

MADRAS RECORD OFFICE.

Government of Madras.

Revenue DEPARTMENT.

G.O. No. 2731

Press
~~Mis.~~

326. 327

Dated 18-11-1867.

Not to be folded or roughly handled

*Proceedings of the Madras Government, Revenue Department,
18th November 1867.*

No. 326. Read the following Proceedings of the Madras Government in the
Public Works Department:—

Passing orders on report of the operations neces- }
sary for conveying the waters of the Perriar } (Here enter 14th November 1867, No. 3,521.)
river to the low lands of Madura.

No. 327. ORDER THEREON, 18th November 1867, No. 2,731.

Irrigation, No. 11.

Communicated to the Revenue Board.

(True Extract.)

(Signed) F. H. WILKINSON,
Acting Under Secretary to Government.

To the Board of Revenue, with Proceedings Public Works Department, No. 3,521.

Exd. S. T. Augustin.

Read the following letter from Captain J. G. RYVES, R. E., Superintending Engineer, 1st Division, on special duty, to the Secretary to Government, Public Works Department, dated Camp at Chinnamanoor, Madura District, 7th August 1867:—

1. In accordance with the Orders of Government, dated 16th January last, I have been engaged since the beginning of February in completing the investigation of the Perryaar project; and, having fully satisfied myself as to its feasibility, in working out its details and preparing the plans and estimates necessary to enable Government to apply for funds for its early execution, in case they consider that the feasibility of the project has been satisfactorily established.

2. Captain Payne, in conjunction with whom I was ordered to complete the investigations, which had already been well advanced by that Officer, worked with me till the end of March, when by the desire of the Superintending Engineer he took up the Tinnevelly Irrigation projects, the submission of which to Government without further delay was called for.

3. In the report which I have now the honor to submit, and in the drawings and estimates which accompany it, full particulars of the proposed works will be found; but I will here notice separately, as briefly as is consistent with clearness, the principal difficulties which will have to be surmounted.

4. The works proposed are simply a bund across the Perryaar valley, and a cutting through the water-shed; the latter being as regards engineering nothing more than an ordinary work, such as may be met with on almost any Railway of any length—the former being an extraordinary work both in the depth of water to be held up by it, and in the special difficulty of establishing a bund across a flowing river which cannot be diverted from its course while the work is being carried on.

5. But independent of all engineering difficulties, the execution of these head works will have to be undertaken under peculiarly unfavorable circumstances, arising from their situation in an uninhabited jungle country, 25 to 100 miles distant from where the labor will have to be brought, and bearing a bad reputation for fever.

6. The great popularity of the scheme among the influential portion of the agricultural community will no doubt be of great assistance to us in the matter of procuring the necessary number of workmen, but, to ensure a steady and certain supply it will be, besides, necessary to pay high wages, and to provide for the comfort of our workmen by housing them well, establishing a good bazaar and easy communication with the principal village in the adjacent low country, and a good Hospital with an experienced Medical Officer and adequate establishment of Medical subordinates. My estimates provide amply for all these requisites, excepting the staff pay of the Medical Officer which, as well as the pay of the Engineer Officers,

is not shown in them. The following are the rates of wages which I have adopted:—

	Rupees.
An ordinary cooly	10 to 12 per mensem.
Wagonmen	16
Miners	15 to 20
Smiths, set (with hammerman and bellows boy)	50
Carpenters	25
Stone-cutters	25
Bricklayers	20

25 Working days in each month.

These rates being more than double the regular Madura rates, and considerably above the Ceylon rates for Tamul labor will, I have no doubt, be sufficient to secure an adequate and steady supply of labor, but with a view to rapid execution of the head-works it will be advisable to employ besides a large gang of (say 250) convicts.

A Company of Sappers would be of great service especially on the cutting, and I trust that when the work is sanctioned, one will be detached for duty at the Perryaar.

7. Besides the obstacle which the remote situation of the works and the fear of fever will oppose to us, but which will, I have no doubt, be overcome under the influence of the popularity of the project, high wages and good treatment, we have to consider how the fever itself will affect the work. The unhealthiness of the Perryaar tract has, I have reason to believe, been much exaggerated. The Goodaloor jungle, at the southern extremity of the Cumbum valley, and at the foot of the hills, above and beyond which the Perryaar flows, is no doubt very unhealthy during the dry months of the year; and although I have not heard of a single case of jungle fever which has been satisfactorily traced back to the Perryaar tract, most probably that tract is also unhealthy during March, April, and May, and till the south-west monsoon has set in. But from all that is known of the country, it appears to be quite free from the fever malaria from the commencement of the south-west monsoon in June till the end of February. Our working season in the hill tract would, therefore, commence in June, and on the 15th February we would stop work there, and transfer our workmen to the works on the Soroollyaar and the Vigay channels. If this limit to the working season be rigidly adhered to, and the workmen be supplied with good cumbies and comfortably housed in warm water-tight huts, erected on elevated breezy situations, I feel confident that the Perryaar fever would not touch us. Nevertheless, the Doctor should have *carte blanche* both as to the quantity and quality of quinine and bark, regardless of what it may cost.

