

MADRAS RECORD OFFICE.

Government of Madras.

Revenue DEPARTMENT.

G.O. No.	630	Press
		Mis
21-22		
Dated	3-17-	1870

Not to be folded or roughly handled

*Proceedings of the Madras Government, Revenue Department,
3rd May 1870.*

No. 21. Read the following Proceedings of the Madras Government in the
Public Works Department:—

Communicating to the Board of Revenue, with }
instructions, Note by the Chief Engineer for } (Here enter 26th April 1870, No. 1,100.)
Irrigation on the revised estimate for the Madras }
Water Works Project.

No. 22. ORDER THEREON, 3rd May 1870, No. 630.

Land Revenue.

COMMUNICATED to the Board of
Revenue and to the Acting Director
of Revenue Settlement.

2. As the revision of the assessment of the Madras District has long been contemplated, and as the Government understand that the demarcation and survey of the Sydapett Talook has been already completed, the simplest course will be for the Acting Director at once to commence settlement operations in this talook.

3. Mr. Banbury will accordingly be directed to report whether he is in a position to carry out this arrangement by transfers from the working parties of other districts, as no expenditure in excess of the Budget provision for the department can be sanctioned. Mr. Banbury will also be good enough to state within what date he will be in position to afford the information desired by the Public Works Department in regard to the rates to be imposed upon the lands which will be affected by the Red Hill Irrigation Project.

(True Extract.)

(Signed) R. A. DALYELL,
Acting Secretary to Government.

To the Board of Revenue.
„ the Director of Revenue Settlement.
„ the Public Works Department.

Exd. F. R. Bantleman.

*Proceedings of the Madras Government, Public Works Department,
25th April 1870.*

No. 349. Read the following Note by the Acting Chief Engineer for Irrigation, dated Fort Saint George, 21st January 1870, No. 17:—

Read the following letter from the Acting Superintending Engineer, 4th Division, to the Acting Chief Engineer for Irrigation, dated Madras, 30th August 1869, No. 2790.

I have the honor to submit, with reference to marginal Orders,* a revised estimate for the Madras Red Hill Project, amounting to Rupees 10,42,640, which is in excess of the original estimate, Rupees 6,11,759, sanctioned by the Government of India—G. O., Madras Government, No. 3,293, dated 16th October 1866—by the sum of Rs. 4,30,881. The estimate is accompanied by an original report† from Captain Scott,

22 Plans.
2 Statements.
1 Abstract estimate.
1 Letter.

* G. O., No. 1501, dated 12th May 1868.
Do. „ 3913, „ 15th December 1868.
Do. „ 941, „ 20th March 1869.

† No. 162, dated 9th July 1868.

R. E., the Executive Engineer in charge, by two comparative statements showing the difference of cost between the original and revised estimate, and cost of work already carried out and to be executed compared with the original estimate; also abstract estimate, abstract comparative statement of work done, and schedule of original and revised rates. Twenty-two plans of the principal works in the project also accompany this report.

2. The principal items making up the estimate are as follows:—

	RS.	A.	P.
Anicut in Cortelliar River	59,448	8	6
Upper channel and Masonry works	1,99,305	8	11
Cholaveram bund and Masonry works.	2,79,060	4	11
Channel between lakes and do.	90,631	7	11
Red Hill Lake and do.	2,62,902	15	6
Maintenance	7,041	9	0
Madras channel, Government contribution.	15,559	0	0
Superintendence and contingencies 5 per cent	45,551	11	3
Compensation for lands... ..	83,140	0	0

Total... 10,42,640 0 0

3. The Government Order, No. 2708, dated 17th August 1869, reviews to a very recent date the state of progress made on this project, and the prospects held out of increased revenue returns from the additional water already diverted by the Cortelliar Anicut into the Cholaveram Lake, and which supply is likely soon to be carried on to the Red Hill Lake. It is unnecessary therefore to make any report at present on this head.

4. The causes which have led to the increase in the estimate are enumerated in Captain Scott's letter, and may be particularized as follows:—*First*, enhanced rates paid for all descriptions of works; *secondly*, improvements in the designs of the works ensuring solidity and better adaptation for the purposes intended by their erection, but at greater cost; *thirdly*, omission of necessary items in the original estimate; *fourthly*, additions to the works entered in the original project, and *fifthly*, expense of maintenance since the commencement of the works.

Cost. of 1870 Madras.

REVENUE.

THE BOARD OF REVENUE,

Dated May, 3rd.

Recd.

G. O., 3rd May 1870, No. 620.

MAY.

1869, 21-62.

Madras Red Hill Project.—Proceedings Public Works Department communicated to Board of Revenue (Fort St. George), 17th October 1869. Settlement to report when it will be able to complete settlement of project with the Government of India.

5. *Increased rates paid for the different description of works.*—In framing the original estimate Mr. Fraser, the Executive Engineer, I believe, was influenced by a desire to keep down the total amount of outlay as much as possible, under an impression that if the supposed financial results of the project appeared of a less remunerative character than that shown in his report of the 20th February 1866,

there would be a difficulty in getting the project passed. He was, therefore, inclined to enter the very lowest rates possible, and in some instances below what the work could possibly have been carried out for; but, at the same time, owing to the urgent instructions, to make rapid progress, given to Major Magnay, who succeeded Mr. Fraser in the supervision of the project, very high rates were paid to Messrs. Morgan and Co. for the anicut and other works, and higher probably than need have been paid if departmental agency had been employed. The Executive Engineer, however, was of opinion that the employment of contractors enabled him to ensure much more rapid progress. To instance a few examples of difference of rates, the earth-work has reached Annas 3 Pies 8 per yard, when the original rate did not exceed 3 annas. Clay puddle was priced uniformly at 6 annas, but has cost $7\frac{1}{2}$ and $9\frac{1}{2}$ annas per yard. Gravel has risen from 4 annas to 4-9, and as much as 7-9. Packed laterite and laterite in chunam from 2 and $4\frac{1}{2}$ rupees to 3 and $6\frac{1}{2}$ rupees per yard. Mr. Fraser's rates for dressed granite stone of all dimensions were obviously quite inadequate, unless he contemplated very inferior work, which could hardly have been the case. He allowed Rupees $16\frac{1}{2}$ per yard only, whilst the work has been carried out at 61-9. Brick-work has also been increased from Rupees 3, 12, and 6, to Rupees 4, 8, and 7. Captain Scott states that these are the rates obtained after actual experience on the works, and as he is obliged to draw most of his labour and most of his carriage for material, as well as some of the material itself, from Madras, eight miles distant, he was unable to work at a lower rate. My own experience shows me that the cost of daily labour has increased within the last three years, especially Stone-cutters and other Artificers' wages.

6. *Improvements in the designs of the works.*—In my report, dated 2nd August 1867, No. 2190, printed at the head of G. O., No. 2783, dated 10th September 1867, I entered fully into the question of altering the designs for many of the masonry works, in consequence of the unsuitable character of some which had been proposed, and of the slight dimensions given to the masonry walls and foundations. As these suggestions to alter the majority of the designs have been carried out, it is unnecessary to enter fully into the matter here, or to refer otherwise than briefly to a few of the alterations made. Colonel Anderson, the late Chief Engineer for Irrigation, gave Captain Scott the benefit of his experience in designing some of these works, and prior to his appointment a few were in progress when I was in charge of the Division in 1867, such as the anicut and sluices. The anicut itself was entirely remodelled, as Mr. Fraser's plan of a curved crest and apron, the former seven feet wide resting on a core of earth and gravel well rammed, above sand, with front and rear walls of concrete, with rough stone in chunam above, was abandoned for a body wall of laterite in chunam, $6\frac{1}{2}$ feet wide at crest, resting on wells nine feet deep, with a solid foundation above of four feet. This section of

anicut though expensive to build was more feasible of execution than Mr. Fraser's walls, which were to be sunk fifteen and thirteen feet deep into the bed of the river of concrete and rough stone at bed level, one as foundation to the anicut, the other as retaining wall to the sloping apron, which was to be fifty feet in breadth. In place of the two aprons fifty-seven feet in breadth, two aprons thirty feet wide of stone in chunam and packed stone have been built, and a third apron is required in front of the under-sluices, with a retaining wall on wells. The head-sluice in the Cortelliar River was designed of ten vents five feet wide and eight feet high to crown of arch. The piers were two feet six inches thick, and the abutments three feet six inches, to be carried up as face-walls above the crowns of the arches $10\frac{1}{2}$ feet high. The wing walls were two feet thick. The shutters were eight feet seven inches high and were to be worked by a rack and pinion at a height of $23\frac{1}{2}$ feet from the sill. The floor of the vents were $2\frac{1}{2}$ feet thick of stone on concrete, and the foundations of the piers were only $1\frac{1}{2}$ feet more in depth. The road-way was six feet wide, and the two aprons twenty-eight feet wide. In the work as carried out, the same number and size of vents were adopted, but the piers and abutments, which were carried up above the piers as face-walls to the height of the road-way twenty feet, were made three and five feet thick. The aprons are wider and more solid, protected by retaining walls on wells; the inner one between wing-walls twelve feet four inches, and the front one of loose stone fifteen feet wide. The work also is built on wells nine feet deep, with a solid foundation above of three feet. The road-way is ten feet wide, and the work is connected with the anicut by substantial wings. Mr. Fraser's intention was to divert the Boosykhal surplus into the channel, and to carry the drainage, from the point of interception by an under-tunnel below the bed of a curved form, with a sectional area of 114 square feet, into the Cortelliar. The other large surplus stream was to be diverted into the channel. In carrying out the diversion in connection with these jungle-streams, the whole of the water has been passed into the supply-channel, and two substantial banks have been thrown up across the Boosykhal, one at the point where it is turned into the channel, and another where the latter crosses it further down in its course. A calingulah of 150 feet in length has been constructed to afford an escape for surplus waters into the Cortelliar River. On my last inspection of the drainage at this point, it appeared to me that a regulating work might hereafter have to be built across the channel where the Boosykhal enters it. Large quantities of silt are brought down into the bed, and the head of the small cut into the channel is affected by the rapid flow from the jungle-stream. The velocities varying so much in the natural and the artificial water-course, there is a certainty of heavy silty deposits forming just below the junction, and clearances have already had to be carried out. The cart bridges across the channel were to be of masonry with single arches, forty-five feet span, on foundations of a peculiar design. They have been carried out with timber superstructures, resting on two piers with three openings of eighteen feet to allow of the future widening of the channel. One bridge on the high road and across the supply-channel from the Cholaveram to the Red Hill Lake has a span of forty feet, and the road-way is carried on plate iron girders and iron cross girders supporting timber joists. The foot bridges were to have been of forty feet span timber trussed, but they have not been carried out. It was intended to have carried the drainage of the country across

the channel by under-tunnels, but masonry inlets or dams have been provided instead to utilize the water, excepting in two instances where an aqueduct connecting two portions of a tank and an under-tunnel have been built. The head-sluiice to the channel supplying the Red Hill Lake, in the bank of the Cholaveram Tank, was designed of ten vents of five feet. The piers were to be $2\frac{1}{2}$ feet thick and carried up as face-walls twenty-seven feet from sill to top of road-way, and only $1\frac{1}{2}$ feet thick. The flooring was to be two feet six inches thick, and below this the foundations were to be sunk two feet more. The sluices were to be worked by cog-wheels twenty-five feet above the sills. The road-way was seven feet wide. The sluice now building has ten vents of four feet. The piers are four feet thick in front, and three feet in rear; the arches, abutments, and wings also are thicker than originally designed. The sluice-gates have arrangements for working them twenty-two feet above the floors. The pressure of water will be twenty-one feet. The road-way is increased to nine feet. The flooring is three feet thick, and the foundations are sunk two feet more. The whole of the face of the piers, cutwaters, and floorings are of cut granite stone. The Cholaveram Tank Irrigation Sluice was designed with $2\frac{1}{2}$ feet depth of foundations, the floorings reduced to two feet. The side-walls were to be raised $21\frac{1}{2}$ feet above the vent, with an average thickness of $2\frac{1}{2}$ feet. The shutters from sill to handle were $27\frac{1}{2}$ feet long. The sluice now building has a larger opening, and the walls and foundations are increased slightly in dimensions. It is intended that the arrangements for opening the shutters of this sluice should be placed twenty-seven feet above the floors, owing to the height of water in the tank. There is only to be one new sluice in the bank, instead of two, as water will be drawn off through a vent in the wing-wall of the supply-channel sluice. Mr. Fraser intended to alter the Polur and another irrigation sluice in the Red Hill Tank, but instead of this, owing to the difficulty of making the alterations satisfactorily, two new sluices are being built on a design by the late Chief Engineer for Irrigation. The native method of allowing the water to enter the sluice by plug holes at different depths of the water, corresponding to every ten feet, has been adopted, and the work is very massive, the front of the sluice extending forty-two feet beyond the crest of the bund. I am afraid it will be found an unsatisfactory arrangement, costly, and difficult to keep in repair. The calingulah at the Cholaveram Lake has been altered. Two will be built in lieu of it, one consisting of twenty vents six feet span with a total length of $167\frac{1}{2}$ feet. The calingulah designed by Mr. Fraser for the Red Hill Lake was placed on too low a level necessitating the excavation of a channel on the laterite rock. A retaining wall of masonry, instead of a bank of earth between the old and new proposed calingulah has been built, the old work being built into the calingulah masonry wall. This work is to be 575 feet long, strengthened by counterforts at twenty-five feet intervals and four feet thick at top. The height of water in the tank can be regulated by this wall, which will be raised in graduation to suit the capacity of tank required, and until such time as the tank banks are sufficiently consolidated to bear the whole pressure of water which it is proposed to bring into the reservoir.

7. *Omissions of necessary items.*—Captain Scott points out that the turfing of the banks, excavation of surplus channels from calingulahs, and foundations to revetment walls were omitted. There are also omissions in the estimates for masonry works on account of filling and excavating under the head of earth-works. The remarks

on the works noted in last paragraph refer to numerous small items which have been left out in the planning and estimating for the project.

8. *Additions to the works entered in the original project.*—The principal additions under this head are the surplus calingulah* in the bed of the main supply-channel, and the calingulah† in the Cholaveram Lake.
- | | |
|----------|---------|
| * Rupees | 6,322. |
| † „ | 17,057. |

The substitution of a masonry wall for the earthen bund in continuation of the northern extremity of the Red Hill Tank bank, which was to have been built between the old and new calingulah, has increased the cost considerably, as this work is estimated at Rupees 23,000.

9. *Maintenance of the work.*—This is not a usual charge in the estimate, but as the works have been in progress for three years, and there is no provision in the Budget under this head, a sum of Rupees 7,041 has been entered for maintenance.

10. Under G. O., No. 2,163, dated 3rd July 1869, a sum of Rupees 15,558 has been paid this year to the Municipal Commission, Madras, as the Government share of contribution towards the construction of the delivery channel from the Red Hill Lake to the town of Madras. I have reduced the contingencies in Captain Scott's estimate from ten to five per cent. under G. O., No. 3,298, dated 16th October 1869.

11. The alignment of the channels and general design of the project have not been altered, and as Government have already been put in possession of the surveys as well as the plans for the two tank banks, the designs now submitted only comprise the works which have been altered entirely or modified from the original ones, and also the additional masonry works not entered in the original estimates. That portion of the work also which was originally included in the scheme and which embraced the supply-channel from the Red Hill Tank to Madras has been handed over to the Municipal Commission, and will be modified by them in accordance with the revised scheme for supplying water to Madras.

12. In paragraph 6 of the Government Order, No. 1102, dated 11th April 1866, it is shown that Mr. Fraser contemplated that the storage of sixty millions of cubic yards of water additional for irrigation purposes, would suffice for 8,000 or 9,000 acres of waste land capable of nunjah cultivation, yielding a revenue of 60,000 rupees, or about ten per cent. on the estimate. The increase now made in this original estimate would reduce this profit to six per cent; but I think it desirable that definite arrangements should be made to ascertain the extent of actual land under the influence of the tanks, which is now partly conjectural on Mr. Fraser's part. With this object in view, I am employing a Surveyor under Captain Scott's orders to run lines of levels and to connect his work with that carried on by another Surveyor who is engaged in surveying the ground near the Vulloor anicut now in course of erection across the Cortelliar River to the east of these tanks. Captain Scott is making inquiries also as to the extent of the demarkation carried out by the Revenue Survey Department, Mr. Thornhill, the Acting Collector of Madras, forwarded a list in December last of ten tanks, with an aggregate ayacut of 5,849 cawnies, and Rupees 25,184 assessment, which might be brought under the influence of the Red Hill and Cholaveram Tanks were water available for irrigation.

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13. I am now drafting a report to Government on information just received from Captain Scott, to the effect that he has made arrangements at the head-sluic of the supply-channel to the Red Hill Lake to admit water down to this reservoir, and that on the 25th instant the fresh in the Cortelliar River, which had been utilized and turned into the Cholaveram Tank, had been passed on and water was flowing into the Red Hill Lake.

No. 265.

MEMORANDUM.

The accompaniments of the letter, No. 2790 of the 30th ultimo, from the Superintending Engineer, 4th Division, transmitting revised estimates for the Madras Water Works, show that of the total increase, by which the revised exceeds the sanctioned estimate, Rupees 1,24,848-13-3, are due to alleged inadequacy of the rates originally allowed; but, throughout the papers, the undersigned has been unable to find any such analysis of the rates, as would show the correctness of those on which the revised estimate has been based. It is not enough to say, * that the work of each kind already done has cost so much, and that the rates have been determined from this fact. What is necessary is that the Government should have the best possible information as to the reasonableness or otherwise of the expenditure incurred, or stated to be necessary, and that a definite conclusion should be arrived at as to the real value of the several parts of the project when completed in the manner now intended.

Captain Scott's letter paragraph 2.

* Note at end of revised estimate.

