CHANNEL

CHUKRAMELLUR

PALAR RIVER

SOUTH INDIAN RAILWAY

CONJEEVER

MAPURAM

KISTNAPURAM

MADRAS RAILWAY

KORTALAYAR RIVER

POSHALI

KASAVARAM ANICUT (41.16)

COOUM RIVER

TIRUVALLUR

TRIPASUR

SIVANVAYAL

KATANKAL SUPPLY CHANNEL

BOOSIKAL

AREA 62 SQS MLS

AREA 44 SQS MLS

TAMARAPAKKAM ANICUT (38.25)

KORTALAYAR RIVER

AREA 11 SQS MLS

CHOLAVARAM TANK

AREA 23 SQS MLS

RED HILLS TANK

ENNORE

MADRAS

BAY OF BENGAL

(Office of the Chief Engineer for Irrigation) Chepauk June 1882

(Govt Lithic Dept Chepauk August 1882)

For Chief Engr for Irrigation.

REFERENCES.

			AREA IN SQS MILES.
LIGHT SHADE OF BLUE. CATCHMENT BASIN OF KORTALAYAR ABOVE TAMARAPAKKAM ANICUT			1105
DARKER — Dº —	Dº	OF REDHILLS TANK	23
	Dº	OF CHOLAVARAM TANK	11
NARROW BAND OF BLUE	Dº	OF KATANKAI	62
	Dº	OF BOOSIKAL	44
		TOTAL	1245
DEDUCT AREA OF CATCHMENT ABOVE KASAVARAM ANICUT MARKED			268
LEAVING AREA OF CATCHMENT BASIN OF PROJECT			977 SQS MILES.

THE FIGURES IN BRACKETS DENOTE RAIN FALL IN INCHES.

PLATE II.