8. The limit thus set upon our working season will of course add much to the cost of the undertaking, as we shall lose the best months for work in the bed of the river. And this brings me to the next difficulty, viz., (1) getting a footing for the work in the bed of the river, and (2) carrying it on in spite of floods, when we have no means of diverting the stream from its bed (hemmed in, as it is, on both sides by precipitous hills) until the water surface has been raised to the level of the saddle (E), which is 110 feet above the bed of the river.

9. This difficulty will be overcome with the aid of powerful syphons and by carrying on the earth and puddle-work in front of a stone-dam. The former to pass the river over the work during the eight or ten weeks that operations will go on in the river bed, and the latter to protect the surface of the work done from erosion by the current of the big freshes of the following rainy seasons. The proposed method is explained in sufficient detail in Appendix marked A. I should state, for the information of Government, that the use of syphons on a great scale in the way I propose is not a novel or untried expedient, for instance the bund across the great breach* in the Lincolnshire sea dyke was constructed under

* Of 1862.

syphons. Having been an eyewitness of the success of the plan on that occasion, it occurred to me at the time that it would be peculiarly well adapted to meet our difficulty at the Perryaar.

10. The estimates (Nos. 2 and 3) for the bund and cutting being prepared in terms of labor and materials, will enable Government to judge whether the assumed rate of progress, daily and monthly, may be safely reckoned upon. 650 men for the bund and for the cutting 400, the bund party at work for five seasons, the cutting party for the first three only, is the strength I require to carry out the works in the time and at the cost shown in my report and estimates. If we find that we cannot command this moderate strength, we shall have to reduce the quantity of work set down for each season, and the work will take longer to complete, and cost more than my estimate. But by an unrestricted supply of convict labor to make good any deficiency in the required strength, the completion of the work in the estimated time at the estimated cost may be ensured. I would rather not have the convicts, and they should not be called in if we can in any way (not involving long delay in the completion of the works) do without them.

11. As regards the great depth of water to be held up by the bund, I see no reason for doubts of success, if only the bund be made sufficiently massive and be carefully constructed. The depth of water in front of the bund at the deepest point, measured from the bed of the river,

* In Spain there is a bund (masonry) which holds up a depth of water nearly as much as this. I know of no other bund retaining more than 100 feet depth of water.

will, in the ordinary state of the river, be about* 140 feet, and in floods from ten to sixteen feet higher. But before the bund is completed, the river channel in

its front will be filled with silt to a height of at least 30 feet at the toe of the bund's front slope, and extending with gradually diminishing depth probably a mile and a half up the river bed, so that we shall be guarded against the most serious effect of the great depth, viz., percolation between the base of the bund and the rocky bed of the river, before that great depth exists to produce the effect. And this deposit in front will go on year by year adding to the security of the bund. Within three or four years after the completion of the bund the depth of water will be

reduced from 110 feet to 60, and ultimately† there will be no lake at all but

† In our grand-children's time.

a flat valley, only inundated during high freshes, through which the Perryaar will flow to the cutting.

12. The only other obstacle to be got over is that arising from the head works being situated beyond the British frontier. As it happens, the ground (or at any rate a considerable portion of it) which they will occupy is, and has for many years been, in dispute between the Travancore Circar, and, I believe, the Gantapanaikenoor Zemindar, the greater part of the catchment basin of the Perryaar above the bund is (undisputed) Travancore territory. The area which will be occupied by the works and lake will be about 4,000 acres, and we shall require the privilege of felling timber and bamboos, &c., within that area, and of making roads to and from and through it.

13. The preceding remarks refer to the head works in the Perryaar tract, where the chief difficulties will be met with, but supposing them to be satisfactorily disposed of, and the Perryaar water to be flowing down the Vigay, there yet remains another point regarding which Government should be forewarned. I allude to the possibility of the proprietors of the Ramnad and Shevagunga estates objecting to the construction of new channels from the Vigay to distribute the Perryaar water; or, after allowing the construction of these channels to pass in silence, claiming the right to a certain share of water before any may be taken by the new channels. There is reason to fear that if such a claim were raised in a Court of law it would be not easy to refute it, though it would be very easy to show that the claimants got as much water as they ever did. After the Perryaar water has reached the Vigay, it will always be possible for any one interested to assert that it is Vigay water, not Perryaar water, and to object to being forestalled by a new channel above them.

14. With reference to this question, I have ascertained that the Ramnad and Shevagunga ryots have no claim, at least no instance of its having been asserted is known, to any fixed share of Vigay water. They do not claim to cut corumboos in the Madura reaches of the river, even when the river bed is gridironed with them, and when not a drop is flowing past the limits of the district to water their withering crops. In fact they receive water only when the Vigay is in fresh sufficient to wash away corumboos. But this, it will be observed, might not preclude their raising a claim against a new or even an enlarged channel.

15. With a view to facilitating the settlement of the question, if it ever does (as it probably will) arise, I have requested the Superintending Engineer of the District to have accurate river registers kept at the Perranny, Chittanny, and at the Vigay pavement, so that, by the time the Perryaar water is turned into the Vigay, we shall have a record of the quantities of water flowing past those points during the year. In distributing the water (after the Perryaar works are in operation), I would then arrange that the flow past the Perranny and Chittanny should be at least as much as the average of those five years, and would establish a fixed gauge register in the cutting and another above the infall into the Soroollyaar, the reading on which, taken daily and communicated by tappal to the Overseer or other person in charge of the head sluices at the Perranny and Chittanny, to be acted upon according to fixed instructions. It would be well to have another register on the Vigay, above the point where the Soroolly joins it. We should then be in a position to prove, from our recorded register, in any Court of law what proportion

of the supply at the Perranny on any day of the year or for the whole year was Perryaar water, and I would invite the Ramnad and Shevagunga Zemindars to depute one of their servants to satisfy themselves that the registers were accurately kept and correctly gauged.