2. The variations from the sanctioned designs have been very considerable, and many of them may have been judicious or, indeed, necessary; but without some more clear information as to the propriety of the actual cost of work done, it is not practicable to form an opinion as to whether their real value should be taken as Captain Scott puts it at Rupees 2,82,704-13-0, or some smaller amount.

3. It would be of advantage to show:—

1st.—What has been the history of the work, that is what officers have had charge of it, and for what periods.

2nd.—What were the proportions of the principal descriptions of work done during each period, with the average rates for such period of each kind.

3rd.—The data of the present rates for each principal description of work at three different places, viz., at the head works, at the Cholaveram Tank, and at the Red Hill Tank, should be given in detail; and, for those materials which have to be brought from a distance, the average distance of cartage should be ascertained and stated.

4. To enable a comparison to be made, the data for the rates paid for similar work in the neighbourhood, which has been carried out under distinct and separate superintendence, should be ascertained, and particular care should be taken to obtain the daily rates for different descriptions of labour, also for carts, &c., with the loads,

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and mileage rates where such have been given. The road-works for gravel, the Cortelliar bridge for masonry, the Vulloor anicut across the Cortelliar and other works in the taluq will doubtless afford the desired information.

5. The rate for concrete will require careful investigation. That at the head works is stated to have cost Rupees 5-8-0 a cubic yard; at the cart and foot-bridges of the main channel the rate is Rupees 3-4-6; at the Red Hill Tank masonry dam, Rupees 2-15-0. It is explained that the first is for hydraulic concrete, which would doubtless make some difference, but not, it is thought, more than a few annas the cubic yard. Even the lowest rate appears to the undersigned somewhat high, when it is remembered that the bulk of the material was available on the spot.*

* End of Red Hill Tank.

† Two rupees a lineal foot difference between wells sunk and those to be sunk.

Similarly the rate for wells† at the head works and for laterite in chunam require full explanation. It is observed, with regard to the latter, that the rough stone apron of the weir, which appears, from the drawings, to be of laterite, cost Rupees 3-0-4‡ a cubic yard, while the rate for the masonry is Rupees 7-6-2.

‡ Really 2-12-5 for work already done, vide Comparative Statement No. 2.

Such a difference between the two, supposing similar materials to have been used, is not in accordance with what is usual.

6. It should further be stated what works, or portions of works, were done on contract, and where rates higher than those sanctioned were given; the circumstances should be reported as clearly as may be practicable.

7. The Order of Government of the 10th September 1867, No. 2,783, gave the Superintending Engineer large discretionary powers in modifying the designs and arrangements of the works; it is not, however, clear whether such alterations as were decided upon were put on paper and estimated for at once, or whether it was left to a future time to discover what the alterations would be likely to cost.

8. The Superintending Engineer has, with reference to the change made by the Government of India in the first estimate, reduced the contingencies of the revised estimate from ten to five per cent.; but it would seem to have been overlooked that the total sum, Rupees 45,551-11-3, allowed by Colonel Bean, is nearly 10,000 rupees less than that already expended,§ so that, allowing only five per cent. on

§ Statement 3 of estimate (revised.)

expenditure after the 31st March last, about 22,000 rupees will have to be added to the estimate. Explanation will, of course, be required as to the reason for the excess in the proportion of five to three of the charges on this account incurred prior to the date just mentioned, and it should be shown what descriptions of charges are included. It will be well to give a classified abstract memorandum, and should any charges not contemplated to be met from the five per cent. allowed have been debited thereto, it should be shown what the circumstances were.

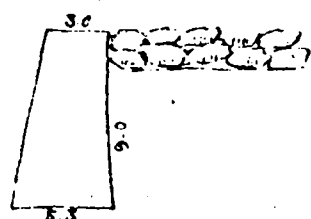
9. Probably many of the following points have been reported on from time to time, and the determining circumstances or the reasons for the decisions come to may be on record: it will be well, however, to have them all noticed in connection with the revised estimate:—

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1st.—Mr. Fraser's anicut was to have been 600 feet in length, that built being 469 feet only. What is the relative position of the latter with reference to the former? Do both anicuts allow the same depth of water on the head sluice cill when the Cortelliar is flush with the dam crests? The wells of the anicut are shown as just touching the clay; they ought to have been carried down some little way into it. Are the wells under the body of the dam correctly shown, or were they placed

Cross Section, Plan 1.

with those of one row opposite the spaces of the other row? Are the wells of the wing correctly shown, and was some part of the wings built on wells, as indicated on the plan, and the rest with solid foundations, as shown in section? Is there any-



thing to prevent a retaining wall* of brick masonry being substituted for the wells of the proposed additional retaining wall: the cost would be about one-half that of the estimated arrangement? From what distance is the apron stone brought? Can lumps of stone instead of regularly

quarried stones be got within a moderate distance, and at a cheap rate? Why has the rate entered in the estimate for apron stone risen from 2-12-5 to 3-9-0 per cubic yard? It would seem to be advisable, if possible, to get a cheaper material and allow more of it. The outline of the wing wall should be shown on the cross section of the anicut Plan 1. This section does not agree with Section C. D., Plan 3, and the plan and section of anicut Plan 1 do not agree: there are some other differences which have been noted in pencil. Will there not be a risk of scour between the head and under-sluices, and should not the latter have an upper rough stone apron; also a groyne at the north end of the under-sluices to prevent scour along the upper face of the anicut?

2nd.—Has it been ascertained that the pressure required to lower the head sluice shutters when the river is in flood will not be sufficient to disturb the masonry pillars into which the timber beams, which sustain the pressure, are to be inserted? What is the object of the upper beam; will the screw thread be engaged there, or simply pass through a smooth bore? As the necessary lift of the shutter is five and a-half feet only, it is not clear why the lift bar should be threaded for more than that length below the under side of the collar. The levels of the cill of under-sluices, crest of anicut, normal extreme flood, extreme flood as raised by the anicut, should all be marked upon the cross section of the head sluice, as also the level of full supply in the main canal.

3rd.—Channel from Cortelliar to Cholaveram Lake. The increase in quantity of earth-work is large. A general plan* showing the whole channel, the alterations made, with such longitudinal and cross sections of the altered parts as may be necessary to show where the 86,000 cubic yards of additional work were done should be prepared and sent in.

4th.—The special provisions in the original estimate in connection with the Boosykhal were an upper dam and an aqueduct; these are combined in the Abstract Comparative Statement No. 2, and the sum entered is Rupees 7,078-7-6; but in the

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other Comparative Statements the entries are for the aqueduct Rupees 3,275-1-9, upper dam Rupees 1,141-2-6; these amounts would appear to be incorrect, as the former and larger sum agrees with the abstract estimate given in paragraph 44 of Mr. Fraser's Report. Plan and sections of the dam, as designed by Mr. Fraser, and as actually executed should be given. It is observed that the Comparative Statement shows nothing in the original estimate for the lower dam across the Boosykhal, but there must have been embankments up to the aqueduct on each side, and these double banks would have required as much material as the single bank right across and perhaps more. This provision was probably made in the channel estimate, and it should be ascertained what it was; for either the quantities as executed at the dam must be added to those of the channel, or Mr. Fraser's quantities for the banks must be taken out of the channel and set against the dam. The result will be that instead of the 86,000 cubic yards abovementioned, there will be some 100,000 cubic yards additional.

5th.—Cart and foot-bridges.—In Mr. Fraser's estimate the bridges allowed were:—

		RS.	A.	P.
* Between Cholaveram and Red Hills.	6 Cart-bridges for main channel.....	12,177	15	0
	3 Do. for supply* do.	6,088	15	6
		18,266	14	6
	4 Foot-bridges for main channel. 3,350 8 0			
	1 Do. for supply do.... 837 10 0			
		4,188	2	0
	Total... 14	22,455	0	6

In the Abstract Comparative Statement seven bridges are entered for the revised estimate, but there appear really to be only six, viz., five on the main channel and one on the supply channel. Of these—

The cost of 5 is put at Rupees 5,412-3-0 =	27,060	15	0
and „ of 1 „ „ 8,710-13-10 =	8,710	13	10
	35,771	12	10

It will be well to state what the circumstances were which made eight out of fourteen bridges unnecessary. Plan No. 7 shows the bridges on the main channel; each has three spans of seventeen feet at bed level, and the roadway is carried upon teakwood girders, the under side of which is nine feet above bed. The waterway provided is much in excess of that of the channel, which is thirty feet wide at sole, and forty-two feet at the six feet level, which was that of full supply in Mr. Fraser's design. Two spans of twenty-five feet each would have been apparently ample even for a wider channel at some future time. It should be explained why timber platforms were substituted for brick-arches. The original rate, Rupees 7-4-0, for the latter was very ample, and, had arches been given, there would have been a saving of about 1,000 rupees per bridge, or perhaps more, and such bridges would have been less liable to decay. Plan No. 18 shows the remaining bridge. Here, after abutments had been built, as the plan would seem to indicate, for an arched bridge an iron girder bridge was substituted, and there has consequently been a

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great waste of masonry. The rates at this bridge appear to be very excessive, and it does not seem improbable that, had a suitable design for, say, two spans of twenty-five feet been carried out in laterite with brick-arches, a bridge, with ample waterway, might have been provided for one-half the sum which that, with iron girders, will come to.

It should be remembered that the full Cholaveram Tank level will extend up the main channel nearly to its head sluice, and that the bridges in the several miles require to have their roadways at different heights above canal-bed. Also that the level of embankments from the third mile downwards requires to be fixed with reference to the crest (ultimate) of the Cholaveram Tank escape, and not to the full supply of the channel independently of the backwater.

6th.—Items 7, 8, 9, and 11 of the revised estimate* appear to supersede the item 11 Irrigation under-sluices of the original estimate. If so, it should be

*See Abstract Statement No. 2. explained what were the circumstances which led to the modification. The inlets, item 8, are estimated to cost 100 rupees a foot, which appears to be a very-large sum. It is requested that it may be stated what area of drainage had to be provided for at each inlet.

7th.—As far as can be judged from the Plan No. 8, the crest of the Boosykhali calingulah is below the level of the Cholaveram Tank water to the extent of some 2½ feet. If so, this should be corrected, and the level of the banks should be looked to.

8th.—The difference in quantity of earth-work in the Cholaveram Tank-bund requires to be fully and completely explained;

Mr. Fraser allowed cubic yards 285,447, at 3 annas = 53,521 5 0

The revised estimate „ 502,994, at 2-11½ = 91,982 0 11

217,547 38,460 11 11

The remarks in Comparative Statement No. 2 are altogether inadequate, and it should be shown exactly where Mr. Fraser's estimate was incorrect, and what, on an average of cross sections, was the extra work done in seating the puddle. The excavation of the revetment foundation could be but a trifle out of the enormous difference shown. The increase in the quantity of revetment is perhaps accounted for by the remark that the original estimate did not provide for foundations; but nevertheless it will be better to show for each length of the bund exactly what Mr. Fraser allowed, and what the work as carried out required. About the former, Sheet No. 13, of the plans illustrating Mr. Fraser's Report, gives some information, but nothing has been sent in to show wherein the latter differed from the former. In support of the rates, Rupees 2-11-5, for work already done, and, Rupees 3-3-0, for that remaining to be executed on the 31st March last, full details showing cost at quarry, distance of cartage, particulars of cost of building, etc., should be given. The rates for gravelling appear to be high; 5 annas and 5 pies a cubic yard for work done, and 10 annas for that yet to be completed. These should be compared with the rates paid for this material on the trunk road close by. At the bund there will be an addition for lift, but on the other hand the cost of laying would be much less.

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The turfing is no doubt necessary, but the rate is about double what should be necessary if the proper time of the year be chosen. At any other time the turfing would not root properly, and the money spent would be thrown away.

It is believed that a brick-in-chunam parapet would be liable to crack from the unequal settlements of the revetment, with its backing of gravel and puddle, on which the parapet would be built. A dry stone (laterite) wall would probably be, and look better. The cost apparently would also be less. Plastering in any case should not be allowed.

The entries relating to the parapet in the revised estimate are—

	RS.	A.	P.
Brick-in-chunam, 1,293 cubic yards, at Rupees 4-8-0 =	5,818	8	0
Concrete, 918 do. do. 3-8-0 =	3,213	0	0
Plastering 639½ squares at do. 2-4-0 =	1,438	14	0

Total... 10,470 6 0

against Rupees 4,236 allowed in the original estimate. It is not quite clear how the first quantity (1,293 cubic yards), which differs from that (1,412 cubic yards), allowed by Mr. Fraser, has been arrived at. From the longitudinal section (Sheet 13) the length of the bund would appear to be 12,225 feet, which, for a parapet two feet high and eighteen inches wide, would give 1,358 cubic yards. However, taking the larger quantity, 1,412 cubic yards at 3½ rupees—a rate which probably will suffice for a parapet of two stones, as appears to have been intended*—the cost would be Rupees 4,942, to which may be added 1,412 × ¼ × ¼ of concrete for a levelling course; and to prevent rain-water from the top of the bund penetrating under the parapet, and allowing 3½ rupees for this, though it would seem to be too much, the total cost of the parapet would be 4,942 + 686 = 5,628 against Rupees 10,470, a not unimportant difference.

* When the cross sections were drawn.

9th.—*Cholaveram North Calingulah.*—The remark that the original rate, Rupees 4-8-0 per cubic yard of laterite masonry, was insufficient requires some demonstration.

10th.—*New Calingulah of twenty vents.*—This as estimated for is a very costly work (over Rupees 100 a foot). What is the object of constructing the upper part with vents? Perhaps two or three

vents at one end might be useful for the supply of other tanks, but otherwise it would seem to be advisable to make this a flush-escape, and not only so but to place its crest 6 or 9 inches above full tank level; so that in ordinary seasons the north calingulah may discharge the surplus, it being better situated for doing this with comparatively little wear and tear. The rates are high, and that for laterite masonry is between twenty and twenty-five per cent. higher than for this work at the north calingulah already built. In any case the granite grooves in the piers on the crest can be omitted as unnecessary, and the 130 feet of planking, three feet high, need not be more than three inches thick, or 97½ cubic feet instead of 130 cubic feet; the rate 3½ rupees for this is again too high for simple planks. The wing should be altered as in blue pencil.

11th. *Cholaveram Irrigation Sluice*.—How is it that 4,000 cubic yards of bank had to be moved? The old bund at this point was low and, for an opening of twenty yards in width, the quantity of soil would have been about $\frac{1}{4}$ th of that entered. Rates require explanation. There appears to have been an omission of the sluice gearing. It will be noticed that the rate for the shutter of this sluice is lower than that for simple planking at the calingulah. The wood-work shown in the longitudinal section of this sluice is apparently the lifting bar of the shutter.

12th. *Channel between tanks or supply channel*.—The difference between Mr. Fraser's quantity, cubic yards 2,59,596, and that 2,28,203 of the revised estimate should be explained. The rates for the cutting appear to be excessive. What is the cost of quarrying laterite stones for masonry and revetments, and what is the daily hire of a cooly? The undersigned has seen laterite as hard as any in this channel taken out of a much deeper cutting for less than half the maximum rate, 1 Rupee, which would be applicable, it is considered, only to the indurated surface. The 5-annas rate, as also $2\frac{1}{2}$ annas for loam, are apparently extremely high. Judging even by districts in which labour is more scarce and expensive, it is thought that the cost of this channel has been 20,000 to 25,000 rupees more than should have sufficed.

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(c.)—The expenditure for maintenance of each tank for the same period.

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11. The Collector of Madras should be communicated with in view to the utilization of the additional supply which will probably be stored this year, and he should be asked to give information as to whether any channels will be required to be executed at the cost of Government. It will be advisable also to make some provision in the estimate for such works of distribution, for otherwise it is not clear how the water will get to distant villages, which have at present no channel, added to which the distribution must be under proper regulation; and this means that distributing dams will require to be provided for each separate area (one or perhaps two or three such areas within the limits of a village), and these works and channels also, and perhaps too compensation for land, will cost money. At present no information appears to be available as to the area hitherto cultivated, which will be a very good guide, as the former capacity of the tanks is known, to what the additional supply will suffice for. As a guess, however, the entry of 25,000 rupees may be made, unless Colonel Bean has, or obtains, information, which will enable him to make a better approximation to the probable cost.

*Proceedings of the Madras Government, Public Works Department,
26th April 1870.*

12. The enclosures of the Superintending Engineer's letter are herewith returned.

(Signed) JOHN MULLINS, Major, R. E.,
Actg. Chief Engineer for Irrigation.
FORT SAINT GEORGE, 7th Sept. 1869.
To the Acting Superintending Engineer, 4th Division.

No. From the Acting Superintending Engineer, 4th Division, to the Acting Chief Engineer for Irrigation and Joint Secretary to Government, dated Madras, 15th January 1870, No. 5,047.

WITH reference to your memorandum, No. 265, dated 7th September 1869,

1 Report with appendix.
1 Revised estimate.
1 Comparative statement.
41 Plans.

* One plan (No. 11) not received but will be sent.
I have the honour to forward a report in original from Captain Scott, R. E., Executive Engineer, Red Hills, dated 1st January 1870, No. 1, together with 42* plans and a revised estimate amounting to Rupees 10,39,176, for the Madras Water Works Project, with comparative statement showing the causes of increase and decrease between the several items of the two estimates; Captain Scott reports at length on the several points regarding the causes of excess over the original grant referred to in your memorandum, and furnishes an appendix giving copies of the contracts entered into for works, the analysis of the original and revised data, estimates and measurements based on them of portions of the principal works, and particulars of ayacut assessment, present average cultivation, irrigable area, and probable returns, received from the Collector, of the tanks dependent on the Red Hill and Cholaveram reservoirs, as well as of others likely to be brought under the influence of these works.