SKETCH MAP

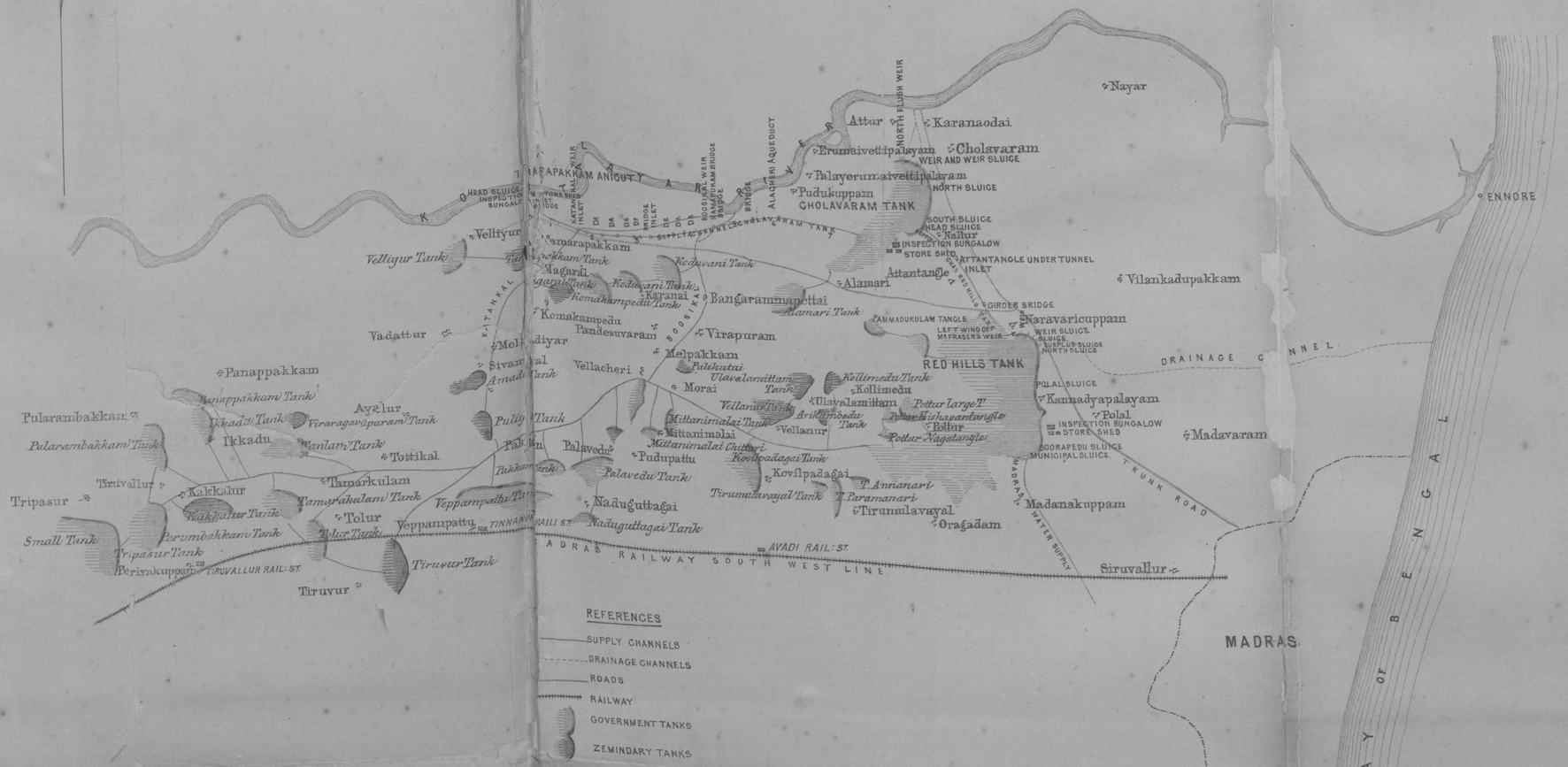
OF

MADRAS WATER SUPPLY AND IRRIGATION EXTENSION PROJECT

SCALE 2 MILES TO AN INCH

0 1 2 3 4 5 6 7 8 9 MILES

TRANSFER BY T. THAGARAJOO AND LITHR BY R. J. BALDREY GOVT. LITHR DEPT. MADRAS 1882.



REFERENCES

- SUPPLY CHANNELS
- DRAINAGE CHANNELS
- ROADS
- RAILWAY
- GOVERNMENT TANKS
- ZEMINDARY TANKS

Office of the Chief Engineer for Irrigation
Chepauk June 1882

W. S. Waldrey
Supt and Manager

Govt Lith Dept Chepauk
August 1882

For Chief Engr for Irrigation

50

E.E.D.

Bud 2/4/7 4

M. E. I.

So far as I can see the paper will be eventually communicated to

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Finl Dept
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Rev. Board
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O.L.S. 13.9.
E.J. 21/9.

E) 1

It is sufficiently
clear from the call originally
made by the G of I in this
matter, and from the
tenor of their subsequent
letter No 159 dated
23d May 1881 that it
would only call forth
a further demand coupled
more than likely with
disparaging remarks to
submit as now proposed
the supplemental memo
by Mr Jones as forwarded
under cover of letter No 1085
dated 10th Sept. 1881 from
the President Municipal
Commission

In para III of his letter
Mr Jones distinctly says that
none of the information asked
for by the G of I in para 3
of Circular No 28 P.W.
of 9th May 1879 can be
furnished by him

The only way as it

Seems to me of
dealing in a satisfactory
way with the reference
is for your Office to
take the matter in hand
and have a comprehen-
-sive statement on the
lines laid down by the
E of I [illegible] for submission

As there appears to
have been only 12½ gallons
per head available or
distributed in 1879 which
for some 200,000 inhabitants
only, while the projected
supply seems to have
been 20 gallons per head
for 525,831 souls some
special explanation appears
to be called for with
reference to Para I of
Captain Tomkins's letter
No 203 M of 24 August
1880

~~[illegible]~~

21/9/81

43

E I

Are you in a
position ~~to give~~
any further information
in regard to this
matter?

~~[illegible]~~

2/3/82

W. 84

W – I have not
taken the narrative
in hand & will
complete it as soon
as possible. Press
of other work has
prevented my
taking it up before.

[illegible]
19/3
for E. I.

CAW
~~Stand~~ over
~~[illegible]~~
21/3/82

(9)

E.W.

My Office contains no
information as to the supply
proper of the City of Madras
beyond the data on which
a certain quantity of water
has been advised to be
reserved for the use of the
City and these will be
looked up. All the rest of
this part of the information
required by the Government
of India will have to be ob-
tained from the municipality.
I am sending instructions
to have a narrative of the
Madras Water works and Irrigation
extension project prepared so
as to give in a condensed form
the history of the scheme from
its being taken up by the late
Mr Fraser in Lord Napier's time
about 15 years ago.
This will include much of the
subject matter referred to in para
2 of G of I letter in Pub. No 164 I.W.
13 June 879.
The part of G of I Cir XXX Dev. of

...S No. 2476 R.W. 27/10/80

which my office can answer only fully are the items under III & IV down to the commencement of the Municipal works. We have the sketch map so far — I can give no information regarding I & II

[illegible] 3/10/81

E)

When do you think the professed narrative may be looked for?