16. The Ramnad and Shevagunga ryots will of course receive considerable benefit by the additional supply thrown into the Vigay; but it is nevertheless probable that the question above noticed will be raised. The difficulty would perhaps be met by allowing the Ramnad and Shevagunga Zemindars to share with Government the expense of the project, giving them a proportional share of the additional water; but in that case Government would have to interfere with its own ryots in the matter of corumboos, and there would be such complication of interests that it would be an arrangement not easy to carry out satisfactorily. There would be some saving in the cost of the project, as some of the new channels would not be required, and the others would be smaller and shorter than they otherwise would be. But looking to the complication and interference involved in such an arrangement, and to the great need of water in the Meyloor talook, I am of opinion that we should use as much of the additional Perryaar water as our ryots want, and allow any surplus to flow down the Vigay, a free gift to our neighbours below us.

17. For the sake of distinctness I have, in my report, assumed that the whole of the additional irrigation will be below the Perranny,* and, because it gives the maximum cost of the undertaking, the estimates are framed on the same hypothesis.

* 25 miles west of Madura town, marked on Maps 5¹ and 5² by a red bar and letter P. There is little doubt, however, that the Soroolly ryots will not allow the Perryaar water to pass the heads of their channels without taking as much of it as they can use in the extension of their paddy crop. The Perryaar water used for this purpose must be distributed entirely by the flowing channels, and none of it should be stored in the Soroolly tanks. If the ryots in this part of the district could be brought into communication with the sugar exporters, three or four thousand acres of sugar-cane could be raised along the banks of the Soroolly.

18. The results of the investigation ordered by Government are—

- (1.) That the project is feasible.
- (2.) That it will cost (including distribution) £ 175,000.
- (3.) That it will supply, annually, water sufficient for the irrigation of 149,000† acres of paddy, in addition to the 40,000 or 45,000 acres already under irrigation by the Vigay and its tributaries.

† The aggregate area of the two crops raised during the year.

INTRODUCTION TO REPORT ON THE PERRYAAR PROJECT.

The principal division of the Madura District, consisting of the three talooks, Meyloor, Madura, and Tirumungalam, is a strip of country running north and south; its eastern boundary marching with the adjoining Zemindary estates of Shevagunga and Ramnad, and on the west separated from the Dindigul division of

the district by the mountains and jungle which extend almost continuously from Nutton on the north to Srivilliputtur on the south, where they run into the general range of the Western Ghats, which here separate British territory from the Travancore country.

Its area, excluding uninhabited mountain and jungle, is about 1,200 square-miles, with a population of very nearly half a million.

The Vigay river, passing through the only opening in the hills, which form the western boundary, flows across the strip; the length of its course within the limits above defined being about thirty-three miles. In this length several river channels are taken off, most of them to fill tanks during the short and uncertain periods of Vigay freshes. The principal channels are the Vadakurri, the Tenkurri, the Nelloor, and the Madacolum.

"Vada"—north.
"Kurri"—bank.
"Ten"—south.

The two first named have the advantage of anicuts across the river at their heads, the other two as well as all the other channels are supplied by means of temporary spurs (made of grass and sand—corumboos) run out into the river.

The numerous tanks supplied by the channels were many of them first class reservoirs originally, but are now so silted up as to be capable of storing not much more than half the quantity of water they were designed to hold; they occupy a great deal of valuable land, and in the attempt to get as much water as they require, the ryots of one tank frequently cause injury to their neighbours above them, by damming up their escape calingulaks and flooding land by the extended water spread.

The tanks having become shallow in proportion to the area of the water spread, there is enormous waste of valuable water by evaporation; I calculate that this waste amounts to at least thirty per cent. of the water stored.

The character of the Vigay makes the tank system essential. For some reason or other the quantity of water received into the channel of the river bears a very small proportion to the rain-fall on its catchment basin, the average annual rain-fall registered at Periacolum and Madura is 32 and 41 inches respectively. On the Cumbum valley (where no register has been kept) it is at least as much as at Periacolum, in the Wursanaad valley it is probably less; taking it at only 33 inches over the whole catchment basin above the Peranny, it would amount to 3,600 millions of cubic yards per annum, and supposing that only one-third of this found its way into the streams and rivers, so as to be available for irrigation, there would be more than enough (with due allowance for the enormous waste on tanks) for three times the extent of paddy crop now raised.

Yet it is affirmed by good authority that in an average year not a drop of Vigay water reaches the sea, but this I think is hardly sufficiently well established to be accepted as the fact. My belief is that sufficient water for more than double the present area of irrigation *does* flow down the Vigay, but that three-fourths of the annual supply passes down the river at three times the rate at which all the channels together can draw off water from it, so that if the big freshes could be detained, so as to be spread over, say sixty days, instead of running off at three times the

rate in twenty days, it would be found that there would be water enough (if the tanks could contain what it would be necessary to store) for double the present area of rice-crop.