2. In forwarding originally the revised estimate and accompaniments with my letter of the 30th August 1869, No. 2,790, I was aware that the comparative statement likewise furnished at the same time was not so satisfactory a document as to the completeness of its information in regard to the causes of excess as it might be made, but as I knew that any further investigation into the matter would lead to much delay and protract further for some months the submission of an estimate which the Governments of Madras and of India had more than once expressed a wish to have placed before them, I did not insist upon Captain Scott's furnishing a more detailed report based upon further and more scrutinizing investigation. I was the more led to take this course, from the fact of the project having been entrusted to several Executive Engineers in succession, and of the work having been already three fourths completed, so that the rates entered in the revised estimate had been obtained from the actual cost incurred during the progress of the operations. Under these circumstances, I forwarded the papers with such explanation of causes of excess as were afforded in the remark columns and in Captain Scott's report, paragraphs 5 to 8, also, of my letter of the 30th August last, report, in detail on the changes in the designs of masonry works which have caused a deviation from the original estimate, and also refer to the subject of the enhanced rates which have had to be allowed. The subsequent report, however, of the 1st instant from the Executive Engineer, furnishes to a great extent the information asked for in your memorandum, and it will not be necessary for me to refer otherwise than very briefly to the several points touched upon by Captain Scott.

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3. The revised estimate, as now submitted, exceeds the original one by Rupees 4,27,417, and the principal causes of excess are attributable generally to the change in the plan of the Cortelliar Anicut and head-sluice, to the increased amount of cutting and embankment in the upper supply channel, and embankment and stone-work in the Cholaveram and Red Hill tank bunds. The amount of puddle and gravel-work in the latter also has been increased. The bridges have cost more than originally intended, and two expensive masonry works—a calingulah at Cholaveram tank and a masonry dam in the Red Hill bund, have been added. A quarter of a lac of rupees has been added for the distribution channels and dams, and the amount of sundries has been proportionately increased by the increase of estimate.

4. The following are some of the principal items of excess in the revised estimate:—

Anicut on Cortelliar River.

	RS.	RS.
Laterite masonry, excess	14,671	
Brick wells, do.	9,416	
Concrete, do.	6,987	
Total...		31,074

Head Sluice at Anicut for Supply Channel.

Laterite masonry, excess 1,056 yards	8,213
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Upper Supply Channel.

Earth-work, excess 86,059 cubic yards	6,064
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Accommodation Bridges.

Wood-work, excess	7,821
Masonry	4,312

Rough-stone Apron.

Earth-work and concrete	3,800
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Total... 15,933

Deduct saving in arch-work	5,285
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And in brick masonry	1,260
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6,545 9,388

Calingulah in Upper Channel.

New work, excess	6,480
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Cholaveram Tank.

Earth-work on bund, 193,340 cubic yards excess	30,009
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Revetment do. 1,952 do. and 23,469 yards	
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at higher rate	29,325
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Gravelling, excess	5,004
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Puddling, 13,195 cubic yards	12,904
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Turfing	1,581
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78,823

Cholaveram Tank Calingulah.

New works, excess	16,716
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Cholaveram Tank Sluice.

Laterite masonry, excess	2,352
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Granite, do.	4,040
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6,392

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Item	Rs.
Low masonry, excess	5
do	5,069
	15,024
Deducting brick masonry	3,063
	11,961
Earth-work, excess	33,538
Embankment	4,350
	37,888
<i>Red Hill Tank Calingulah.</i>	
Excavation in laterite rock, excess	6,114
Laterite masonry	2,136
	8,250
<i>Red Hill Lake Bund.</i>	
Earth-work, 107,890 cubic yards excess	25,765
Revetment, excess	19,265
Gravelling, do.	3,059
Puddling, do.	3,450
Turfing, do.	3,349
	54,888
<i>Soorapady and Salipet Bunds.</i>	
Earth-work, excess	4,119
Rough-stone pitching	2,505
	6,624
<i>Red Hill Tank Masonry Dam.</i>	
New work, excess	22,471
<i>Sluices in Red Hill Tank.</i>	
Laterite masonry, excess	10,309
Granite do.	11,256
	21,565
Removing silt in channel	4,683
<i>Allowance for distribution.</i>	
Channels and dams, excess	25,000
Contingencies, additional	19,115
	3,75,595

These items alone make up Rupees 3,75,595 of the excess of Rupees 4,27,417 over the original estimate. The various items of excess making up the balance are shown in the following statements accompanying.

5. *History.*—Captain Scott has detailed in his report the dates of relief of the three years of the project and the progress made under each Engineer. The work was begun in February 1867, at which date Captain Magnay relieved this office, and gave the contracts, for all the masonry works, to Messrs. Morgan and Co. The cutting of the channels and raising of the tank bunds were

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also given by him to other contractors. The former contractors began the Cortelliar Anicut in May 1867. The rates given for the wells and masonry under water were high, but the rate for masonry above foundation was Rupees 5-12-0, and this firm did not find this allowance remunerative. Captain DeC. Scott, R. E., relieved Captain Magnay in December 1867, and he found that these contractors had not made much progress with the masonry, the foundations having been laid at the anicut only. The upper channel was then nearly completed. Half the Cholaveram tank bund and lower supply channel had been carried out. The Red Hill tank bund had made considerable progress. Finding the progress under these contractors unsatisfactory and that little work had been done in 1868, Captain Scott finally took away all contracts from Messrs. Morgan and Co., in February 1869. The revetment of the Cholaveram tank could not be carried out by the other contractors for Rupees 2 8-0, and the rate was raised to Rupees 3 per yard. As these men were still dissatisfied their services were dispensed with, and the revetment work of this tank and of the Red Hill tank were carried out by departmental agency from May 1868, but the rate has not, on trial, been found capable of reduction.

6. As regards your remarks in paragraph 5 on the great difference of cost which appeared to prevail between hydraulic and common concrete, and on the general high cost of this material, I observe that Captain Scott reports that Messrs. Morgan's rates were Rupees 3-8-0 per yard, and that the rate by departmental agency was Rupees 3-3-4 per yard. At the Red Hill's work it was as low as Rupees 2-11-2. This would give from Annas 1 Pies 7, to Annas 1 Pies 10, per foot, whilst the Madras data is upwards of two annas. Again for hydraulic concrete the cost in Madras is doubled and amounts to Annas 4 Pies 4 per foot. The cost therefore at the Cortelliar Anicut of Rupees 5-8-0 per yard would not contrast so unfavourably with this data, which amounts to Rupees 7-2-9 per yard, considering that in both localities the gravel has to be brought by cart, a distance of many miles.

7. As regards the cost of masonry works below foundation level, the Executive Engineer reports that the charge for baling water is included in the rate.

8. You have drawn attention to the large sum already expended in contingencies which will render the amount* at five per cent., which I entered in the revised estimate, quite inadequate to meet the past and probable outlay, I beg however to refer to the statement of contingencies forming a portion of the appendix, wherein it is shown that a sum of Rupees 26,530 has been wrongly charged to the head but now transferred to works.

9. *Site of Anicut.*—This was changed to a point 600 yards lower down the river, in order that a thinner stratum of sand above the clay might be taken advantage of when sinking the wells, which were founded on clay. The height of anicut as before will admit of a head of six feet at the sluice.

10. *Retaining wall for apron.*—It is only intended to use wells where the depth of sand is such as to prevent solid masonry being laid for the wall.

11. *Apron.*—The stone for the apron was brought from six miles distance, and varied in the work from Rupees 2-10-0 to Rupees 3-6-0 per yard, according to

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3. The revised estimate, as now submitted, exceeds the original one by Rupees 4,27,417, and the principal causes of excess are attributable generally to the change in the plan of the Cortelliar Anicut and head-sluice, to the increased amount of cutting and embankment in the upper supply channel, and embankment and stone-work in the Cholaveram and Red Hill tank bunds. The amount of puddle and gravel-work in the latter also has been increased. The bridges have cost more than originally intended, and two expensive masonry works—a calingulah at Cholaveram tank and a masonry dam in the Red Hill bund, have been added. A quarter of a lac of rupees has been added for the distribution channels and dams, and the amount of sundries has been proportionately increased by the increase of estimate.

4. The following are some of the principal items of excess in the revised estimate:—

Anicut on Cortelliar River.

	RS.	RS.
Laterite masonry, excess	14,671	
Brick wells, do.	9,416	
Concrete, do.	6,987	
Total...		31,074

Head Sluice at Anicut for Supply Channel.

Laterite masonry, excess 1,056 yards	8,213
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Upper Supply Channel.

Earth-work, excess 86,059 cubic yards	6,064
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Accommodation Bridges.

Wood-work, excess	7,821
Masonry	4,312

Rough-stone Apron.

Earth-work and concrete	3,800
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Total... 15,933

Deduct saving in arch-work	5,285
And in brick masonry	1,260

6,545 9,388

Calingulah in Upper Channel.

New work, excess	6,480
------------------------	-------

Cholaveram Tank.

Earth-work on bund, 193,340 cubic yards excess	30,009
Revetment do. 1,952 do. and 23,469 yards	29,325
at higher rate	5,004
Gravelling, excess	12,904
Puddling, 13,195 cubic yards	1,581
Turfing	
	78,823

Cholaveram Tank Calingulah.

New works, excess	16,716
-------------------------	--------

Cholaveram Tank Sluice.

Laterite masonry, excess	2,352
Granite, do.	4,040
	6,392

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	RS.
Lat. masonry, excess	5
do	5,069
	15,024
Deducting brick masonry	3,063
	11,961
Earth-work, excess	33,538
Embankment	4,350
	37,888
<i>Red Hill Tank Calingulah.</i>	
Excavation in laterite rock, excess	6,114
Laterite masonry	2,136
	8,250
<i>Red Hill Lake Bund.</i>	
Earth-work, 107,890 cubic yards excess	25,765
Revetment, excess	19,265
Gravelling, do.	3,059
Puddling, do.	3,450
Turfing, do.	3,349
	54,888
<i>Soorapady and Salipet Bunds.</i>	
Earth-work, excess	4,119
Rough-stone pitching	2,505
	6,624
<i>Red Hill Tank Masonry Dam.</i>	
New work, excess	22,471
<i>Sluices in Red Hill Tank.</i>	
Laterite masonry, excess	10,309
Granite do.	11,256
Removing silt in channel	21,565
	4,683
<i>Allowance for distribution.</i>	
Channels and dams, excess	25,000
Contingencies, additional	19,115
	3,75,595

These items alone make up Rupees 3,75,595 of the excess of Rupees 4,27,417 over the original estimate. The various items of excess making up the balance are shown in the following statements accompanying.

5. *History.*—The various items of excess making up the balance are shown in the following statements accompanying. Captain Scott has detailed in his report the dates of relief of the three years of the project and the progress made under each Engineer. The work was begun in February 1867, at which date Captain Magnay relieved this Officer, and gave the contracts, for all the masonry works, to Messrs. Morgan and Co. The cutting of the channels and raising of the tank bunds were

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also given by him to other contractors. The former contractors began the Cortelliar Anicut in May 1867. The rates given for the wells and masonry under water were high, but the rate for masonry above foundation was Rupees 5-12-0, and this Firm did not find this allowance remunerative. Captain DeC. Scott, R. E., relieved Captain Magnay in December 1867, and he found that these contractors had not made much progress with the masonry, the foundations having been laid at the anicut only. The upper channel was then nearly completed. Half the Cholaverum tank bund and lower supply channel had been carried out. The Red Hill tank bund had made considerable progress. Finding the progress under these contractors unsatisfactory and that little work had been done in 1868, Captain Scott finally took away all contracts from Messrs. Morgan and Co., in February 1869. The revetment of the Cholaverum tank could not be carried out by the other contractors for Rupees 2 8-0, and the rate was raised to Rupees 3 per yard. As these men were still dissatisfied their services were dispensed with, and the revetment work of this tank and of the Red Hill tank were carried out by departmental agency from May 1868, but the rate has not, on trial, been found capable of reduction.

6. As regards your remarks in paragraph 5 on the great difference of cost which appeared to prevail between hydraulic and common concrete, and on the general high cost of this material, I observe that Captain Scott reports that Messrs. Morgan's rates were Rupees 3-8-0 per yard, and that the rate by departmental agency was Rupees 3-3-4 per yard. At the Red Hill's work it was as low as Rupees 2-11-9. This would give from Annas 1 Pies 7, to Annas 1 Pies 10, per foot, whilst the Madras data is upwards of two annas. Again for hydraulic concrete the cost in Madras is doubled and amounts to Annas 4 Pies 4 per foot. The cost therefore at the Cortelliar Anicut of Rupees 5-8-0 per yard would not contrast so unfavourably with this data, which amounts to Rupees 7-2-9 per yard, considering that in both localities the gravel has to be brought by cart, a distance of many miles.

7. As regards the cost of masonry works below foundation level, the Executive Engineer reports that the charge for baling water is included in the rate.

8. You have drawn attention to the large sum already expended in contingencies which will render the amount* at five per cent., which I entered

* Rupees 45,531.

in the revised estimate, quite inadequate to meet the past and probable outlay, I beg however to refer to the statement of contingencies forming a portion of the appendix, wherein it is shown that a sum of Rupees 26,530 has been wrongly charged to the head but now transferred to works.

9. *Site of Anicut.*—This was changed to a point 600 yards lower down the river, in order that a thinner stratum of sand above the clay might be taken advantage of when sinking the wells, which were founded on clay. The height of anicut as before will admit of a head of six feet at the sluice.

10. *Retaining wall for apron.*—It is only intended to use wells where the depth of sand is such as to prevent solid masonry being laid for the wall.

11. *Apron.*—The stone for the apron was brought from six miles distance, and varied in the work from Rupees 2-10-0 to Rupees 3-6-0 per yard, according to

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its size. It is not desirable to use smaller and less expensive stone, as the low specific gravity of laterite renders it peculiarly liable to the action of river freshes unless the blocks are large. Captain Scott gives his views as regards the erection of aprons and groyne above the anicut and wing-wall. I think this addition may stand over for the present, as the scour may not be great but yet sufficient to carry off any accumulation of sand.

12. *Upper Supply Channel.*—A section of the channel has been prepared, and the computation of excavation accurately prepared. The total amount taken from the sections gives 63,398 cubic yards, but the actual excavation carried out amounted to cubic yards 55,000 for the channel, to which must be added cubic yards 18,500 for the diversion channel of the Boosykhul river, and for the embankment cubic yards 3,886, making cubic yards 77,483 in all. The sole of the channel was originally widened to thirty feet from twenty-four feet as intended.

13. Mr. Fraser's estimate for the Boosykhul river diversion was wrongly estimated. The amount of work carried out was 9,225 cubic yards.

14. *Bridges over the two channels.*—There is no doubt that a saving of 500 rupees in each bridge might have been effected by adopting brick arches. The timber superstructures were found more expensive than was anticipated, but they caused much saving on the embankments forming the approaches. Care has been taken, as Captain Scott points out, to regulate the waterway and level of roadway with reference to the backwater from the tanks. The iron girder bridge on the road from Red Hills to the anicut over the lower supply channel was expensive, as the cost of the girders at the Public Workshops was excessive, and the carriage very high. If a masonry arch, however, had been constructed, it would have raised the roadway to eleven, instead of four feet. I would point out that the number of these bridges was fixed by Colonel Anderson, the late Chief Engineer for Irrigation, and experience as yet shows that they are sufficient for the traffic of the country. They were made with a waterway according to their present enlarged dimensions, in order to allow of the channel being widened eventually to sixty feet.

15. This contemplated widening of the sole of the channel also accounts to a certain degree for the extra cost of the inlets which have in consequence been built with more expensive side-walls, etc.

16. *Boosykhul surplus calingulah.*—Captain Scott points out that it was never intended to raise this calingulah to the height of that of the Cholaveram tank. It was found that if this escape was kept at this level, the rich valley on which the stream runs would be extensively swamped. In fact, Colonel Anderson thought that it would probably be found desirable hereafter to reduce the level of this tank by three feet, if not more, the crest of the calingulah being raised to fifteen instead of eighteen feet. The Boosykhul calingulah, however, was to be provided with dam stones to admit of the level being raised, if thought desirable.

17. *Cholaveram tank bund.*—Sections of this tank have been taken throughout and the cubic contents carefully calculated. They will be found, with those for the Red Hill tank, in the appendix. The quantity of soil in the main bund was found to be in excess cubic yards 107,475, on the northern extension 48,714, and in the southern extension 18,563 yards, making a total of 174,752 cubic yards. In the revetment a saving of 270 yards on the main bund, and in the other bunds 1,262

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and 375 cubic yards excess, total excess 1,367 cubic yards. The puddle 3,665, 7,668, and 1,882 yards, were in excess, making a total of 13,215 cubic yards, and the gravel 803, 2,156, and 1,035, total 3,994 cubic yards in excess.

18. Captain Scott explains that, owing partly to a mistake on setting out the work, and partly to the thickness of puddle having been changed, the bank had to be cut away and thrown back. He also states that Mr. Fraser did not calculate for the full height of the bank in estimating for the widening, and these causes have caused the excess. The estimate for the parapet wall of the tank has been revised and reduced.

19. *Cholaveram 20-vent Calingulah.*—The vents of this calingulah were approved of by Colonel Anderson, and the cill being three feet below the crest, it was intended to regulate the supply in the tank by means of shutters, and to irrigate from this work, if necessary and desirable.

20. *Cholaveram Irrigation and Channel head sluice.*—The site for the former was not fixed until the bank was thrown up, which accounts for the excess of earth-work. One sluice for irrigation is taken off from the wing of the head sluice—an arrangement which I do not generally approve of, but which was adopted by Captain Scott with my consent to save time and expenses in its construction. The gearing of the sluices are of iron, and the same arrangement is proposed for both.