[signature] 4-10-81

E.W.

It will depend chiefly upon the Officer appointed to succeed Mr Vincent. If he had nothing else to do the information required by G of I XXX. III would take many days even if the Registers are complete

[illegible] 4/10/81

C.A.W.

Must I fear stand over till Col. [illegible] is able to take the question up

[signature]

1

46

A
[illegible]

47

Public Works Department.

PROCEEDINGS OF THE MADRAS GOVERNMENT.

Under date the

Read the following :—

Endt. from the Genl. Dept on letter from the President Munl. Commr. Madras No. 1085 d 10 Sept 1881 —

H.S. No. 1538 d/13 Sept. 1881.

Ordered to be forwarded to the Govt. of India with reference to their letter No. 159 M d/23 May 1881.

H.S. No. 21/9/81

Forwarded.

Cancelled

Ch

[signature] 13/9

with [illegible]

Supplemental Memorandum

on

Madras Water Works supplying as far as possible the information called for in Circular N° XXX of the 24th August 1880 and Circular dated Simla 24th September 1880 and Circular Simla 9th May 1879 N° 28 of W.

With reference to the first mentioned Circular.

Para I The Water Supply of the City of Madras is imperfectly distributed as may be seen from the accompanying map, many portions of the town not being reached at all. It is however believed that about one half of the population or 200,000 persons use the supply. The supply in 1879 amounted to 5,362,185 cubic yards (see Memorandum C of N° 1038 W of 22nd April 1881) The daily supply per person would therefore be $\frac{5,362,175 \times 27}{365 \times 200,000} = 1.98$ c ft. say 12½ Gallons

Para II The supply is, as has been previously stated, brought to Madras in an open channel and as the pipes bifurcate at a short distance from where they are connected to the Channel, it is impossible owing to the varying draughts on the pipes to

to make any comparison between theoretical and actual discharges or with regard to loss of head by bends &c.

Para III. The Red Hills Tank whence Madras derives its supply is not in charge of this Department and therefore none of the informations required by para III is available in this office; it may however be noted that the rainfall has an effect on the tanks very insignificant when compared with the supply it receives from the Cholavaram Tank above it, which is again supplied from the Kortallior River as previously described. The map now forwarded shews the existing and proposed lines of distributing pipes in Madras. The Government Survey Map of Saidapet Taluq to which I beg leave to refer shows the Red Hills Lake and the Delivery Channel.

Circular dated Simla 29th May No 280 W.

The population of Madras 406,117, at last Census is spread over an area of 26·82 square miles and it is improbable that the water supply will ever be brought within

within reach of all the inhabitants to - The area to which it is at present proposed to confine the water supply has been delineated by a red boundary line on the map previously referred to and proposed lines of pipes are also shewn on that map.

When projecting the water supply it was thought that the arrangements designed would allow of a supply of 20 Gallons per head per day for the then estimated population of 5145831 = 10,916,620 Gallons = 1,746,659 cft

It is not now believed however that any very much greater quantity can be supplied with the existing works than that now being so.

Madras 4 August 20. 1881. } (signed) I A Jones CE
Vice President M M C.

(True Copy)

A Arundel
President M M C.

CURRENT No. 1322

PUBLIC WORKS DEPARTMENT.

53

PROCEEDINGS OF THE MADRAS GOVERNMENT.

~~UNDER date the~~

Read the following :—

From the Government of India No 159 P.
Dated 23d May 1881.

Referring to your letter No 1039 W
dated the 22d April 1881, I am
directed to state that the Me-
morandum therein submitted
on the Madras Water Supply
Scheme, is wholly deficient
in the Special information
called for in Circular Nos 28
and XXX P. W. dated the 9th May
1879 and 24th September 1880
and to request that a further
Report with this information
embodied in it may be sub-
mitted to the Govt of India

Order thereon 3rd June 1881 No 1386 W.

Communicated with
reference

reference to G.O. No. 1038 W d/ 22d April 1881, to the Financial Deptt in view to the President Madras Municipality being called upon to furnish further details in accordance with the undermentioned G.O's

No. 1641 W. d/ 18th June 1879
" 7476 a W d/ 27 October 1880

(True Extract)

C. Carson, Captn R.E.
Ag. U. Secy to Govt. P.W.D.

To
Financial Department.

Fin. 2473/81

55

NOTE.--This paper should be returned with reply, and should not be marked in any way by the receiving office. 10 JUN 81

505

Fil. (Water Supply) Dept.

1881.

Public Works Department.