However this may be, there is no doubt as to the main fact, that the supply of water obtained from the Vigay is so precarious and scanty that even in good years the paddy crop barely covers 22,000 acres annually, although the existing channels and tanks command land enough, and have sufficient hydraulic capacity, for the irrigation of fully double that extent of crop if only a sufficient supply of water delivered at a regular moderate rate be ensured.

This Vigay irrigation is situated in the Madura talook, the middle one of the three named above. In the Meyloor talook there is but one river, and that but a small stream, at its northern extremity, under which a small extent of land receives a good and certain supply. All the rest of this talook is dependent for irrigation on the local surface drainage, stored in small shallow tanks, the majority of them being mere ponds. Situated, as all the land of this talook is, within a few miles of the watershed, there are no well-defined streams; the Allighiry hills form a dyke, turning all the hill streams to the north and south round the flanks of the talook.

The north-east monsoon, from which this talook receives what rain it *does* get, is very uncertain so far south and inland, and the mountains to the west of it (the streams from which, as above shown, do not flow through this talook) no doubt draw away from it a considerable proportion of the rain cloud which may have travelled so far.

Under these circumstances, it is not surprising that agricultural operations are but seldom rewarded by a good crop. If the ryot is so fortunate as not to find the ground as hard as brick at the ploughing season, the chances are that rain necessary to bring the crop to maturity will not fall at the expected time.

And the cultivation of wet crops is hardly a less precarious business, failure being attended with greater loss, and success attained generally at much expense of labor and money on raising water from wells and pools.

Almost every alternate season is one of scarcity in this talook, and when an exceptionally dry year occurs, there is severe distress, and the population is thinned by death and emigration. In 1861-62 and again last year it suffered severely in this way.

If the water supply in the Vigay were sufficient, half of Meyloor could be irrigated from it.

Years before the country came into our possession, the Native rulers appear to have recognized the need of a better supply of water for the Madura District: several not very skilfully devised attempts were made to turn streams flowing on the hill table land west and south of the Cumbum valley through the water-shed separating them from the Madura rivers. (See reports by Captain Faber in 1837, by Captain Horsley in 1846, by Captain Scott in 1856, and by myself in 1859 and 61.) In 1837 Captain Faber proposed the diversion of a small stream (the Chinna Moollyaur) from the mountains at the southern corner of the Soroolly valley, which though comparatively but a small measure of relief, would have been beneficial

and remunerative. It was taken in hand in 1838, but given up in consequence of the workmen asking higher wages than was anticipated.

The streams which these projects were to turn into the Madura District are tributaries to the Perryaar, the river which I propose to deal with.

From a Report by Mr. Hodgson, dated 28th March 1803, which has lately (17th November 1865) come to light, we learn that at that time there was in existence a tradition ("handed down from father to son, through many generations") of a scheme for the improvement of the Madura and Ramnad Districts apparently identical, as regards the stream which was to be the means of improvement, with the project which I proposed to Government in 1862, and which forms the subject of the following report; but this tradition appears to have been extinguished by the unfavorable report of the late Sir J. L. (then Captain) Caldwell notwithstanding the very slight basis on which that report was founded.

REPORT ON THE PERRYAAR PROJECT.

1. The Perryaar has its sources on the northern slopes of a mountain range—6,000 feet above the sea—about fifty miles north-east of Palamcottah in N. Lat. $9^{\circ}10'$, whence it flows from south to north till it reaches N. Lat. $9^{\circ}31'$ where it turns due west.

2. At the angle formed by this change of direction it receives the united streams of the Perrya and Chinna Moollyaar, which bring to it the drainage from the mountains and forests to the west and south. Here the Perryaar is only four miles distant from the southernmost sources of the Sorooollyaar. And its bed only 170 feet below the water-shed ridge from which those sources flow. This, therefore, is the point where I propose to turn its stream into the Madura rivers.

3. The required works will be—

(1.) A bund to close the valley by which at present it takes its course to the westward.

(2.) A cut through the water-shed, which separates that valley from the head-waters of the Sorooolly.

4. The first points to be settled are the exact site of the dam and the level at which the water is to be taken.

Site for the Bund.
See Drawings Nos. 1 and 2.

5. The site which I have fixed upon as the best is immediately above the second bend, 800 yards below the *debutchure* of the Moollyaar. This site will give us the advantage of a saddle where the escape can be established, detached from the bund. Here too the bund will be shorter and take a smaller quantity of material than at any other site immediately below the Moollyaar junction.

Rocky bed of river a disadvantage.

6. The soil here as elsewhere on these hills is good, an argillaceous loam, varying in depth from a few inches to many feet; below it is the rock, gneiss and sienite. This rocky substratum, exposed as it is in the river bed, is a serious disadvantage, as it will facilitate percolation beneath the bund, and that too just where the water pressure will be the greatest.

Bund to be of earth, not of masonry.

7. I have decided against a masonry bund for the following reasons:—

(1.) Its enormous cost, more than three times that of an earthen bund.
(2.) The uncertainty of our being able in anything like a reasonable time to execute such a work (requiring a very large number of skilled workmen) in such an out-of-the-way part of the country, and where every parah of lime would have to be brought 25 miles.