21. *Channel between tanks.*—Sections and plan of this channel are forwarded. The fall and alignment were altered by Captain Magnay. The fall was originally intended to be three feet per mile throughout, and it is possible that portions of the channel bed would have borne the velocity caused by this fall; but after the cill of head sluice had been fixed, and the channel cut to three feet per mile, the cill was lowered one and a half feet more below the crest of the old calingulah, and the fall reduced to one and a half feet. The cost of cutting excavation in loam is high; but it must be remembered that, when operations began, the project was considered on the light of a famine work, and coolies were sent out from Madras in great numbers for employment indiscriminately under Mr. Fraser, the able bodied as well as the weak and infirm were hired, and a fair day's work for a full day's wage was not in all instances obtained. The rock was so hard that in many places it had to be blasted; 12 annas per yard, therefore, was not considered too high, and the Executive Engineer states that the quarry stone proved cheaper in the end for the works, and that double the above price for quarrying and loading on bandies per yard was paid. I am surprised, however, that he found the stone too brittle for use, as after many years' experience of this material for building purposes, I can say that, in my practice, I have always used the very hardest description, in preference to other, for new works.

22. *Red Hill Tank-bank.*—Captain Scott gives sections of this work, and goes fully and carefully into the calculations of the solidity of the bund. He found the quantity of cubic yards as follows in excess:—

	Earth-work.	Revetment.	Gravel.	Puddle.
Main bund.....	88,374	1,458	3,405	2,110
South extension...	4,229	103	229	875
Total cubic yards.	92,603	1,561	3,634	2,985

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23. The Sooropadu and Solapet bunds at the extremity of the tank are also slightly in excess of the original estimate.

24. *Red Hill Tank embankment near old calingulah and new masonry dam.*—It was originally intended that a calingulah, 300 feet long, designed with forty vents of five feet wide and cill one yard below the proposed calingulah, should be built. The old existing calingulah was to be built up two yards in the first year, and a temporary bund to raise the water to this level built, and the former work has been carried out, whilst the next season it was intended that the crest of the escape should be kept one yard below the full proposed level.

25. The masonry dam is an expensive work, but it must be remembered that it superseded the bank extension, which was to cost Rupees 3,652; also the proposed new calingulah referred to above and the temporary dam. The masonry dam also is formed in portion of the wall which was thrown for six feet high across the old calingulah.

26. The clearance of the channel has been rendered necessary from the accumulation of deposits thrown into the upper channel by the flood-waters of the Katenkhal and Boosykhal stream especially, and by the erosion of the channel-banks. You will find that I have referred to this subject, and the causes of accumulation in the supply-channel, in paragraph 6 of my former Report. I think it probable that the head of the channel where it receives the Boosykhal water will have to be regulated and perhaps sluices built in the body of calingulah.

27. In thus going over briefly the several items of the revised estimate, and the causes of the increase in the working quantities, I have only slightly touched upon the subject of rates which, as a rule, have been raised on the works throughout, since the commencement of the project. I do not find that Captain Scott has gone into the subject of the comparison of these rates with those prevailing in the neighbourhood on works undertaken by the Range Officer. On comparing the two, however, from data in my own Office, I find that the prices paid are somewhat in favour of the range works, and particularly so in the item of well-work. Captain

* 4½ feet diameter.

† 3 " "

Scott's wells have cost from 7 rupees* to 4 rupees† 10 annas per foot, whilst those sunk at the Cortelliar river-bridge

cost 3 rupees per foot of the smaller size. The brick-work in chunam at the Red Hill Project averages, for the superstructure, Rupees 4-11-6 per yard, whilst the range rate is Rupees 4-8-0, and even less. I do not find that the laterite in chunam varies much in price; if any thing the rate is in favour of the Red Hills work. The cut granite stone-work is certainly very expensive, and a third more than that prevailing in the range, if we may judge from the very small quantity carried out, and than that prevailing at Saint Thomas' Mount; but the work at the Red Hill and Cholaveram Tanksluices is better; also it is "three line" dressed, and the stones are of larger size. I ascertained this morning at the Mount that inferior work there, "two line" dressed, is now costing 1½ rupees per foot, or 40 rupees per cubic yard. It must be taken into consideration that the demand for stone-cutters exceeds the supply, and owing to the paucity of these work-people they are exorbitant in their rates for contract-work, and idle and independent on the works, knowing that

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if they are dismissed, their places cannot be readily supplied. The cost of excavating gravel is much the same at all works, and the enhanced rate is caused by the bandy carriage, which is 1½ and 2 annas per mile, and by the tamping and watering.

28. In considering what are the rates which may be considered fairly remunerative to contractors, and which, in all fairness, may be paid on this work, it ought to be considered that the operations were commenced with an entirely new staff of executives and their subordinates, as none of the permanent Overseers of the department were employed on the work. Captain Scott also was placed in charge immediately on his arrival from England, and before he had gained any Indian experience; Captain Magnay likewise was in bad health for a considerable period during his executive charge. The masonry works were all given on contract; in the first instance to the Firm of Morgan & Co., and though they subsequently failed in their engagements under their Contract, it was supposed at the time that they had means at their command and labour at disposal, which would enable them to carry out the works on more favourable terms for Government than other contractors, a portion of the excess outlay on the lower channel, when operations were first undertaken, is clearly attributable to the mode in which the work was first organized; coolies in large numbers having been sent out from Madras to Mr. Fraser, and instructions issued to that officer to employ all the men, women, and children who came to him for employment, in order to find them relief.

29. As regards the probable remunerative character of this project, I wrote to the Collector of Madras on the 16th October 1869 for fuller details regarding the probable increase of cultivation under the tanks likely to be supplied by the enlargement of these reservoirs, and Mr.

Letter, dated 7th October 1869, No. 382.

Thornhill promised to have the necessary investigation made. The papers received with Captain Scott's letter, which were formerly furnished to Colonel Anderson by the Collector, show that 11,272 cawnies of waste land, assessed at Rupees 33,835, may be brought under cultivation if water is available; and that a probable increase from this land and from second crop cultivation may be expected, amounting to Rupees 82,160.

30. In addition to this source of revenue, it is intended that the Municipal Commissioners of Madras should draw off for their water-supply 40 millions of cubic yards at the cost of 1 rupee for every 1,000 cubic yards.

31. The capacity of the tanks, after their bunds have been raised, will amount to 138 millions of cubic yards, and allowing 38 millions for the Mirassidars under their present rights of cultivation, and the quantity stated above for the Madras Water-supply, there will remain 60 millions cubic yards sufficient for the irrigation of six thousand cawnies; supposing the land assessed at 7 rupees per cawny, the return on increased cultivation will amount to 42,000 rupees, and this, added to the cost of the water supplied to Madras, 40,000 rupees, will make the total 82,000 rupees, which, on an expenditure of 10,39,176 rupees, will yield a profit of eight per cent.

32. In G. O., No. 1,102, dated 11th April 1866, Government assumed that the rate of Rupees 7 per acre was a fair assessment for the land under these tanks; but I have taken the same amount as the return *per cawny*, in order not to place the remunerative character of the project in too fair a light, and also to allow of the maintenance of the works being deducted from the profits.

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No. . Read the following letter from the Executive Engineer, Madras Water Works, to the Superintending Engineer, 4th Division, dated Red Hills, 1st January 1870, No. 1.

I HAVE the honour to re-transmit herewith the revised estimate and plans of the Madras Water Works Project, with documents giving the additional information required by the Acting Chief Engineer for Irrigation in his memorandum, No. 265, of the 7th September 1869. I shall proceed to notice the points referred to in that memorandum seriatim, commencing with a history of the work:

II. G. O., No. 2,374, of the 27th July 1866, directs the commencement of the Madras Water Works under Mr. Fraser, Executive Engineer. The excavation of the channel from the Cholaveram to the Red Hill Tank was commenced on the 20th August 1866, that of the upper channel, i.e., from the Cortelliar River to the Cholaveram Tank, on the 2nd February 1867.

Captain Magnay relieved Mr. Fraser of the charge of the project on the 16th February 1867. The former officer in his Administration Report for the year states that he found 480 coolies engaged in the excavation of the channel between the lakes, and 1,600 on that from the Boosykhal River to the Cholaveram Tank. A certain number of men were also quarrying stone for the revetment to the bunds of the tanks, but no other work seems to have been taken up at that date.

Captain Magnay further gives the following as the rates for which the excavation then going on had been contracted for, viz. :—

On channel between the lakes.

	RS.	A.	P.
Clay or loam per cubic yard.....	0	2	6
Gravel do.	0	5	0
Rock to three yards depth	0	12	0
Rock below three yards depth	1	0	0

On upper Channel.

Ordinary soil per cubic yards.....	Annas 2
Hard gravel	" 4

2. Captain Magnay, as Executive Engineer in charge, continued the operation of channel excavation; he entered into contracts with several native contractors for the excavation of the channel between the Boosykhal River and the Cortelliar River, and for raising and revetting the bunds of the two tanks. He also, with the approval of the Superintending Engineer, 4th Division, contracted with Messrs. Horgan & Co. for the construction of the whole of the masonry works in connection with the project.

3. It is necessary to observe here that none of these contracts are formal. In the case of those for excavation for channels or forming bunds or bund revetment, a memorandum of the rate at which work of the nature described is to be done, and a general specification has been written out and signed by the contractor; but there is no penal bond for failure in carrying out the work;

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there is no definition of the quantity of each kind of work or material contracted for, nor are the plans of the works to be executed referred to in the agreements or specifications where such exist, as explanatory of the contract.

4. As a rule, the only Natives who come forward to take up work of the kind referred to possess but a small amount of capital; they have usually no theoretical and little practical knowledge of their business, and they are unwilling to enter into formal engagements.

When they commence work they are often quite ignorant of the cost of that which they undertake; they may accept inadequate rates. any rates which are offered to get the work into their hands, but they take care to remain unfettered, and commencing on a small scale, they feel their way and trust to eventually getting prices which will pay them.

5. The contract with Messrs. Horgan & Co. already referred to requires Messrs. Horgan & Co.'s Contract now carried to be noticed, as it turned out unfavourably for the project. A copy of the Agreement signed by them is attached together with the schedule of rates and specification which accompany it.

6. Under this Agreement they commenced on the 15th May 1867 the construction of the anicut and head sluice on the Cortelliar River, and by the end of September of the same year, they had made good progress in the foundation of these works.

They had also built the calingulah of the Red Hill Lake and the abutments of a cart-bridge, but at all the other masonry works their progress was nil.

Other work executed by Horgan & Co.
Rates paid to Messrs. Horgan & Co. disproportionate.

Well foundations, Rupees 7-2-7 per square-feet.
Masonry under water, Rupees 8 per cubic yard.
Superstructure brick, Rupees 4-8-0 per cubic yard.
Superstructure laterite, Rupees 5-12-0 per cubic yard.

Work first executed by the contractors in favourable situations.

7. It will be observed that the rates agreed to be paid to them for well foundation work and masonry under water are disproportionately high when compared with the rate for brick-work and masonry in superstructures; further the site of the Red Hill calingulah is at a laterite stone quarry, and the bridge constructed by them is a quarter of a mile from the same quarry.

8. When these contractors were, in February 1868, required by me to proceed with other works in the Red Hill Lake and the Cholaveram bunds they expressed their inability to undertake any of them, and requested to be allowed to limit their operations to the masonry works on the channel from the Cortelliar to the Boosykhal River, and as they had collected no proper materials at the works abandoned by them; all the time which had elapsed between their acceptance of the contract and this date had been entirely lost so far as these were concerned.

No material collected at these works.

Loss of time in consequence.

9. The progress of these contractors with the works which remained in their hands was subsequently very unsatisfactory in consequence of their finding that the rate of Rupees 5-12-0 a cubic yard allowed for the laterite superstructures

The progress of the contractors with the works remaining on their hands was unsatisfactory.

The work executed in some cases bad.

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was not profitable. The quality of the work executed by them was in several instances bad; the rate was increased, but the rate increased without better results. The Executive Engineer was compelled to take into his own hands work after work, and finally in February 1869 they were discarded altogether after causing very great loss of time.

10. Captain Magnay being compelled by ill-health to proceed to England on furlough, he was relieved by me on the 11th December 1867, at that date the following was the general state of progress of the work. The foundations of the body wall of the anicut and retaining wall with its apron were built to the level of the bed of the river. The foundations of the body of the head sluice to the supply channel were carried up to the same level. The excavation of the whole supply channel from the Cortelliar River to Cholaveram Tank was completed with the under-mentioned exceptions, viz. :—

General state of the works.

Anicut.

retaining wall with its apron were built to the level of the bed of the river. The foundations of the body of the head sluice to the supply channel were carried up to the same level. The excavation of the whole supply channel from the Cortelliar River to Cholaveram Tank was completed with the under-mentioned exceptions, viz. :—

Head sluice.

Supply channel in the Cholaveram Lake.

the Cortelliar River to Cholaveram Tank was completed with the under-mentioned exceptions, viz. :—

$\frac{3}{4}$ of a mile from head sluice ($\frac{1}{2}$ excavated.)

$\frac{1}{2}$ do. through Alichary Tank (untouched.)

$1\frac{1}{2}$ do. deep cutting at Alamady ($\frac{1}{2}$ excavated.)

Boosykhah diversion channel.

The Boosykhah diversion channel was completed for two-thirds of its length.

The earth-work of the Cholaveram Tank bund was considerably advanced about 189,070 cubic yards of earth out of an estimated total of 478,787 cubic yards having been thrown up.

Cholaveram Tank embankment.

Only 3,130 cubic yards of revetment had been built.

The excavation of the channel between lakes for one mile was completed; for one mile half excavated, and for half mile untouched; the latter portion being

Channel between lakes.

that part running through the laterite rock ridge near Cholaveram Tank.

The earth-work of the Red Hill bund had made considerable progress, but only 2,076 cubic yard of revetment had been laid.

Red Hill Lake embankment.

10. The following tabular statement shows approximately the quantity of work executed at the several sections of the project when Captain Magnay was relieved, the rates paid, and the names of the contractors.

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Name of Works.	Approximate quantity executed up to 10th Dec. 1867.	Proportion of work executed to the whole.	Per	Rates heretofore paid or contracted for.	Names of Contractors.
					RS. A. P.
<i>Head Sluice and Anicut.</i>					
Earth-work for foundation, C. yds.	7,910	·358	C. yd.	0 2 3	Messrs. Horgan & Co.
Brick-wells sunk.....L. ft.	1,296 $\frac{1}{2}$	·749	L. ft.	7 2 7	
Concrete.....C. yds.	1,009 $\frac{1}{2}$	·811	C. yd.	5 8 0	
Laterite masonry in chunam under water. C. yds.	2,746 $\frac{1}{2}$	·782	..	8 0 0	
Brick-work in chunam under water ... C. yds.	160 $\frac{1}{2}$	1·00	..	5 8 0	
Rough-stone....."	490	·249	..	3 0 0	
Pointing.....Sgre.	200	·392	Square.	1 12 0	
<i>Supply Channel to Cholaveram Lake.</i>					
Excavation of earth. C. yds.	4,70,812 $\frac{1}{2}$	·738	Gravel... C. yd.	0 4 0	Shunmuga Moodelly. Cundasaany do. Teruvangada Chetty. Gopaul Rajoo. Veeraragavooloo.
			Loam... ..	0 2 0	
				0 2 3	
<i>Cholaveram Bund.</i>					
Earth-work.....C. yds.	1,89,070	·375	C. yd.	0 2 7	Coopatha Moodelly & Co.
Revetment....."	3,130	·117	..	2 0 0	
Gravelling....."	2,239	·123	..	0 3 0	
Puddling....."	5,681	·114	..	0 8 0	
<i>Supply Channel to Red Hill Lake.</i>					
Earth-work loam...C. yds.	45,534	·842	C. yd.	0 2 6	Veeraragavooloo.
Gravel....."	38,489 $\frac{1}{2}$	·432	..	0 5 0	
Do."	3,333	·837	..	0 8 0	
Do."	4,067	·286	..	0 10 0	
Rock above three yards ...	14,298	·815	..	0 12 0	
Do. below three yards ...	9,536	·457	..	1 0 0	
<i>Cart bridge No. 1 on Supply Channel between lakes.</i>					
Earth-work for foundation, clay.....C. yds.	171	1·00	C. yd.	0 2 3	Messrs. Horgan & Co.
Do. gravel... ..	367	1·00	..	0 5 0	
Laterite masonry in chunam under water. C. yds.	137 $\frac{1}{2}$	1·00	..	8 0 0	
Do. in superstructure...	221	·333	..	5 12 0	
Pointing.....Sgre.	6 $\frac{1}{2}$	·812	Square.	1 12 0	
<i>Red Hill Bund.</i>					
Earth-workC. yds.	89,914 $\frac{1}{2}$	·36	C. yd.	0 3 0	Veeraragavooloo. Coopatha Moodelly & Co., Soondra Moodelly and Co. Do. Do.
Revetment	2,076	·100	..	2 2 0	
Gravelling	1,762	·122	..	0 3 3	
Puddling....."	4,191 $\frac{1}{2}$	·097	..	0 7 3	
<i>Red Hill Calingulah.</i>					
Excavation in gravel.C.yds.	305	1·00	C. yd.	0 8 0	Messrs. Horgan & Co.
Do. in rock .."	915	1·00	..	0 12 0	
Laterite masonry in Chunam.....C. yds.	703	1·00	..	5 12 0	

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11. The progress of the revetment to the bunds had been, up to this date, exceedingly small; the contractor for the Cholaveram Bund applied for an increase of rate for this work in December, stating that the price given of Rupees 2-8-0 per cubic yard was totally inadequate; they demanded Rupees 3-8-0 per cubic yard. The question was investigated by the Superintending Engineer and Chief Engineer for Irrigation, on the occasion of their inspection of the works in January 1868, and an increased rate of Rupees 3 per cubic yard was offered, and reluctantly accepted by the contractors; a proviso was made at the same time that the work should be of better quality than heretofore. Their progress continued to be exceedingly unsatisfactory, and they again applied for an increase rate in February 1868 finally; as they were evidently dallying with the work, and refused to make greater progress unless the price given was Rupees 3-8-0 per cubic yard, the Executive Engineer was under the necessity of entirely dispensing with their services.

12. In like manner the petty contractors employed on the revetment of the Red Hill Bund complained of the price given. Their rate of progress did not at this time exceed four cubic yards per diem.