P.W. E-1 / 5274 /81

No. 1386 W

Dated 3rd June 1881

Despatched

Received 4 June /81

CURRENT No. 1322

SUBJECT.

Cong letter from the Govt of India calling for further report and certain particulars in connection with the Madras Water Supply Scheme -

No. 996

Referred to the President of the Municipal Commission, Madras, in continuation of G.O. No. 1038 W, dated 22nd April 1881, with request that the further information desired may be supplied.

P. W. C. No. 1085

Municipal Office.

PUBLIC WORKS AND CONSERVANCY DEPARTMENT.

Madras, 10th September 1881.

CURRENT No. 2473

From A. T. Arundel Esq,
President, Municipal Commission.

To
The Chief Secretary to Government
Ootacamund.

SIR,

In returning the papers that accompanied your No. 996 dated 7th June 1881 I have the honor to forward a further report on the subject from the Vice President together with a map[x] showing the distribution of water pipes in the city of Madras.

x per Book Post

I have the honor to be
Sir,
Your most obedt Servt
A T Arundel
President Munl Comm

may be sufficient. Yours &c

Ǝ. C. No 1642W. D/ 18.6.79
" " 2076 W D/ 2.9.80
Mis No 2318 W. D/ 6.10.80
B. No 2476 A.W D/ 27.10.80
Ǝ. C. No 1038 W. (1039 W) D/ 22nd April /81
B. No 1386 W. D/ 3.6.81.

P.W.C. No 5274.

Finl (1881) Depb.
~~Finl~~ Water Supply
Madras ~~Municipality~~

R.D.
3 SEP 81

From.
The President
Municipal Commission
Madras.

To.
The Chief Secretary
to Government
Ootacamund.

PM & C No 1085.

Dated.. 10th }
Despd.. 10th } September 1881
Recd 12/15 Sep. 81

Enclosures - 2.

No. 2473 -

Subject

Forwards a further report with map shewing the distribution of water-pipes in the City of Madras.

No 1538

Transferred to the Public Works Dept.

Ootacamund
13 Sept 1881

[signature]

W. 68. I.

Note

Encl 1 — The accompanying monograph on the Madras Water Supply and Irrigation Extension Project compiled by Mr. Vincent under instructions by Colonel Mullins has been prepared in compliance with letter No. 159-M dated 23rd May 1881 from the Assistant Secretary to the Government of India, and is submitted to Government.

Ootacamund }
24th July 1882 }

John Astie Colonel R.E.
Ag: Chief Engineer for Irrign.

To.
The Joint Secretary to Government
P.W.D. Irrign. Branch

P. W. Cho. 5094

Recd. 31 July '82

E.I

No. 603 I. Irrigation

PUBLIC WORKS DEPARTMENT.

63

PROCEEDINGS OF THE MADRAS GOVERNMENT.

UNDER date the 2nd August/82

Read the following:—

Note by the Ag: Chief Engr. for Irrigation { A.E. No. 68. I dated 24 July 1882

the Monograph 135 copies of

110 copies of No 6039.

36/2 of docket

Ch. E. for Irrn ✓

Supdg Engr. Fifth Circle ✓

Sar P.W.A. ✓

Financial Dept ✓

Rev. Dept ✓

Board of Revenue ✓

Ordered that the Monograph on the Madras Water supply and Irrigation Extension Project be forwarded to the Government of India with reference to their letter No. 159-M dated 23rd May 1881.

2. Ordered also that a copy of these Proceedings be forwarded for the information of the Secretary of State.

Jon

24-8

25/7/82.

Pltt

26/7/82

70

2807

7-19820

may be supplied

H.E. No. 604 I. d/ 2nd August 182

Forwarded to the Govt of India -

[illegible] 24/8

H.E. No. $\frac{33}{605}$ I. d/ 2nd August /82

To the Most Hon'ble the S. of S. for I.

My Ld Marquis,

We have the honor to forward for Your Lordship's information a monograph on the Madras Water Supply & Irrigation Extension Project.

C

15-2-27 III
5/1/28 II
11-7-29-B. III.

5794.

Govt. of {1882} Madras.

PUBLIC WORKS.

Dated

Rcvd.

Encl.

G. O., 2nd Instr. 1882, No. 603/4/5/

Nos. 13-14
15-
16

Madras water supply
Chronographon the
— and Irrigation extension
project forwarded to the
Govt. of India.

Madras water supply
Chronographon the
— Irrigation extension
project.

Chronographon the
Madras water supply
Irrigation extension
project
Govt. Receipt Regr.

3/3/8