(3.) Moreover, a masonry bund, even though founded on rock, has its disadvantages; especially when, as in our case, the depth of water to be held up is very great; and the necessary* provision for emptying the lake, a source of weakness and danger, which an earthen bund would not be exposed to.

* Necessary in the case of a masonry bund for the inspections and repairs which would certainly be required.

8. The serious risk of percolation between the rock and its base is the sole objection to an earthen bund. The soil being so good it will in all other respects be better than one of masonry, stronger, less permeable in its mass, and far more likely to endure for ages.

The risk of percolation met.

9. By the following method I believe the danger of percolation above alluded to will be removed. The execution of the works will occupy four or five working seasons. In the first season I propose to throw a loose stone dam across the bed of the river, which will raise the water surface 20 to 60 feet, according to the state of the river. The earthen bund will be constructed in front of this stone dam, as shown in sketch No. 6, and the stone dam will be ultimately raised to the 120 feet level, and form a rear retaining wall to the bund. In the still water in front (of the work in progress) the silt brought down by the river will be deposited. I expect that the accumulated deposit of three seasons will be at least 30 feet thick, with a long slope extending a mile and a half up the river's bed. In this silt the toe of the front slope of the bund will rest, and subsequently additional layers

See Section on A B C, sheet No. 4.

will be superposed whenever a fresh big enough to top the escape occurs.

10. The plan and sections on sheet No. 4, with the particulars of dimensions on the same sheet, give a better notion of the proposed bund than any written description could convey. It will be observed that I have not adopted the English practice of splitting the bund into two parts by a central vertical puddle-wall, that practice is, in my opinion, bad. It is evident that, if the puddle-wall is required at all, the earth in front of it will at the best be fluid mud, so that the effective bund to resist the water pressure is reduced to the puddle-wall and the earth in rear of it, i. e., to a bund of half the mass with a front slope of about $\frac{1}{4}$ to 1. If the earth in front does not become semi-fluid mud, or is not permeable to water, no puddle is required at all. The proper place for the puddle is as a lining to the front slope.

11. After much consideration I have fixed upon 133 feet above the B. M.* on rock at Moollyaar junction as the proper normal level for the surface of the lake. It might be anything between 0 and 180 feet above that datum, but

* Captain Ryves' bench mark N.—Rock in Perrya Moollyaar 40 yards from junction with Perryaar.

The proper level for the surface of lake.

practically the limits are 105 feet and 155 feet. The following tabular abstract of estimates of the works adapted to these two extremes, and to the four cases at 10 foot intervals between them, give a comparison of the quantity of work in each, its cost, and the time it will take to execute (the latter of course supposing the supply of labor to be the same for each).

Comparison of work and its cost for different levels of lake surface.

Level at which the water is taken.	BUND.			ESCAPE.		CUTTING.		TOTAL.	
	1,000 Cubic yards of Earth.	Stone.	Lacs of Rupees.	1,000 Cubic feet of masonry.	Lacs of Rupees.	1,000 Cubic yards of Rock.	Lacs of Rupees.	Lacs of Rupees.	Number of seasons' work.
105	813	200	3.6	33	.37				
115	1,020	205	4.5	100	.67	1,012	14.20	18.17	14
125	1,260	210	5.6	215	1.22	702	9.83	15.00	10
135	1,480	220	6.4	390	1.80	431	6.05	12.87	7
145	2,020	235	10.5	...	.75	215	3.10	11.40	4
155	2,530	250	13.0	...	.25	89	1.26	12.51	5
						30	.51	13.76	6

The two extremes have in their favor that no artificial drop wall would be required for the escape, a little scarping and blasting of a rocky saddle being all that would be required for that essential adjunct; the minimum extreme has, besides, the

* 3 miles long.
75 feet deep at the deepest.
35 .. average depth.

advantage of less water pressure to deal with, but the rock cutting* through the water-shed would be very heavy, and consequently, in respect to cost, and

† E on sketch No. 2,
and .. 3.

‡ at F on ..

to the time it would take to carry out, this (and in a less degree the 115 feet level) must take a very low place in the order of selection. I reject the 145 and 155 feet levels on account of the greater water pressure and the extra length of bund (across saddle†) necessary, disadvantages which are not counterbalanced by the advantages of a natural escape.‡ There remain the 125 and 135 feet levels, either of which is, in my opinion, better than any of the other four in the table. I have adopted the 133 feet level as the datum for my designs and estimates, because at that level the quantity of rock to be blasted for the cutting will about supply the quantity of stone required for the dam, economizing thereby time and money.

12. Having thus decided on the normal level of lake surface, I proceed to fix the dimensions and relative levels of the cut and escape. I take the following to be the proper conditions to be fulfilled by these works:—

(1.) At the normal water level the cut to discharge the average (exclusive of big freshes) stream of the Perryaar, during the eight months, May to December including.

(2.) No water to run to waste over the escape until the inflow exceeds an ordinary big fresh.

(3.) In extraordinary floods the lake surface, when at the highest, to be 12 feet below the top of the bund.

The length available for the escape is about 600 feet (without blasting away the opposite hill) across the saddle (E) west of the north end of the bund: the normal water level is to be 133 feet, and I estimate that the area of the lake surface will be $3\frac{1}{2}$ square-miles at the 133 feet level, increasing to five square-miles at the 150 feet level. Taking these data, I find that the following will satisfy the above conditions.

Dimensions and levels of the cutting escape and feet.