13. Endeavours were made to procure other contractors. Advertisements calling for tenders were inserted in the Government Gazettes, but none came forward, and in May 1868 it became necessary to carry on the work at the Cholavaram Bund, as well as the bulk of the masonry works (given up by Messrs. Morgan and Co.,) by departmental agency. This inferred the manufacture or purchase of tools, plant, and materials of every kind; the procuring of labour, skilled and unskilled, and of subordinate superintendence for its direction, and as only one overseer, with a few months' training in the department, could be spared for this project, while all others, including the Office Establishment, were engaged temporarily, and had never been in the department before, it is obvious that some time was required to organize and place matters on a satisfactory footing.

14. At this time also the details of the project, as presented by Mr. Fraser, were under revision, and it was considered absolutely necessary to cancel entirely the *whole* of the designs of the masonry works previously estimated for, and to prepare others.

15. The orders of Government on the several reports of the Superintending Engineer and Chief Engineer for Irrigation while approving of the proposed alterations, at the same time, impressed on the officers concerned, the necessity of making rapid progress with the works. The designs for the masonry works were prepared, as they were successively to be

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taken up for construction; those for the head sluices to the supply channels from the Cortelliar river and from the Cholaveram tank to the Red Hill tank as well as the irrigation sluices in the Red Hill tank bund, were furnished to me by the Chief Engineer for Irrigation through the Superintending Engineer of the 4th Division; those for the bridges and inlets on the upper channel as well as the waste weirs to upper channel and reservoir, were drawn by myself from sketches furnished by Colonel Anderson. The details being modified, of course, to suit the circumstances in each case. The remainder, viz., irrigation sluices for the Cholaveram reservoir, masonry dam, and works on channel between lakes, were designed by myself and submitted for approval before they were commenced.

16. It had already been found that the rates given in the original estimate (presumably founded on proper investigation and trial) could not be depended on, and consequently the only alternative was to ascertain, in the course of construction, of the earlier works, what the cost of the different descriptions of works would be; moreover the nature of the alterations necessary in the details of the original project were progressively ascertained and carried out, so that no complete and final estimate could be made at the commencement.

17. It was under the circumstances above noticed that the execution of the project devolved upon me. In carrying it on it has been found that there is much scarcity of skilled labour, and in fact of labour of all kinds, except that required for the construction of earth-works. Every inducement has been given to the petty contractors to increase their rate of progress with the revetment of the bunds, which is a work of great magnitude. Endeavours made to induce contractors to increase their rate of progress. Enhanced rates have been offered conditionally on a certain minimum quantity being executed monthly, but they have hitherto failed to earn the premium.

18. In the masonry works too where granite forms part of the construction, such as the sluices in the bunds and channels, it has been impossible to procure the skilled stone-cutters in any thing like the numbers required to make the progress usual with works, into which this material does not enter. As regards the collection of materials for the masonry works generally the time, between February 1867 and March 1868 when Messrs. Horgan and Co. gave up the greater part of the works, had been lost. Nevertheless substantial progress was soon made, and as the establishment of the range became trained in field, and office duties, an accurate system of account for each section of the earth-work, and for each masonry work, was established showing the expenditure debitable to each sub-head.

19. The statement below gives the cases in which the rates paid at the commencement of the work were increased, and the amount of increase; that following shows the quantity of work of each kind executed by contractors and by departmental agency up to the 31st March and 31st October, respectively, and the cost per unit of measurement.

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Names of Contractors.	Nature of work executed.	AMOUNT OF INCREASE OF RATE IF ANY.		Remarks.
		From	To	
Messrs. Horgan and Co.	Laterite masonry in chunam, in superstructure at anicut and head sluice.	RS. A. P. 5 12 0	RS. A. P. 6 8 0	Insufficiency of original rate as exhibited in analysis of cost furnished by contractors, see appendix A.
Coopatha Moodelly and Co.	Earth-work at Cholaveram.	0 2 7	0 3 0	The rate increased in cases where the soil was gravel on representation by the contractors of the insufficiency of the rate.
Do ...	Revetment at do. ...	2 0 0	2 8 0	The rate was increased after urgent representation by the contractor and investigations of cost.
Veeraragavooloo. ...	Earth-work at Red Hills.	0 3 0	0 4 0	The rate increased for excavation in clay where baling was necessary to keep the pits dry, and includes watering and ramming.
Do ...	Revetment at do. ...	2 8 0	3 4 0	This rate is confined to that portion of the bund most distant from the quarry, and was given after experience had shown that the former rate was insufficient.
Soondra Moodelly and Co.	Do... ..	2 8 0	2 12 0	The rate increased, as it was found necessary to do so to remunerate the contractors sufficiently to incline them to carry on the work on a proper scale.
All contractors ...	Gravel Puddle in extension of the Red Hill Bunds.	0 4 0 0 8 0	0 8 0 0 10 0	The materials having to be carted from a distance to be used in the extensions of the bunds, the rates given for similar work in the main bunds are insufficient. In the case of these the puddle clay is carried by basket, and the old revetment broken up, has served for the gravel.

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Names of Contractors.	Nature of work executed.	Quantity executed from 11th Dec. 1867 to 1st April 1869.	Average rate.			Remarks.
			RS.	A.	P.	
Messrs. Horgan and Co.	Earth-work C. yards.	99,907½	0	2	4	
	Brick-wells sunk L. feet.	158½	6	12	11	
	Concrete C. yards.	447½	5	3	1	
	Rough-stone in apron..... "	1,887½	4	10	2	
	Laterite masonry in chunam under water and in superstructure ...	6,214½	6	7	3	
	Dressed granite C. feet.	811½	2	4	0	
	Arch-work in laterite C. yards.	65½	10	0	0	
	Pointing walls Sqre.	169½	1	12	0	
	Centerings to arch No.	10	10	0	0	
	Mangoewood sheet piles... Sqre.	449	0	7	6	
	Wood-work C. feet.	380	3	4	0	
Veeraragavooloo. ...	Earth-work C. yards.	2,88,395	0	4	4	
	Revetment "	2,112½	3	5	11	
	Puddling "	3,838½	0	8	0	
	Gravelling "	1,377	0	4	0	
	Turfing Sqre.	10,939½	0	1	4	
Cundasamy Moodelly...	Earth-work C. yards.	63,193	0	2	3	
	Revetment "	311½	3	1	0	
	Gravelling "	158	0	8	0	
	Puddling "	3,158½	0	7	6	
	Turfing Sqre.	6,524½	0	0	9	
	Rough-stone C. yards.	291½	2	0	0	
Coopatha Moodelly and Co.	Earth-work "	1,11,090	0	2	8	
	Revetment "	109	2	8	0	
	Gravelling "	3,595	0	3	0	
	Puddling "	6,231½	0	8	0	
Soondra Moodelly and Co.	Earth-work "	16,140	0	2	6	
	Revetment "	4,100½	2	11	11	
	Gravelling "	2,550½	0	4	0	
	Puddling "	14,085	0	6	5	
Satiapatty Moodelly ...	Earth-work "	11,853	0	2	9	
Shunmuga Moodelly ...	Do. "	9,491	0	2	0	
Ruthnum Moodelly ...	Do. "	993	0	3	2	
From 11th Dec. 1867 to 31st October 1869.						
By Deptl. Agency ...	Earth-work C. yards.	1,48,741	0	2	9	
	Brick-wells sunk L. feet.	312	6	2	0	
	Concrete C. yards.	3,925½	2	4	1	
	Rough-stone "	1,199½	3	4	3	
	Arch-work in bricks.....	357	4	2	3	
	Brick-work "	895½	4	6	0	
	Laterite masonry.....	8,703½	5	15	1	
	Granite do.	9,123	2	2	3	
	Pointing Sqre.	1,033	0	14	0	
	Wood-work C. feet.	1,781	3	0	4	
	Revetment C. yards.	9,381½	2	15	9	
	Gravelling "	6,486½	0	10	0	
	Puddling "	23,569½	0	7	3	
	Turfing including trimming the slopes Sqre.	26,064	0	1	5	

III. In the cases where the rates paid for work in the period included in the above table were higher than those previously given. The following causes for such increase which are of general application may be noted.

1. Native contractors tendering for work to be executed under verbal or informal agreements, which do not bind them to finish work at a certain rate within a certain time, when subjected to competition, almost invariably tender at a lower rate than will pay them, trusting to obtain higher rates as already explained.

2. In the case of either masonry or earth-work a contractor can of course begin at a far lower rate than that at which it would pay him to complete the work. In the case of a channel the cost to himself rapidly increases, with the depth of cutting in the case of a bund on masonry work with the height to which it is raised.

3. As all the contracts entered into when these works were commenced were of the nature described, as the natives tendering were competing with each other, and as the channels were deepened and the bunds and masonry works were raised during the period compared in the above statement, the tendency to increased rates follows inevitably.

2. A schedule of the rates for different descriptions of work at several localities within the limits of the country traversed by the channels, etc., accompanied the revised estimate forwarded to you on the 9th July 1869. This has been corrected, and to it has now been added a statement of the daily wages current in the district for labour of various kinds.

Appendix B.
Analyses of the different rates.
The cost of materials delivered at the site of several works, and analyses of the rates for the principal description of work at the three localities referred to in the 3rd paragraph of the memorandum of the Acting Chief Engineer for Irrigation. Specifications of the work are also given; strict attention to these has been enforced, and it need hardly be pointed out that, unless the standard of work executed at other places is the same, no direct comparison can be instituted.

3. The rates given for concrete, as regards the head works and upper channel, were mainly derived from the schedule accompanying the written agreement entered into by Captain Magnay with Messrs. Morgan and Co., and referred to in paragraph 2. of this report. Their analyses of the rates for common and hydraulic concrete accompanies the schedule. The quantity of chunam and sand used appears to be unnecessarily large, the proportions for work executed subse-

quently by departmental agency on the channel are given in the schedule of rates,

Rate for concrete by departmental agency. appendix B. The cost being Rs. 3-3-4 per cubic yard as compared with Rupees 3-8-0 given by Messrs. Morgan and Co. The actual average for the channel works is Rupees 2-12-0. As there was frequently broken stone to be found near the works, the addition of burnt clay

"Hydraulic concrete" unnecessary. ground to powder, with a view to rendering the lime hydraulic, was discontinued by my direction as being unnecessary and of doubtful efficacy, but this was after the quarter portion of the concrete work had been completed by the contractors. The cost of the concrete used at the Red Hill tank is made out in the analysis attached to the schedule above referred to. The material used is the gravel or angular stone, principally gneiss picked out from soil composed of disintegrated laterite, and varying from one inch to 2½ inches in diameter.

Cost of concrete at the Red Hill tank works. Broken laterite is not suited for making good concrete, as it is easily crushed and contains a large per-centage of friable earthy matter. The soil may perhaps contain 20 per cent. of suitable material.

Material used for concrete. Broken laterite stone not suitable.

4. The difference between the cost of wells sunk and those to be sunk given in the estimate is caused by the fact, that the former were of 4½ feet internal diameter; the latter three feet.

Comparative statement.
Cause of difference between cost of wells sunk and to be sunk.

5. The rate Rupees 7-2-7 for masonry executed at the head works is a general one, derived from the schedule of Messrs. Morgan and Co., including that in foundation under water at Rs. 8-0-0, and that in superstructure at Rupees 6-8-0; the cost of baling is included in the former.

6. An analysis of the rate for the masonry in superstructure, as given by the contractor, is inserted in appendix A; that for work subsequently done near the same spot by departmental agency, is given in appendix B., No. XVIII.

Laterite masonry analysis by contractors.
Laterite masonry by departmental agency.

7. The cost of the rough-stone apron of the weir Rupees 3 per cubic yard is made up of three items, viz., rough unshaped stone of various sizes for lower courses at Rupees 2-12-0 per cubic yard, quarried stone roughly squared of not less than 2½ cubic feet each closely fitted for the top course at Rupees 3-3-0 per cubic yard, and larger stones of the same description four cubic feet each at Rupees 3-6-0 a cubic yard. The cost of undressed building stone per cubic yard of the size used, viz., 3' × 1'—6" × 1'—3" and 2' × 1'—6" × 1'—3" was Rupees 3-8-0 to Rupees 3-3-0 per cubic yard. The

Rough-stone apron to anicut, explanation of rates.
Cost of building stone.

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former rate was paid by the contractors, Morgan and Co. The lighter stone was partially stripped from the apron by the Reason for using heavier stone in anicut apron. moderate freshes in the river in October and November 1868, and it seemed necessary to use large sized stone more immediately below the anicut.

Analyses of rates for rough stone-work. 8 Analyses of the rates for the different classes of rough stone-work are inserted in appendix B.

Sundry charges unduly increased. 9. The charges to the sundries of the estimate have been unduly increased under circumstances detailed below.

In consequence of the failure of several of the contractors to carry on the works satisfactorily, the necessity was thereby incurred of considerable expenditure in the purchase of tools, plant, and rest so for their execution by departmental agency. A considerable portion of this expenditure has been charged to estimate as sundries, instead of being met by the budget allotment under this head, because the Superintending Engineer had no available funds. The Executive Engineer of course could not foresee the necessity for the outlay, and had not made a demand during the previous year which might have secured the sum required.

Expenditure on stock improperly debited to sundries. Expenditure on stock materials at the site of the works or in store has been improperly debited to sundries. The value of stock has now been deducted from sundries, and being treated as work already done, it is also deducted from the total of the column "work to be done" in the comparative statement. A very considerable proportion of the expenditure on sundries is made up of temporary work, which may properly be detailed in the estimate and of expenditure by Mr. Fraser in 1867-68 which could not be detailed. A schedule of the charges improperly debited to sundries is now attached (appendix C.)

These have been removed from the account and have been charged as noted.

IV. The change made in the position of the anicut constructed on the Cortelliar river, as compared with that proposed by Mr. Fraser, is noticed in the report to Government of the Superintending Engineer of the 4th Division, dated 2nd August 1867, and in G. O. thereon No. 2,783, which approves of it.

2. Mr. Fraser selected for the site of his work a point about 600 yards higher up the river. The site on which the work was actually built showed a thinner superstratum of sand over the clay, and was considered on that account more advantageous. Mr. Fraser's anicut gave on the sill of his sluice a depth of water of six feet which is maintained.

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3. The wells for the anicut foundation were sunk till they entered and were bedded evenly on the clay, the irregularities in which were cut away to receive them.

Anicut well foundation. The wells of the wing-walls are correctly shown. At some portion of the site the clay approached within such a distance that the excavation could be carried down to it with baling, and at those places wells were not used.

Wing-walls partly on wells. 4. Wells will only be used in the foundation of the retaining wall, where the thickness of sand over the clay is such that the latter cannot be reached by ordinary excavation carried on without baling of an expensive nature.

Retaining wall to apron. The depth of sand given by the borer when it was tried was nine feet, and an excavation of this depth could not be made without a coffer-dam. Water in quantities is met six inches below the surface.

Wells necessary. 5. The distance of the quarry, from which the rough-stone for the anicut apron is brought, is six miles; explanation has been given above on the subject of the cost of this material. Rough lumps of laterite varying from one to two cubic feet each can be procured for Rupees 2-10-0 a cubic yard, quarried stone about 2½ cubic feet each for Rupees 3-3-0, and stones four cubic feet each for Rupees 3-6-0 a cubic yard.

Distance of quarry from head works. The smallest stone has been used for the under-courses of the apron; the next size was used by the contractor for the top course, of which a great portion was stripped off or dislodged last year, and the larger size has been used by myself this year for repairs and renewal of top course immediately below the anicut.

Cost of various bunds of rough-stone. Nature of stone used at different parts of the apron. The apron, if extended, can probably be built exclusively of the smallest stone.

6. The wing-wall has now been shown in the cross section of the anicut, and the section corrected where necessary.

7. It would not appear likely that there would be an accumulation of silt in the corner between the anicut and head sluice. The scour along the anicut through the under-sluices will, it is imagined, be more than compensated for by the silt brought down by the river, and it is not considered worth while to insert an item for rough-stone and groyne in the manner mentioned.

8. The lifting gear formerly shown for the head sluice is that provided by Mr. Fraser in his designs submitted to and approved of by Government; no calculation was made recently of the lifting or lowering power available, but a modified arrangement is now shown of which the parts are made.

Lifting gear for sluice shutters.
Revised form.

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The screw is worked by a capstan fixed to the upper cross beam which is connected with the lower one by a cast iron frame. The lower cross beam will be secured to the masonry by $1\frac{1}{4}$ inch bolts three feet long, these will be built in, and the lower ends welded to iron discs of boiler plate. The screw thread is now shown to the depth required, viz., about six feet. The levels of the cills of under-sluiques, crest of anicut, and flood-levels are shown.

V. A plan of the supply channel from the Cortelliar river to the Cholaveram reservoir and the Boosykhal diversion channel with longitudinal and cross sections and calculation of the cubical content are forwarded, vide appendix D.

The line of direction of the channel proposed by Mr. Fraser where it deviates from that excavated is indicated by a red line.

Cubical content of supply channel excavation. 2. The actual content of the channels computed from the working sections appears to be 6,33,980 cubic yards.

The length of the channel estimated for by Mr. Fraser was eight miles, 1,043 feet; that excavated, eight miles, 1,980 feet, showing an extra length of 937 feet. The diversion channel from the Boosykhal river was estimated for originally, as 12 feet wide at the bottom, with a length of 2,400 feet, it was considered necessary to enlarge the cross section and make the channel 30 feet wide, while it is 2,775 feet in length; finally the channel where it crosses the Allacharri tank is embanked on the upper as well as the lower side to retain the tank supply, for this extra excavation was necessary.

These differences are nearly sufficient to account for the excess in quantity (86,000 cubic yards) of earth excavated over that estimated, for, as follows:—

Statement showing how increase in quantity of excavation in revised estimate is made up.		Extra content of cutting in main channel	
from the working sections	...	C. yds.	55,102
Extra excavation in diversion channel	...	"	18,500
Raising embankment on upper side of channel at Allacharri tank...	...	"	3,886
Total...	...	"	77,488

3. The provision made by Mr. Fraser for the earth-work in connection with the crossing of the Boosykhal by the main channel, in addition to the mere excavation for the foundation of his aqueduct is only 2,355 cubic yards, which is inserted as a quantity in the calculations for the channel excavation (item No. 186 of detailed estimate.)

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This earth-work called in the revised estimate the lower Boosykhal dam, is not included in the quantity returned as channel excavation executed, consequently the equivalent item should be taken out of Mr. Fraser's estimate for the channel when comparing it with the revised estimate. The increased quantity in the latter is, therefore, really 88,355 cubic yards, in lieu of 86,000 cubic yards; nevertheless the calculation above given of extra work covers this excess within 10,867 cubic yards.

VI. A plan, as well as longitudinal and cross sections of the upper and lower dams across the Boosykhal River are attached (Appendix E.), together with a computation of the quantities of excavation, &c., in the upper dam. No plan of the dam proposed by Mr. Fraser, in connection with the diversion channel, appears to have been made, it is indicated on the survey and longitudinal section of the Boosykhal River Sheet No. 10 of the original series of plans.

The proposed level of the dam, as shown in the section of the river, appears to be 68.68 above mean sea level, or about four feet above the level of the water in the Cholaveram Tank.

The length of the dam provided for in the detailed estimate is 600 feet, average breadth in cross section $18\frac{1}{2}$ feet, average height 7 feet, cubical contents 2,850 cubic yards.

2. The dam actually constructed is 700 feet in length, with an average breadth in cross section of 30 feet, an average height of 10.2 feet, and the total excavation for forming the bund, including that in the bed of the river for puddle, &c., is 9,225 cubic yards. The present width of the top of the bund is about nine feet, but if raised to the level intended by Mr. Fraser, it would be only $4\frac{1}{2}$ feet wide. The section of the bed of the river shows that the quantities entered in the original estimate were not founded on reliable data.

3. Puddled clay was not provided for in the estimate alluded to, but considering that there will be a depth eventually of fourteen feet or even sixteen feet of water against the bund, and that there was about ten feet of loose sand in the river-bed above the clay substratum, it was necessary to use it largely.

VII. There are five cart bridges on the upper channel, and one on the lower channel; additional means of crossing the latter is provided by ramps cut at two points when the ground is rocky. The position and number of the cart

bridges on the upper channel were decided on by Colonel Anderson, R. E., on the

The number provided is sufficient. occasion of a visit of inspection. The number now provided seems to be quite sufficient as far as can be judged at present, and therefore it appears unnecessary to estimate for more.

2. The question of the construction of the bridges and the water-way to be provided is discussed in the report to Government of the Chief Engineer, Irrigation, noted in the margin.*
- Settlement of construction and water-way.
- * No. 18, dated 9th January 1868.

A water-way of sixty feet is recommended to admit of the ultimate widening of the channel to that width. Masonry piers and timber platform are also preferred. The suggestions made in that report are generally approved of in G. O. No. 255, 24th January 1868. The cost of teak timber has been considerably in excess of what was supposed to be the market price, and this construction appears now at a disadvantage with that suggested by the Acting Chief Engineer, Irrigation, of brick arches on laterite piers.

3. The probable cost of a bridge of equal water-way of the latter kind would be, I think, not less than Rupees 4,900, which would indicate a saving of Rupees 500 per bridge when compared with the actual cost of the timber bridge. There would, however, be the disadvantage in the latter of embanked approaches if the arch is clear of the backwater from the tank.
- Probable cost of an arched bridge of equal water-way.

4. The design for the cart bridge on the channel between lakes, which appeared to have been proposed by Captain Magnay, consisted of a pair of trussed queen-post girders of wood resting on laterite masonry abutments.
- From Girder bridge.
- Construction first proposed.

The abutments were built when that Officer was relieved.

5. I found on inquiry that the use of builtup wooden girders of this description had not been attended in this country with satisfactory results, and as the construction of a metalled road to Vellore, leading over the bridge, had recently been commenced, it appeared desirable to adapt it for a considerable traffic.
- Reasons for abandoning wooden builtup girders.

Under these circumstances, I suggested to the Superintending Engineer that iron plate girders, constructed in the Public Workshops, should be substituted for the wooden builtup girders, of which the design was in the office. It was, I believe, the first occasion on which iron girders had been used so far from Madras, except on the Railways, and there was the uncertainty to a considerable extent, as regards cost, of an experiment.

6. The quantity of material in the land-piers was wrongly computed in the estimate under review. This has now been corrected, but it is still somewhat excessive.

The rates are those accorded to the contractors Messrs. Morgan and Co. for all the masonry work, and for the particular locality they are very high; thus the total cost of the bridge is unduly swollen, and its construction compares

Rate for masonry in abutments, high.

unfavourably, in point of economy, with that preferred by Captain Mullins. It must be pointed out, however, that the situation is unfavourable for arches, as the bridge is situated at a low level, and in the backwater of the Red Hill Tank.

The road-way of the bridge is now four feet, with arches it would be eleven feet above the ground.

7. The level of the road-way of each bridge on the upper channel has been separately considered with reference to that of the backwater of the Cholavaram Tank when full, and has been so regulated that the bottom of the girders should be not less than two feet six inches above the highest water level.
- Road-way level of cart bridges has been duly attended to, with reference to level of backwater.

8. In like manner the spoil-banks of the channel have been formed principally on the lower side, and made up to a proper height with reference to the level of the crest of the escape of that tank.
- Level of spoil-banks arranged with reference to level of backwater.

VIII. The substitution of masonry inlets on the upper channel, in lieu of under-tunnels is recommended by the Chief Engineer, Irrigation, in his report of the 9th January 1868, No. 18, and that recommendation is approved of by G. O., No. 255 of the 24th January 1868.

Paragraph 6 of Memorandum.

Inlets on supply-channels.

The soil in which these inlets are built, for the most part, affords a bad foundation, necessitating considerable excavation and masonry. Moreover, they had to be designed with a view to the ultimate widening of the channel, and the side walls are consequently extended somewhat more than would otherwise be necessary, while, at the same time, there is more revetment of rough stone. These circumstances have added to their cost.

Causes of enhanced cost.

9. The approximate area drained by the inlets, nine in number, between the Katankal and Boosykhah Rivers, is twelve square miles. No. 1 inlet near Thamarampaukum serves principally to pass into the channel flood-water from the Cortelliar River, which was occasionally discharged at a point some 600 yards above the anicut, and ran into the marshy ground between the head-sluice and 2nd mile on the channel.
- Area drained by inlets.

10. The crest of the Boosykhah calingulah was advisedly made three feet below the level of the full supply of the Cholavaram Tank, with the intention that the retention of the water at a higher level should be effected by a temporary mud dam on the calingulah, if it was ever considered expedient to do so. It is necessary here to call attention to the fact that Colonel Anderson, in his report
- Paragraph 7.
- Boosykhah calingulah.
- Level of crest.
- Cause of reduction of level of crest of calingulah.

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to Government of the 9th January 1868, recommends that the calingulah of the Cholaveram Tank should not be raised to the full level designed by Mr. Fraser, till all settlement of the bund had ceased, and, in fact, considers it a question whether the surface of the water should ever be brought within six feet of the summit of the bund, having in view the possible effect of storms.

11. The change in the arrangements, in connection with the crossing of the Boosykhah valley by the main supply channel, exposes that valley to be flooded between the upper and lower dams to the level of the crest of the Cholaveram Tank escape. A contour 64.68 above mean sea level, which is that of Mr. Fraser's calingulah, skirts the village of Single-cooppum and includes nearly the whole of the cultivated land in the valley on either side of river. Above the upper dam the same contour cuts off a portion of the villages of Kallicooppum and Boosykhah. All this land is of rich quality and is continuously under cultivation, being irrigated by wells in the river bed.

Effect of change in designs in connection with the Boosykhah River.
See Plan of upper channel No. —.
Inundation of the Boosykhah valley.
Land of good quality swamped.

12. These considerations led to the fixing of the present limit of the Cholaveram Tank water at a level one yard below that originally intended; the escapes in the channel and the tank embankment being built up to this level. The latter was, however, designed with piers three feet high so as to afford the means of raising the water one yard at any future time without alteration or additions to the construction.

The full supply-level of the Cholaveram Tank now assumed is one yard below that originally planned.
The escapes regulated accordingly.
The object of Piers in the Cholaveram calingulah.

IX. A longitudinal section of the Cholaveram bund has been prepared, and also a complete series of cross sections. These show the quantity of earth-work thrown up on the 31st March 1869, and that required to complete the embankments. A detailed estimate for the whole work is attached to these plans, showing the areas of the cross sections and the calculation of the cubical contents, not only for earth-work, but for puddle, gravel, turfing, &c.

Appendix F.
Cholaveram Reservoir Bund.
Appendix F.
Detailed estimate and calculation of quantities in the Cholaveram embankment.

Summary of results of comparison with original estimate.
The result of the comparison of the present with the original estimate may be summarised as follows:—

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MAIN BUND, CHOLAVARAM.

	Assumed by Mr. Fraser.	Revised Estimate from longitudinal and cross sections.
<i>Earth-work.</i>		
<i>Earth-work.</i> Average sectional area of the bund.....	13,955 Sq. yds.	160.90
Length of bund.....	1,783 Yds.	1,779½
Cubical contents of earth-work for bund proper.....	184,041 „	222,657
Mean vertical height above country.	27.8 feet.	28.76
Excess earth-work in revised estimate for bund proper..... C. yds.		38,596
Add for earth thrown up in excess out of section.....		15,112
Add for cutting back the old bund, rooting out sluices, and sundry works ..		17,543
Add for ring-bund to head-sluice... ..		2,013
Add for channel embankment.....		4,012
Add for excavation for foundation of revetment.....		7,333
Add for earth washed down from embankment during two years and compression in bank 1/8.....		22,866
<i>Total excess.</i> Total excess Earth-work for Main Bund.		1,07,475
<i>Revetment, Puddle, and Gravel.</i>		
<i>Revetment.</i> Average vertical height along face of Main Bund	27.8 feet.	25.11
Length of bund... ..	1,783 yards.	1,779½
Average area of revetment.....	7.66	7.07
Do. of puddle.....	15.55	15.84
Do. of gravel.....	5.22	5.06
Cubical contents of revetment	13,657 C. yds.	13,337
Do. of puddle.....	27,725 „	27,810
Do. of gravel	9,307 „	8,924
<i>Excess Revetment.</i> Excess of revetment in Main Bund, revised estimate.....		
Excess of gravel in Main Bund.....	383	
Add gravel in foundation... ..		1,186
<i>Do. Gravel.</i> Total excess of Gravel...		803
Excess puddle in Main Bund, revised estimate.....		105
Add puddle in foundation... ..		3,560
<i>Do. Puddle.</i> Total excess Puddle, revised estimate...		3,665
2. NORTH EXTENSION OF CHOLAVARAM BUND.		
<i>Earth-work.</i>		
<i>North extension.</i> Average sectional area for earth-work.	41.34 Sq. yds.	62.8 Sq. yds.
Length of bund.....	2,022 yards.	1,951 Yards.
Cubical contents of earth-work for bund proper.....	83,589 C. yds.	110,276 C.Yds.
Mean vertical height above country....	14.5 feet.	17.27 feet.

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MAIN BUND, CHOLAVARAM.—(Continued).

	Assumed by Mr. Fraser.	Revised Estimate from longitudi- nal and cross sections.
<i>Earth-work.—(Continued.)</i>		
Excess earth-work in revised estimate for bund proper.....		26,687 C. yds.
Add for earth thrown up in excess out of section.....		10,000
Add for earth formed on sites of masonry works subsequently decided on, viz., calingulah and new irrigation sluices. Sundry earth-work and compression in bank, earth washed down.....		Included in cross sections. 12,027
<i>Excess Earth-work.</i> Total excess Earth-work in the North Extension over original estimate.		48,714 C. yds.
<i>Revetment, Puddle, Gravel.</i>		
<i>Revetment, &c.</i> Average vertical height along face of North Extension.....	14.5 feet.	17.27 feet.
Length of bund.....	2,022 yds.	1,951 yds.
Average area of revetment.....	4.0 Sq. yds.	4.7 Sq. yds.
Do. of puddle.....	7.0 "	11.1 "
Do. of gravel.....	2.66 "	3.8 "
Cubical contents of revetment.....	8,088 C. yds.	9,350 "
Do. of puddle.....	14,154 "	17,920 "
Do. gravel.....	5,378 "	6,234 "
<i>Excess Revetment.</i> Excess of revetment in North Extension of Cholaveram Bund, as per revised estimate		1,262 C. yds.
Excess of gravel behind revetment.....		856 "
Add do. in foundation.....		1,300 "
Total excess Gravel...		2,156 C. yds.
Excess of puddle.....		3,766 C. yds.
Add puddle in foundation...		3,902 "
Total excess Puddle...		7,668 C. yds.
<i>South extension. 3. SOUTH EXTENSION OF CHOLAVARAM BUND.</i>		
<i>Earth-work.</i>		
Average sectional area for earth-work in bund proper.....	55 Sq. yds.	77.66 Sq. yds.
Length of bund.....	431 yards.	433 1/2 yds.
Cubical contents of earth-work for bund proper.....	17,817 C. yds.	30,872 C. yds.
Mean vertical height above country....	14.5 feet.	17.45
Excess earth-work in revised estimate for bund proper.....		13,055 C. yds.
Add for earth thrown up in excess, compression in bank, and sundry earth-work.....		5,508
<i>Excess Earth-work.</i> Total excess earth-work in the South Extension.....		18,563

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MAIN BUND, CHOLAVARAM.—(Concluded).

	Assumed by Mr. Fraser.	Revised Estimate from longitudi- nal and cross sections.
<i>Revetment, Puddle, Gravel.</i>		
<i>Revetment, &c.</i> Average vertical height along face of south extension.....	14.5 feet.	17.15
Length of bund.....	431 yards.	433 1/2
Average area of revetment.....	4.0 Sq. yds.	4.8
Do. of puddle.....	7.0 "	9.2
Do. of gravel.....	2.66 "	3.2
Cubical contents of revetment.....	1,724 C. yds.	2,099 C. yds.
Do. of puddle.....	3,017 "	4,033 "
Do. of gravel.....	1,146 "	1,399 "
<i>Excess Revetment.</i> Excess of revetment in South Extension (as per revised estimate) above origi- nal estimate.....		375 "
<i>Excess Puddle.</i> Excess of puddle as above.....		1,016 "
Add puddle in foundation.....		866 "
Total excess as above...		1,882 C. yds.
<i>Excess Gravel.</i> Excess of gravel as above.....		747 C. yds.
Add gravel in foundation		288 "
Total excess as above...		1,035 C. yds.

4. Abstract of excesses for Cholaveram Bund as per revised estimate :—

	Main Bund.	North Ex- tension.	South Ex- tension.	Total.
	C. yds.	C. yds.	C. yds.	C. yds.
<i>Abstract of excess.</i> Earth-work.....	107,475	48,714	18,563	174,752
Revetment	— 270	1,262	375	1,367
Gravel.....	803	2,156	1,035	3,994
Puddle.....	3,665	7,668	1,882	13,215

5. The excess in earth-work, which is to be ascribed to the cutting back of the old bund to admit of the full width of puddle, to excavation for foundation and to other sundries not provided for in the original statement, are detailed above. As the extension to the north was, it is believed, laid out and partly thrown up before the error in the width of puddle allowed was discontinued, a portion of the excess width, say 1 to 1 1/2 yards measured horizontally, may be due to this cause.

6. The balance of the excess due to the earth-work being out of section has clearly been caused by the absence of string sections in laying out the work when in process of foundation, particularly Part of the excess due to earth work not being sectioned out.

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at the first stages. On this point I beg to refer you to the reports to Government of the Chief Engineer, Irrigation, Detect already noticed in report to Government. No. 18, of the 9th January 1868, and 13th June 1868, and the Order passed on the first.

The former report was founded on the result of an inspection made immediately after I had assumed charge of the works, and referred to a system which had been carried on from the outset; the orders of Government on the subject were subsequently carefully attended to. There having been no occasion to add to the earth-work in the north extension of the bund, subsequently to the removal of Mr. Pimm, the Overseer who laid out the whole work, the extent of the errors in section have only recently been ascertained. The earth out of plan can be brought into shape and utilised in completing the bund for one anna per cubic yard.

7. The greater portion of the excess appears over the original estimate for earth-work to be owing to the fact that the general plane from which the formation of the bund commences is lower than that assumed by Mr. Fraser. A slight difference in this respect creating an enormous excess in the cubic contents of the bund. The quantity remaining to be done was also over-estimated in the last estimate.

8. The estimate for the revetment has been revised, and a reduction has been made by diminishing the depth to which it is proposed to carry it below the surface of the present ground-line from three feet to one foot.

The puddle and gravel extend about two feet lower. An analysis of the cost of the work is given in the schedule of rates (Appendix B.) The detailed measurements are given in the estimate attached (Appendix F.)

9. The actual cost of turfing has been found to be about one anna per superficial yard. The price charged was supposed to include trimming the slopes and making good where gullies had been washed by rain. The contract rate paid now varies from Annas 0-9 to 1 for a superficial yard.

10. The alteration suggested in the construction of the parapet wall on the top of the bund has been adopted in the revised estimate for both the Red Hill and Cholaveram Lake embankments.

X. The price paid for masonry at the north calingulah of the Cholaveram Tank was at the contract rate accepted by Messrs. Horgan and Co. The analysis of rates (Appendix B.) shows that the price in the original estimate was insufficient.

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XI. The explanation already given, with reference to the level of the crest of the escape in the upper channel, applies to the Cholaveram new calingulah also, which was designed with piers and grooves to afford the means of regulating, to a certain extent, the supply stored in the tank. The estimate has been modified in accordance with the suggestions in the 10th paragraph* of the Memorandum.