Escape crest to be at the $142\frac{1}{2}$ feet level.
Cutting sole 125 ..
Width of cutting with sides sloping 1 to

6, 40 feet.

Top of bund at the $162\frac{1}{2}$ feet level.

The Escape.

13. The escape will consist of three drop walls of masonry built across the saddle west of the N. W. end of the bund, the crest of the second being $12\frac{1}{2}$ feet below that of the front wall, and of the rear wall 14 feet lower than that of the second (see sheet No. 4). The flank of the bund adjoining the escape will be sustained and guarded by a wing-wall 300 feet long and from $16\frac{1}{2}$ to 6 feet high, the opposite end of the escape will abut upon the rocky hill forming the west side of the saddle. The height of the front wall will be 38 feet at the lowest point of the saddle, and diminish to nothing at either side, its thickness at top will be 9 feet, and at its base (where it is highest) 20 feet, the thickness at base varying from $9\frac{1}{2}$ to 20 feet. The foundation will be laid in a trench cut out of the rock. To keep the two basins full, a 3-inch pipe will be carried over the front wall from the 120 feet level in front to the same level in rear; and as an additional security there will be a tamboghy a couple of feet lower than the crest, at each end of the wall. The maximum discharge by the escape will not exceed $6\frac{1}{4}$ millions of cubic yards per hour, which would pass over the crest of the front wall with a velocity of a little more than $12\frac{1}{2}$ feet per second, over the second and third walls the velocity would be respectively 14 and $14\frac{3}{4}$ feet per second, these velocities are not greater than what we have already successfully dealt with. After passing over the rear wall the flood water will flow by a natural gully back into the Perryaar, which it will fall into at about 300 yards distance from the foot of the rear slope of the bund.

Extraordinary floods.

Volume of water in inches of depth over the whole catchment basin.

In 3 days 18 inches.

.. 2 .. $13\frac{1}{2}$..

.. 1 .. 8 ..

.. $\frac{1}{2}$.. $4\frac{1}{2}$..

In 3 days 30 inches.

.. 2 .. $22\frac{1}{2}$..

.. 1 .. $13\frac{1}{2}$..

.. $\frac{1}{2}$.. $7\frac{1}{2}$..

14. The possibility of an extraordinary flood of the magnitude indicated in the margin is anticipated, and the top of the bund fixed at 12 feet above the level to which the surface of the lake would, according to my calculations, be raised by such a flood.

15. Applying as a crucial test the (impossible) second case stated in the margin, it will be found that even then the lake surface would not rise to within

9 feet of the top of the bund, as fixed in

the preceding paragraph. The relative levels fixed for the top of bund; crest of

escape; and sole of cut; and the waterways of the two latter may, therefore, be accepted as perfectly safe.

Soroolly floods.

16. But in the case of the extraordinary flood which (in paragraph 14) I have stated is possible, and, therefore, to be anticipated and provided for; the rate of discharge through the cut would rise to 1, 1½, or even for an hour or two at the top of the flood, to 1¾ million cubic yards per hour, which added to the Soroollyaar's own natural flood discharge would cause very injurious inundations on the paddy lands skirting that stream.

Regulating Reservoir.

17. To prevent this I propose to construct a reservoir in the jungle tract between the foot of the hills and the Vyravenaar, in which the excess above the safe rate of discharge would be retained till the flood had passed off. I do not propose for this purpose a head sluice across the cut through the water-shed, because, as it would not do to trust to its being properly worked by hand in such an out-of-the-way place, it would have to be made self-acting and be liable to get out of order, especially as it would be exposed to the curiosity of the elephants which frequent these mountains. Besides being free from this objection, the reservoir plan has this in its favor, that it would store for subsequent use the excess water, which by the head sluice plan would be discharged over the escape back into the Perryaar below the dam. And against it, the defect of all river-fed tanks, that it will be ultimately choked with silt; but long before this occurs, we shall be able to afford to replace it by a new one, which would probably be formed by an upper bund across the Perryaar itself above the main lake. It should be remembered that the effect of a head sluice would be to raise the flood level of the lake, to meet which it would of course be necessary to make the bund a little higher and the escape drop walls a little stronger, the cost of which, plus the cost of the head sluice itself, would be very nearly as much as the cost of the regulating reservoir.

Effect of the addition to Soroollyaar floods.

See the small general map on Sheet No. 5.

18. The rate of delivery of Perryaar water into the Soroolly stream should not exceed ¾ million cubic yards per hour. This hourly addition to the natural great flood of the Soroolly would raise the water surface about two feet at Oottampollum to 1½ feet at Vecrapaandy. The effect on the Vigay would be considerably less, I calculate that at the Perranny the flood level would not be raised more than five inches by the extra ¾ million per hour.

Capacity of the regulating Reservoir.

19. Taking ¾ million per hour as the maximum limit not to be exceeded, even in very extraordinary floods of the Perryaar, such as would occur only once in many years, it appears (see table C) that in the case of such a flood as that described in paragraph 13, the excess above that limit to the hourly rate of discharge would amount to about 35 millions of cubic yards, the Reservoir will, therefore, be made sufficiently capacious to hold that quantity of water. The works to restrict the maximum rate of delivery within the above limit, would also in a less degree regulate the rate of delivery of the ordinary big freshes. With a view to husbanding the supply of water, means will be provided for turning the whole of

the Perryaar water into the Reservoir, when the Vigay and Soroolly are in flood, and the Perryaar is discharging at not more than the ordinary by fresh rate.