XII. It has already been explained that the site of the new Irrigation sluice in the Cholaveram bund was not decided on, till after the foundation of the bank on the site of the work to nearly full level, and the removal of this earth had to be effected. Mr. Fraser appears to have intended that two new sluices should be built on the site of the old ones; but the position of one was selected by Colonel Anderson to the north of the main bund on laterite soil, which gave a good foundation, and for the other was substituted a tunnel carried behind the wing-walls of the head-sluice by means of which it was fed. These alterations were certainly economical. The rates for these works are analysed in Appendix B.

It is intended that this sluice should be fitted with an iron shutter and gearing similar to that for the head-sluice to the channel between lakes.

XIII. A plan and longitudinal section of the channel between lakes, and a computation of the contents of the excavation required for forming it, are attached (Appendix G.)

2. It will be observed that the blue line on plan which indicates the line taken, deviates from that in red which is as near as possible that designed by Mr. Fraser. This deviation was, I believe, directed by Captain Magnay for the purpose of avoiding a village, and probably because the line selected was more advantageous in other respects.

3. The inclination of the bed of the channel has also been modified, instead of being three feet per mile throughout as originally intended, it is for the first mile, one and a half feet per mile; for the second mile, three feet per mile, and for the remaining half mile, one and half feet per mile.

4. The limit of inclination at the lower end was fixed by Captain Magnay, probably because it appeared doubtful whether the soil there would stand the great velocity due to the fall first proposed. The change of inclination of the bed in the first mile is due to a slight alteration, which was made in the level of the sill of the head-sluice.

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Mr. Fraser proposed to tap the Cholaveram reservoir one yard below the level of the crest of its old calingulah; subsequently the design was to place the sill at the level of the calingulah crest, after the channel had been excavated. It was decided to place the point of exit at an intermediate level, or one and a half feet below the old calingulah crest. To meet this change the sole of the supply-channel was cut down one and a half feet at the sluice and given the inclination described for one mile, so as to intersect plane of inclination of the centre section. The fall of the channel can, of course, be easily increased at its extremities and made uniform throughout at any future time, should experience of its working demonstrate the necessity or advisability so doing.

5. Seeing that these changes have been made in the original design, it seems useless to institute a comparison between the cubical contents as given in Mr. Fraser's estimate, and those derived from actual measurement after execution; but a detail of these measurements has been annexed, (Appendix G.).

6. The rates for the cutting of this channel were, as regards the lower half, fixed by Mr. Fraser; for the upper by Captain Magnay, who entered into a written agreement with a contractor.

I do not know whether these rates were based on data obtained by experiment in excavating portion of the channel. The contractor complains of the result of his contract as regards himself in a pecuniary point of view, and presses for a more favourable classification of soil, and for a higher rate than 12 annas per cubic yard for the rock at the north end.

The Acting Chief Engineer, Irrigation, considers all the rates for the work excessive.

I am inclined to think that the rate for loam (2½ annas) is rather high, as on the upper channel that kind of soil was taken out for 2 annas; but the quantity of loam on the lower channel, unmixed with gravel, was very small. On the other hand a considerable portion of the excavation to the north was through laterite rock of a kind which is never quarried for building purposes, on account of its extreme hardness and brittleness. Ordinary quarry picks were broken in attempting to cut it out, and it had to be blasted and broken up with crowbars.

The excavation through laterite rock was of especial difficulty.

I am able to speak with certainty as to this, because I was very desirous of utilising the stone in the excavation for building revetment, &c., and found, after repeated trials, that the cost of roughly shaped stone out of the cutting exceeded that delivered from a quarry two and a half miles distant.

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The cost of cutting out laterite at the quarries for revetment is Rupees 1-8-0 a cubic yard, including loading on the carts, or double the price paid on the channel for getting out the hard description of stone and forming it on the spoil-banks.

XIV. Longitudinal and cross sections of the Red Hill Tank Bund have been prepared, and with a detailed estimate are attached (Appendix II.). As in the case of the Cholaveram Bund the results are summarised below:—

MAIN BUND.

		Dimensions, etc., assumed by Mr. Fraser.	Dimensions, etc., from revised cross sections.
Earth-work.	2. Earth-work.		
	Average cross sectional area for earth-work	109.0 Sq. yds.	115
	Length of bund	2,865 yards.	2,865
	Cubical contents of earth-work for bund proper	137,520 C. yards.	145,369
	Mean vertical height above base of formation	20.1 feet.	23.28 feet.
	Excess earth-work in revised estimate for bund proper		7,849 C. yds.
	Add for earth thrown up in excess or out of section		23,239 "
	Add for cutting back the old bund		16,148 "
	Add for excavation for foundation of revetment, rooting out old sluices and bungalows, cutting ramps and sundry works, &c.		23,448 "
	Waste from erosion by rain compression in bank		17,690 "
	Total excess Earth-work in Main Bund.		88,374
	Revetment, Puddle, and Gravel.		
	Average vertical height along the face of the Main Bund	24½	24 feet.
	Length of bund	2,865	2,865
Excess Revetment.	Average area of revetment	6.33 Sq. yards.	6.78
	Do. of puddle	13.55 "	14.20
	Do. of gravel	4.33 "	4.4
	Estimated cubical contents of revetment.	18,135 C. yards.	19,593
	Do. do. of puddle	38,820 "	36,929
	Do. do. of gravel	12,405 "	12,665
	Excess revetment in Main Bund as per revised estimate		1,458
	Excess of puddle in revised estimate ..	—1,891	4,001 C. yds.
	Add puddle in foundation		2,110 C. yds.
	Total excess of Puddle...		
Do. Puddle.	Excess of gravel in Main Bund as per revised estimate		260 C. yds.
	Add gravel in foundation		3,145 "
	Total excess of Gravel...		3,405 C. yds.
Do. Gravel.			

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3. SOUTH EXTENSION OF RED HILL BUND.

	Dimensions, etc., assumed by Mr. Fraser.	Dimensions, etc., from revised cross section.
<i>South extension.</i>		
<i>Earth-work.</i>		
Average cross sectional area of bund proper	10 44 Sq. yards.	15.5 Sq. yds.
Length of bund	390 yards.	362 yards.
Cubical contents of earth-work for bund proper	4,071 C. yards.	4,873 ..
Mean vertical height above country ...	7½ feet.	9.0 feet.
Excess of earth-work as per revised estimate for bund proper		802 C. yds.
Add for earth thrown up in excess or out of section		3,427 ..
Add excavation for foundation of revetment, sundry earth-work		
<i>Excess earth-work.</i> Total excess earth-work over original estimate.....		4,229
<i>Revetment.</i>		
<i>Revetment, puddle, gravel.</i>		
Average vertical height along the face of the south extension of the Red Hill bund		
Average area of revetment	2.44 Sq. yds.	2.50
Do. of puddle	4 0 ..	5.8
Do. of gravel.....	1.66 ..	1.9
Estimated cubical contents of revetment. Do. of puddle ...	952 C. yards.	1,055
Do. of gravel ...	1,560 ..	2,105
Do. of gravel ...	647 ..	703
<i>Excess revetment.</i> Excess revetment in south extension as per revised estimate.....		103
Excess of puddle in south extension as per revised estimate.....		665
Add puddle in foundation of revetment.		210
<i>Excess puddle.</i> Total excess of puddle in extension ..		875
Excess of gravel in south extension as per revised estimate		56
Add gravel in foundation.....		173
<i>Excess gravel.</i> Total excess of gravel in extension...		229

4. Abstract of excess for the Red Hill bund as per revised estimate.

	Main Bund.	South Extension.	Total.
	C. YDS.	C. YDS.	C. YDS.
Earth-work	88,374	4,229	92,603
Revetment	1,458	103	1,561
Gravel... ..	260	229	489
Puddle	2,110	875	2,985

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The causes of the excess of earth-work for the Red Hill Lake embankment are the same as in the case of the Cholaveram bund, though they have operated to a less extent.

	Dimensions, etc., assumed by Mr. Fraser.	Dimensions, etc., from revised cross sections.
<i>Soorapadoo and Seetapel bunds.</i>		
<i>Earth-work.</i>		
XV. Longitudinal and cross sections of the Soorapadoo bund are attached Appendix I. ; as before the results are given below :—		
<i>Earth-work.</i>		
Average sectional area of earth-work of bund proper	17.22 Sq. yards.	27½ Sq. yards.
Length of bund.....	1,220 yards.	1,050 yards.
Cubical contents of earth-work for bund proper	21,008 C. yards.	28,803
Mean vertical height above country ...	9.5	10.3
Excess earth-work as per revised estimate for bund proper		7,795
Add earth thrown up in excess of true section washed down by rain		
<i>Excess earth-work.</i> Total excess earth-work in Soorapadoo bund		7,795
<i>Revetment, etc.</i>		
<i>Revetment, Puddle, and Gravel.</i>		
Average vertical height along face of Soorapadoo bund	9.5 feet.	9.88 feet.
Length of bund.....	1,220 yards.	1,050 yards.
Average area of revetment	3.0 Sq. yards.	2.9 Sq. yards.
Do. of puddle	5.22 ..	5.0
Do. of gravel	1.44 ..	1.3
Cubical contents of revetment.....	3,660 C. yards.	3,087 C. yards.
Do. of puddle.....	6,368 ..	3,752 ..
Do. of gravel.....	1,757 ..	1,999 ..
<i>Excess revetment.</i> Excess revetment as per revised estimate		573 less.
Excess puddle as per revised estimate.		2,616 ..
Add puddle in foundation		505 C. yards.
<i>Excess puddle.</i> Total excess puddle		2,111 less.
Excess gravel in revised estimate for backing revetment		242
Add gravel in foundation.....		466 less.
<i>Excess gravel.</i> Total excess of gravel		708
<i>Abstract of excess in the Soorapadoo bund.</i>		
<i>Abstract</i> Earth-work	7,795 C. yds.	
Puddle	2,111 do. less.	
Gravel	708 do.	
Revetment.....	593 less.	

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(3.) The earth-work for the temporary bund extending from the north flank of the old calingulah.

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1,203, the not derivable

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from ayacut area Rupees 23,242; the total area of waste land under the tanks to which irrigation can be extended is cawnies 11,272 with an assessment of Rupees 33,835, and the possible increase of revenue Rupees 82,160. If to the additional possible revenue from extended irrigation is added, the annual payment to be made by the Municipality of Madras for water supplied estimated at 32 millions cubic yards at 1 Rupee per thousand cubic yards, we have a possible total return for outlay of Rupees 1,14,160, which is equivalent to about ten per cent. on the amount of the revised estimate.

3. The above view, however, pre-supposes that the supply of water is sufficient for the area available under the tanks. It remains to be ascertained whether this is the case. The data obtainable for solving the question is very imperfect, as no record has been kept of the quantity of water stored in the tanks during successive years corresponding with the area actually irrigated during each year.

It is, however, stated by the ryots that, when the Red Hill Tank was filled up to the level of its dam stones, the quantity of water stored (38½ millions cubic yards), supplemented by the rain-fall on the land, was sufficient to bring to maturity two crops over the whole nunjah ayacut area under the tank.

This would give nearly 10,000 cubic yards of water for each cawny, assuming, as has been done before, that the capacity of the two tanks will be 138 millions of cubic yards, and that apportionment will be made as follows:—

(1).—To Mirassidars for existing cultivation, cubic yards 38 millions.

(2).—Water Supply of Madras 32 do. We have available a balance of 53 million cubic yards for the extension of irrigation, which, at the rate of 10,000 cubic yards per cawny, would irrigate during the year 5,300 cawnies of waste land. This, at the rate estimated* by the Collector of Madras, should yield a revenue of 38,639 rupees.

4. There seems, therefore, to be sure ground for assuming that, including the fixed annual payment by the Municipality, there will be a good return on the whole Government outlay on the works, even after allowing a wide margin for maintenance, for conservancy establishment, and for bad years.

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5. The extent and directions of the subsidiary channels for distributing the water to the land below the tanks must be determined by a proper survey of the ground. The Revenue Survey Department has engaged to supply copies of the surveys already made, which include nearly the whole of the villages; sufficient information has been acquired to show that the tanks referred to by the Collector of Madras, as those into which it is desirable to direct water, can be supplied from the sluices or calingulals already designed. It would probably be only surplus water which would be dealt with in this way, and consequently it seems hardly necessary to enter into details at present.

6. An item of Rupees 25,000 has been entered in the revised estimate for the construction of the channels and dams referred to by Captain Mullins in the 11th paragraph of his memorandum.

A surveyor is engaged in preparing a general plan of the whole country under the two tanks with levels and contour lines where needed, and a scheme for the extension of the existing distributing channels and for the construction of such others as may be required will be submitted as soon as possible.

XIX. In conclusion, I beg to state that the delay in the re-transmission of the estimate and report has been caused by the heavy work which the investigation of the cause of the discrepancies between the original and revised estimates entailed.

It has been necessary to make surveys of the channel and bunds and to examine the accounts of the range for the past three years, in order to distribute the expenditure to the proper heads.

The rates for the different descriptions of work have been revised and correspond with those derived from the registers of work up to the present date.

The foregoing letters from the Superintending Engineer, 4th Division, with the reports of the Executive Engineer, Madras Water Works, and the memorandum from this Office, will give a clear idea of the course which has been followed with a view to ascertain the cause of the large increase of the cost of this project, and the Appendices A. to K. to the last report of the Executive Engineer show the particulars of measurements, data, etc., on which the revised estimate has been prepared.

2. Appendix M. contains papers relating to the expected returns from the Madras Water Works.

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3. The estimate sanctioned by the Government of India amounted to Rupees 6,11,759, and the revised estimate is Rupees 10,39,175, the difference being Rupees 4,27,416, or an increase of very nearly seventy per cent. on the original estimate.

4. The causes which have led to such a wide difference are—

1st.—Many important modifications of the arrangement and design of the works, beginning at the head works on the Cortelliar River, and carried throughout the whole system from one end to the other. There appears to be no doubt that many important alterations were called for, and that the project would not have secured the objects for which it was sanctioned in a safe and efficient manner, had the original arrangements been carried out. At the same time, an examination of the papers submitted has convinced me that at least some of the changes would not have been adopted in their present form, had the cost of carrying them out been ascertained in the first instance.

2ndly.—The desire to push on the works, the changes in the executive staff, and the novelty of the work at first to the officer who has been in charge since December 1867, have all operated more or less to enhance the cost of the works. It is only right to point out, however, that Captain Scott's last report, with its accompaniments, shows that this officer set himself energetically to work to overcome the difficulties which he experienced at first, and which were due to a great extent to the inability of the contractors to carry out their engagements; thus obliging him to adopt other arrangements, and to make these without increase of cost must, in the absence of any experience of the manner in which such work is usually carried out in India, have been a task of very considerable difficulty. The papers submitted by the Executive Engineer show that the records of work done have been carefully kept, and though it would appear, from paragraph 27 of Colonel Bean's last letter, No. 5,047, that the rates paid on this project are somewhat in excess of those which have proved sufficient on other works in the neighbourhood, it does not seem that there has been a greater difference than may be considered to be accounted for by the circumstances under which the project has been carried out, and in the case of certain descriptions of work, and notably as regards granite masonry, by the class of work executed.

5. The Comparative Statement gives in abstract the particulars of the differences between the quantities and rates of work provided for in the original and revised estimates. The differences in quantity are for the most part explained by changes of design, but it will be seen that in some cases there are considerable quantities which are not so accounted for. Taking, for instance, the Cholaveram Tank, it will be seen from the summary given in paragraph IX of Captain Scott's Report that out of an increase of cubic yards 107,475 in the earth-works of the main bund cubic yards 15,112 are due to earth thrown up out of section; similarly on the north extension cubic yards 10,000 out of cubic yards 48,714 in excess are attributed to this cause; and again on the south extension cubic yards 5,508 out of cubic yards 18,563 are shown not to have been necessary. Altogether out of cubic yards 174,752 of additional earth-work cubic yards 30,620, or nearly eighteen per cent. were really unnecessary, and it is shown that the mistakes occurred at an early period

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of the work, and were due to an absence of sufficient care in laying it out. At the Red Hill Tank also the unnecessary earth-works are shown to be as follow:—

	Total Increase. C. YDS.	Unnecessary. C. YDS.
Main bund...	88,374	23,239
South extension...	4,229	3,427
	92,603	26,666

or the work not required is 28½ per cent. of the whole excess.

6. A few of the principal items of increase may be specially noticed. The Comparative Statement shows that the anicut and head sluice will cost just double the amount of the original estimate, viz:—

	RS.
Original estimate	43,151
Revised do.	86,258*

The designs were materially altered, the site of the former work was changed, and the quantities are not capable of comparison. The contract with Messrs. Horgan & Co. appears at once to have made excess in the rates unavoidable. Some of the original rates, as for instance, dressed granite in the head sluice, Annas 9½ a cubic foot, were manifestly insufficient; but with regard to the laterite masonry, I am of opinion, from the evidence contained in these papers, that the rates 6 rupees per cubic yard for ordinary masonry, and 9 rupees for arch-work might have sufficed.

7. At the Cholaveram Tank the quantities and rates are as follow:—

	Quantity. C. YDS.	Rate. RS. A. P.	
Original estimate...	285,447	0 3 0	Earth-work.
Revised do.	478,787	0 2 9½	
Original do.	23,469	2 0 0	Revetment.
Revised do.	25,421	3 0 0	

With regard to the difference in the rate of revetment, paragraph II.—11 of the Executive Engineer's Report explains the circumstances under which it was raised, and shows that the necessity for an increase was investigated by the Superintending Engineer and Colonel Anderson in January 1868. For the earth-works it is stated in paragraph IX.—1 to 7 of the Report that the greater part of the difference in quantity is due to error in the original estimate. It has already been noticed that eighteen per cent. of the increase is attributable to mistakes. The rate, it will be observed, at which the work is being done is less than that allowed for. The quantities of gravelling, puddling, and turfig, had to be augmented in proportion to the greater section of the bund. The additional cost of the Cholaveram Tank, according to the revised estimate will be Rupees 83,082.