20. The water thus delivered into the Soroolly will flow with that stream to the Vigay, but on its way will pass over several old anicuts which require repair and some improvements and alterations; for these and for embankments, and other minor works connected with the Soroollyaar, I have entered in the estimates a lump sum which I have no doubt will be ample for the work.

21. The works above described will bring the Perryaar water to the heads of the Madura channels at the Perranny and Chittanny, where the distribution for irrigation will commence.

22. Before entering upon this branch of the subject, it is necessary to calculate as accurately as possible the quantity of water we shall have to distribute, on which will depend the dimensions, length, and general direction of the channels.

The Perryaar Catchment Basin.

23. Of course there is no record of rain-fall on the catchment basin of the Perryaar above the point where I propose to take its stream. This catchment basin consists of a net work of mountain ridges divided by ravines, which open out here and there into basins and valleys, and from which issue the numerous tributaries of the Perryaar, many of them considerable streams. The lowest valley is 2,700 feet above sea level, the highest ridge 6,000 feet. The area drained is about 250 square-miles in extent, more than one-third of this is clothed with dense forest and cane jungle, and the gigantic elephant grass covers very nearly all the rest.

Rain-fall.

24. It receives the rains of both monsoons, but its principal supply is from the south-west monsoon. There being no record of rain-fall on the basin itself, I have examined the registers of rain-fall at the nearest stations of the adjacent districts, Tinnevely, Travancore, Cochin, and Madura, and have arrived at the conclusion that in an average year the rain-fall on our Perryaar basin would be at least 79 inches, of which 47 would be received from the south-west, and 23 from the north-east monsoon, and nine by casual showers and storms during the dry weather.

25. The proportion of the rain-fall that drains off the land into the river is certainly much above the average of the South of India.

- (1.) The area drained is small.
- (2.) One-third of it is sheltered from the sun by dense forest.
- (3.) During five or six months of the year, cloud and mist obscure the sun for at least two-thirds of the time it is above the horizon.
- (4.) The ridge and ravine character of the country.
- (5.) The surface drained is rock covered by a thin stratum of soil.
- (6.) Beds of tributaries and of the Perryaar all rock.

26. In my estimate of water supply, I assume that the river will receive 75 to 80 per cent. of what falls

during the south-west monsoon, 60 per cent. of the north-east monsoon rain-fall, and from 53 to 37½ of the dry weather showers, altogether 1,133 millions cubic yards in an average year.

Deduction for waste and net supply at the heads of the Madura channels.

27. The waste by evaporation before the water reaches the Madura irrigation channels will be about 48 millions cubic yards, or rather more than 4½ per cent. on the gross annual supply. And for the waste which will occur in first filling the bed of the Vigay at the end of each dry season, I allow 18 millions, making the total deduction for waste 66 millions of cubic yards, and leaving 1,067 millions for the channels to receive, of which 593 millions will be delivered during the south-west monsoon, or 1st crop season, and 430 millions during the 2nd crop season; 44 millions being received in February and March would not come into use for paddy irrigation, but would be valuable for Sugar-cane or garden cultivation.

28. The amount of rain-fall assumed in the above, being deduced from the averages of quantities registered during a long series of years, does not include the surplus water of extraordinary floods (see paragraphs 12 and 13) which will pass over the escape and back into the Perryaar below the dam. No deduction, therefore, has been made on this account.

29. The following table exhibits my estimates of water supply for each month of an average year. I should note here that the result obtained by the method which I laid down for myself is, in my opinion, much below the truth. I believe the average annual rain-fall to be nearer 100 than 79 inches. I have, however, accepted the results as being on the safe side for our purpose:—

Table of estimated water supply.

Table of estimated water supply.										
	Rain.	Millions cubic yards received by Lake.	LOSS BY EVAPORATION.					Millions cubic yards deli- vered at Perryany	Quantity for each crop.	
			ON LAKE.		IN TRANSIT.		Total Loss Mns. cubic yards.			
			Mns. Square yards exposed.	Rate per month.	Mns. Square yards exposed.	Rate per month.				
April	... Inches. 4.63	43	11	Yards. 30	5	Yards. 27	5.15	85	593 Mns. cubic yards for the 1st or south- west monsoon crop.	
May	... 9.82		11½	25	6½	40	5.53	112		
June	... 11.94	165	11½	15	9	30	4.46	160		
July	... 11.21	170	11½	10	9	20	2.53	167		
August	... 8.12	120	11½	15	6½	25	3.81	116		
September	... 6.03	80	11½	20	5½	30	3.96	75	430 Mns. cubic yards for the 2nd or north- east monsoon crop.	
October	... 11.56	165	11½	15	9	25	4.01	160		
November	... 8.46	125	11½	17	5	25	3.13	45		
December	... 3.03	50	10½	20	4½	30	3.52	20		
January	... 1.52	35	10½	25	4	33	4.04	20		
February	... 0.96	25	10½	30	4½	35	4.75	24	44 Mns. cubic yards.	
March	... 1.80	30	10½	...	...	...	...	...		
Annually	... 78.98	1,133	...	...	...	...	47.95	1067		

30. We have now to...

30. We have now to determine how much land this additional water supply will irrigate, and where this land is to be sought.