8. The following are the similar items for the Red Hills Tank.

	C. YDS.	RS. A. P.	
Original estimate.....	150,419	0 3 0	Earth-work.
Revised do.	325,810	0 3 4½	

Here, 28½ per cent. of the excess in quantity is due to mistakes. It may be observed that the particulars given in paragraph XIV.—1 to 4 of the Report account for an excess of cubic yards 92,603 only, while the difference in the Comparative Statement is cubic yards 107,891, so that 15,288 cubic yards remain unaccounted for. The increase of rate appears not to be satisfactory, for the bund of this tank is longer than that of Cholaveram; the quantity of additional earth-work per yard

* Cholaveram..... 28-76
Red Hills 23-28

run is smaller; the mean vertical height* of the bund above the country is less; and consequently the rate at the Red

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Hills might have been expected to be lower. Perhaps the high rate may be, at least in part, due to the fact that at the commencement, as appears from paragraph II.—10, a contract was given at the full estimate rate of 3 annas, whereas at Cholaveram 2 annas and 7 pies was the rate allowed. If the earlier and easier part of the work cost 3 annas, excess on the whole would be unavoidable. The total increase on the Red Hill Tank is Rupees 57,535.

9. The head sluice to the channel between the two tanks is a work which has been entirely altered in design, and made far stronger than was originally intended. The extra cost is estimated at Rupees 14,215, or about one hundred and fifty per cent. more.

10. The following is an abstract of the Comparative Statement, and shows the differences for each work of the whole project:—

Items.	Original Estimate.	Revised Estimate.	Brief Remarks.
	RS. A. P.	RS. A. P.	
1. Anicut on Cortelliar.	35,144 15 3	60,076 8 2	Site and design changed; original rates too low; actual rates in some instances too high.
2. Head sluice	8,006 4 6	26,181 14 4	Design entirely altered; actual rates high.
3. Channel from Cortelliar, including Boosykal diversion.	83,990 13 0	90,499 6 10	Boosykal diversion channel widened; line altered; extra embanking found necessary.
4. Katenkal diversion channel.	406 4 0		Struck out of the project.
5. Katenkal dam	475 0 0	724 10 2	Arrangements modified.
6. Boosykal aqueduct.	3,273 1 9		Water received into instead of being passed under the main channel.
7. Upper dam across Boosykal.	1,111 2 6	3,765 15 8	Quantity of earth-work more than trebled, and rate doubled; this latter due to long lead for good soil; puddle, gravel, and turf were extras.
8. Lower dam across Boosykal.		4,263 4 7	This is the left bank of the channel and takes the place of the aqueduct.
9. Cart and foot bridges for main channel crossings:— No. 10..... No. 5.....	21,547 6 7	 33,636 14 8 27,051 9 11	Designs entirely altered and waterway increased, <i>vide</i> paragraph VII. of Report. Cost higher than it need have been.
10. Inlets on main channel.			Substituted for under-tunnels, <i>vide</i> Report paragraph VIII.
11. Waste weir in do.		6,480 7 6	Requisite in consequence of the admission of Boosykal water into channel, <i>vide</i> items 6 and 8.
12. Aqueduct on main channel.		6,199 8 7	For the supply of the Alachary tank in lieu of one of the under-tunnels.
13. Cholaveram Lake bund enlargement.	1,25,489 1 0	2,08,537 9 7	Quantities considerably in excess of original estimate; rates for revetment and gravel insufficient, also quantity and rate for puddle; turfing not provided, but considered necessary, <i>vide</i> paragraph 6 above.
14. Cholaveram escape weir at Yeroomottapoliem.	1,400 8 0	1,503 0 0	

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26th April 1870.

Items.	Original Estimate.	Revised Estimate.	Brief Remarks.
	RS. A. P.	RS. A. P.	
15. Cholaveram escape weir with 20 vents.		15,211 0 1	An additional work.
16. Irrigation sluice, Cholaveram Lake.	1,567 0 4	8,461 13 4	Constructed on a new design, <i>vide</i> plan No. 12.
17. Head sluice to supply channel of Red Hills Lake.	9,548 9 6	23,763 12 5	An entirely new design adopted.
18. Channel between lakes	55,414 6 3	94,807 1 0	Quantities of excavation one-fifth less as executed; rates nearly doubled. Cost has been excessive, <i>vide</i> paragraph 9, 12th of memorandum, and paragraph XIII. of Executive Engineer's Report; nearly 6,000 rupees are due to extra work.
19. Irrigation under-tunnels on channel.	14,099 1 9	1,661 8 4	Only one out of 13 constructed.
20. Inlet at Ittentangal...		842 11 0	Substituted for under-tunnel.
21. Red Hills Lake escape weir.	2,655 12 0	10,244 14 3	Rupees 6,114-12-3 are entered for excavation, for which no provision was made. The arrangements were very incomplete. A good deal of the expenditure on masonry might have been saved.
22. Masonry dam with irrigation sluice.		22,471 15 8	Substituted for earthen bund where ground is rocky, <i>vide</i> para. 9, 16th of memorandum, and paragraph XVI. of Executive Engineer's Report.
23. Bund of Red Hills Lake.	92,698 15 0	1,50,233 7 4	Quantities of earth-work much in excess, and of this excess a considerable portion unnecessary; rate for revetment had to be raised nearly fifty per cent; rates for earth-work higher than they should have been.
24. Soorapadu and Seetapet bunds.	15,140 13 9	21,257 9 6	Increase of 38 per cent. nearly in quantity of earth-work; rate doubled, and is unnecessarily high; rate for revetment raised from 2 to 3½ Rupees.
Red Hills Lake irrigation sluices.	814 0 4	28,261 6 10	Designs altogether changed; original estimate altogether insufficient for sluices in a tank of this size. The item granite masonry amounts to rupees 11,336-8-10.
Offices and store-sheds ...		2,000 0 0	
Removing silt from main channel.		4,996 12 9	<i>Vide</i> paragraph 9, 17th of memorandum, and paragraph XVII. of Report.
Contribution for delivery channel.	30,832 0 0	30,832 0 0	
Distribution works below tanks.		25,000 0 0	Some provision necessary and the details are not known at present, <i>vide</i> paragraph 11 of memorandum.
Contingencies	24,941 12 6	44,057 4 8	Proportion about the same in each estimate.
Compensation for land ...	83,140 0 0	83,140 0 0	

11. It is necessary to consider what effect the large increase in the cost of the project will have upon the returns to be expected from the outlay. It will be noticed that with the revised level of the Cholaveram Tank escapes, the additional water available when the tanks are full will be for the—

Cubic yards.

Former capacities. Cholaveram Tank.. 28,468,969 — 6,581,331 = 21,887,638
Red Hill's Tank... 101,981,815 — 38,430,482 = 63,551,333
85,438,971

There will, however, be about 15 millions of cubic yards in the Red Hills Tank, which will not be utilized, owing to the Madras Town Water Supply having been taken off at a higher level, and this will reduce the supply available to 70,439 millions, of which 32 millions are to be devoted to the Town Water-supply at a charge of 1 rupee per thousand cubic yards, producing a revenue of Rupees 32,000, and 38,439 millions of cubic yards will remain available for extension of irrigation. It would appear from the papers given in Appendix M. that the remissions granted for waste and withered crops averaged, for the ten years, up to Fusly 1277 (1867-68), Rupees 8,549 per annum. The lands of the villages heretofore irrigated by the Red Hills Lake and Cholaveram Tank are, including shrotriems—

	Acres.	Assessment. Rs.
Cholaveram Tank	3,152	8,649
Red Hills Lake	5,562	15,796
	8,714	24,445

In the same villages the additional returns expected are—

	Rs.
(1) From the irrigation of 2,700 acres of waste.....	4,953
(2) „ Tirwa jasty.....	1,662
(3) „ Assessment on second crop	7,962
	14,577

The additional lands to which irrigation could be extended are given by the Collector of Madras for each village, and they are—

(4) For the Cholaveram Tank, 5,962 acres of available waste, assessed at	Rs. 13,185
(5) For the Red Hills Lake, 6,243 acres of available waste, assessed at	15,697

The Collector also estimates that from the same villages the Tirwa-jasty derivable would be—

	Rs.
(6) For lands under the Cholaveram Tank.....	2,724
(7) Do. do. Red Hills Lake	15,405
(8) Also second crop assessment, Cholaveram	6,098
(9) Do. do. Red Hills.....	14,474

It appears therefore that the estimated returns, as calculated by the Revenue officers, are from—

Items.

	Rs.
1. Waste in villages at present irrigated from the enlarged tanks... ..	4,953
2. Tirwa jasty do. do.	1,662
3. Assessment on second crop	7,962
4 & 5. Waste in villages not yet so irrigated	28,882
6 & 7. Tirwa jasty do. do.	18,129
8 & 9. Assessment on second crop	20,572
Total...	82,160

12. The first point to be noticed is that these returns are dependent—

1st,—Upon a supply for 14,905 acres of additional land being available, and that the assessment of this area is put at only Rupees 33,835, or a little under Rupees 2-4-4 per acre.

2ndly,—Upon a further supply for second crop cultivation, the area of which is not stated, being forthcoming. Items 2, 3, 6, 7, 8, and 9, added together amount to Rupees 48,325, and were the same

	ACS.	RS.
* Old	8,714	24,445
Waste	14,905	33,835
	23,619	58,280

Average per acre

2 7 6

average* rate as for the first crop taken the area represented would be 19,580 acres nearly. This calculation cannot be far wrong, because it has already been noticed that there are acres 8,714 of existing cultivation, and acres 14,905 of available waste, total 23,619 acres to be irrigated, which is not very much more than the area estimated for the second crop. The second crop is usually a three-months' crop, and therefore I have concluded that the assessment upon it is at any rate not higher than that on the first, a five-months' crop.

13. There is unfortunately no very reliable information as to the area which each tank was capable of irrigating, or of the quantity of water which each actually received in any year, for comparison with the irrigated area of that year. It will be noticed that the Cholaveram Tank, when full, held in its unimproved state 6,581 millions, while the area under it was 3,152 acres, so that the storage was but 2,280 cubic yards per acre. This could not have sufficed, and it must be supposed that it received during the irrigation season more water than would fill it once. The Red Hills Tank, on the other hand, held 38,43 millions, and its acreage was 5,562, or it possessed a storage of 6,932 cubic yards per acre—a quantity which, with additional

supplies, would probably suffice for the whole area under first crop, and for a good

Report paragraph XVIII—3. deal of second crop cultivation, though I much doubt the possibility of the whole area being double cropped, as Captain Scott has been led by the ryots to suppose.

14. I am not disposed to think that the supply of the tanks is, in relation to their greatly increased capacity, so much better than it was before as to make it prudent to calculate upon less than 6,000 cubic yards for the first crop being found sufficient. If this be the case there will, with the water in the Cholaveram Tank at fifteen feet above old full tank level, be 38,439 millions of cubic yards available, which will water 6,400 acres. There would be no risk in raising the level of the water in the smaller tank to the height, eighteen feet, originally intended, after the

banks have had time to settle, but it appears that the alteration of the arrangements for crossing the Boosykhal, whereby the waters of that stream were taken into, instead of being passed under, the main channel, renders it unadvisable to increase the depth, as by so doing much valuable land would be submerged. Under these circumstances the additional area, which will be irrigable, will be only 6,400 acres as above stated.

15. Were the rates entered in the Revenue Statements received from the Collector to be adopted, the returns would be—

	RS.
From the Town Supply	32,000
Do. 6,400 acres, at Rupees 2-7-6	15,800
Total	47,800

which represents a gross return of 4-6 per cent. on the present estimates.

16. The Government, in the Order of the 11th April 1866, No. 1,102, supposed Rupees 7 an acre to be a fair assessment for the land under these tanks, but I am not aware that any settlement of this question of the rates to be charged has actually been made. It appears to me that, considering the circumstances of these lands, situated as they are close to the best market in the Presidency, the present rates, under Rupees 3 an acre on the ayacut of the tanks, as also Rupees 2-4-4, the proposed rate for the waste lands to be irrigated, do not at all represent the fair share of the State in the value of the produce. I would suggest, therefore, that a reference should be made to the Revenue Department, with a view to the early settlement of the rates to be charged, first, on the old lands, and, secondly, on the additional area. I have not omitted the old lands, because I believe that it will be found that they are under-assessed, and because also they will have, as being entitled to be supplied before any of the new lands are irrigated, their value very greatly improved. Were water for irrigation charged for at the same rates as water for the Town Supply, the returns would be from—

	RS.
Town Supply	32,000
8,714 acres, at 6 rupees	Rs. 52,284
Deduct present revenue	21,445
	27,839
6,400 acres at 6 rupees	38,400
Total	98,239

being a gross return of 9-45 per cent., and this is as little as would be likely to yield a net return of five per cent. on the average of years, for it must not be forgotten that the supply is dependent mainly upon the north-east monsoon, and that it is drawn from a comparatively limited tract of country, on the drainage of which there are many other demands. It may perhaps be deemed worth consideration also whether the Madras Municipality should not be called upon to raise their contribution from 32,000 to 50,000 Rupees; the larger sum would still be below the fair value of the water as deduced from the revised estimate.

17. A sum of Rupees 25,000 has been entered in the revised estimate under instructions from this Office to provide for distribution to the additional area to be irrigated. It has not been usual in this Presidency to execute distribution channels under tanks at the cost of the State; but in this case water has to be conveyed to a large number of villages hitherto unconnected with the reservoirs, and some of these are at a considerable distance.

18. The Executive Engineer should, as soon as possible, submit a plan and estimate for the arrangements necessary. It will not be practicable to decide finally what lands are to be supplied with water until the new rates of assessment have been fixed, for it will be seen from the Revenue Statement that some villages are assessed at very much lower rates than others, and, if any adequate returns are to be obtained, the water, which is insufficient for more than about one-third of the total area commanded, and ready for irrigation, should be utilized preferentially on those lands which can best afford to pay for it. The necessity, however, for this prior settlement of the revenue arrangements need not prevent the Executive Engineer running all the levels required, and surveying the lands which it may be proposed to bring under irrigation. Some assistance will probably be obtainable from the Revenue Survey Department. All the distribution should be under regulation, and at every division of the supply there should be a weir (with a clear overfall where practicable), so that the actual discharge may at any time be ascertained and the regulation of the supply, according to the acreage under cultivation, effected. Were the ryots to be allowed to help themselves to water as they pleased, there would inevitably be very great waste, and the remarks above made will have shown that the works will need to be well managed, or they will not pay the interest on their cost.

(Signed) J. MULLINS, Major, R.E.,
Ag. Chief Engineer for Irrigation.
FORT SAINT GEORGE, }
21st January 1870. }

No. 350. ORDER THEREON, 26th April 1870, No. 1,100.

IRRIGATION, No. 19.

His Excellency the Governor in Council considers that, before submitting the revised estimates for the Madras Water Works Project to the Government of India for sanction, it is necessary that the question of the proper assessment of the lands likely to be irrigated should be settled definitively. The papers recorded in these Proceedings will accordingly be communicated through the Revenue Department to the Board of Revenue, who will be requested to ascertain, in communication with the Director of Revenue Settlement, and report with as little delay as possible—

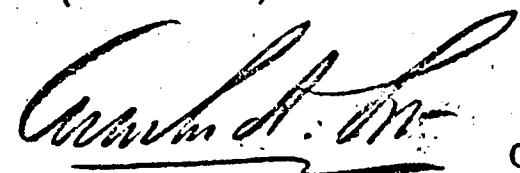
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1st.—What will be fair rates of assessment for waste lands for which a supply of water will be made available from the Cholaveram and Red Hill Tanks.

2ndly.—Whether there are any reasons against the revision of the assessment on lands now irrigated and in the occupation of the ryots, seeing that the character of the water-supply has been greatly improved and rendered secure.

3rdly.—Whether it would be expedient in this case to levy a separate water-cess, or rate, instead of continuing a consolidated assessment.

(True Extract.)



Colonel, R.E.,

Secretary to Government.

~~To the Board of Revenue.~~

- „ Superintending Engineer, 4th Division.
- „ Revenue Department.
- „ Chief Engineer for Irrigation.

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GOVT. OF INDIA

PUBLIC WORKS.

To
THE BOARD OF REVENUE.
&c. &c. &c.

Dated April 26th.
Recd. *27* *Encl.*
G. O., 26th April 1870, No. 1100.

APRIL
Nos. 349-350

Order 630. 3 May 1870

Madras Water Works Project.—Note by the Chief Engineer for Irrigation on the revised estimate for the Madras Water Works Project, communicated to the Board of Revenue with instructions.

27 April 1870

Handwritten notes at top right of page 2.

Read the following Recordings,
P.M. Dept.
(N.E. 26 April 1870, No. 1100)
C^d to the Board of
Revenue and to the
Asst. Director of Revenue.

As the revision of
the assessment of the
Madras District has
long been contemplated,
and as the first under-
stand that the demar-
cation and survey of
the ~~same~~ *by day*
~~work~~ has been
already completed, the
simplest course will
be for the Asst. Director

J. D. S.
[Signature]

at once to commence
settlement operations
in this tract.

Mr. Bannoy will
accordingly be directed
to report whether he is
in a position to carry
out this arrangement.

by transfers in from
the working parties
of other Districts, as
no expenditure in
excess of the budget
provision for the Dept.
can be sanctioned. Mr.
Bannoy will also be
good enough to state

within what date he will
be in position to afford
the information desired
by the P.W. Dept. in
regard to the rates to
be imposed upon the
lands which will be
affected by the Red Hill
Irrigation Project.

PD

- 14. Father O'Donoghue Rec. No. 8 May
- 15. " " " " " " " " " " " "
- 21. " " " " " " " " " " " "

Mont Assarum
et laudat legem
in Madagascari
notis. P. 101

Mont

Legem