31. In an average Madura tank of the first and second classes, the waste by evaporation is about 35 per cent. during the south-west monsoon, and fully 25 per cent. during the north-east monsoon of the quantity stored. It will, therefore, be advisable to irrigate, direct from the river channels, as much land as we can ensure a constant stream for; for this direct irrigation each acre of the 1st crop will require 6,250 cubic yards of water, and for the 2nd or north-east monsoon, crop, 4,500 cubic yards. For the land to be irrigated from tanks, 9,000 and 6,666 cubic yards would have to be stored for each acre of 1st and 2nd crop, respectively. Land receiving irrigation partly direct from the channels and partly by water stored in tanks would require per acre about the means of the above quantities, a large proportion of the land should be irrigated in this way.

32. The following is the way I would dispose of the water. I will assume that for the south-west monsoon, or first crop, the seed beds are sown in the end of April and beginning of May, the paddy planted out early in June, and the crop reaped in September, and that it would require per acre to be watered as follows:—

30 days, 80 cubic yards per diem on ¼th of the area	150 cubic yards.
10 " 75 " " on the whole	750 "
15 " 60 " " " " " "	900 "
30 " 50 " " " " " " "	1,500 "
15 " 60 " " " " " " "	900 "
25 " 70 " " " " " " "	1,750 "

Total for the 125 days ... 6,250 "

Comparing this estimate of requirements with the table of water supply (paragraph 29 ext. in margin), it appears that in August, when the supply is least, the demand will be greatest, by suiting the area to be irrigated direct

from the channels, to the supply of this month, we shall therefore arrive at a safe result. The average daily delivery in August will be 3.74 millions cubic yards; and bearing in mind the regulating effect of the reservoir described in paragraphs 16 and 18 of the Perryaar lake itself, the minimum daily supply may be safely assumed to be at least half the average, or 1.87 millions cubic yards, which is

* 1.87 mns. = daily supply.
70 = acres daily requirement.

it will be as many days at and above, as it will be below that quantity, the area of land to receive half its irrigation direct from the channels will, therefore, be also 26,700 acres.

1st Crop by Perryaar water.

33. The south-west monsoon supply of water will thus be disposed of as follows:—

164 millions cubic yards in direct irrigation of 26,714 acres.

201	do.	do.	{ half direct }	do.	26,714	do.
222	do.	do.	{ half tank }	do.	24,666	do.
593	do.		Tank			

giving a total 1st crop, or 78,094

Second crop by Perryaar water.

find that the north-east monsoon crop would be made up of—

9,000 acres of direct irrigation using 40 Mrs. cubic yards

22,500	do.	{ half direct }	do.	126	do.	do.
39,600	do.	{ half tank }	do.	264	do.	do.
71,100	do.	Tank	do.	430	do.	do.

71,100 do. irrigated by the

35. Making a total addition of 149,000 acres to the annual rice crop, for

Total annual addition to rice crop.

which, allowing one-fourth for fallow, 100,000 acres of land will be required,

78,000 to be cultivated during the south-west monsoon season (May to September), and 71,000 in the north-east monsoon (October to January).

36. Part of this additional rice crop will receive its irrigation from existing channels and tanks, now supplied by the Vigay, and which will be used to distribute also Perryaar water; but a large proportion of the 100,000 acres will have to be sought for in land hitherto beyond the reach of the river channels.

The land for the additional cultivation to be taken in the Meyloor talook.

37. Land of fair quality and of sufficient extent lying at suitable levels can be found in the Meyloor and Tirumungalum talooks, north and south of the tract already partially irrigated by the Vigay. I propose to give the Meyloor talook the preference; because there an artificial supply of water is more needed than in the Tirumungalum talook, which has comparatively a very fair natural supply by the Goondaar and Sheveraycotta streams. I propose, however, to provide for throwing into the Tirumungalum rivers the surplus water of big freshes to fill the tanks on that side when required.

38. I will first explain how the Perryaar water, and how much of the supply will be distributed by the existing river channels and tanks dependent on them.

Distribution of Perryaar water by old Vigay channels.

On the south of the river.

influence of these old channels, is bounded on the south and west by the Tenkurry and Nellayoor channels, the trunk road, and the Goondaar river. It contains 61,000 acres, of which fully 40,000 are fit for paddy cultivation; of the latter (arable area) about one-half is generally under crop in a fair season, 13,000 acres being irrigated, the remainder dry, the extent of irrigation during the south-west monsoon is under 4,000 acres. I therefore propose to allot to this tract Perryaar water, sufficient for the irrigation of 36,000* of first crop and of 27,000† acres of second crop.

* (40,000—4,000)

† (40,000—13,000.)

On the south bank of the river

tract which is within the

th and west by the Tenkurry

Goondaar river. It contains

addy cultivation; of the latter

a fair season, 13,000 acres

irrigation during the south-west

monsoon is under 4,000 acres. I therefore propose to allot to this tract Perryaar

water, sufficient for the irrigation of

36,000* of first crop and of 27,000†

acres of second crop.

South of Vigay.

40. By enlarging the Tenkurry

channel (which draws its supply from

above the Chittanny, the lower of the two Vigay anicuts,) and connecting it with the Nellayoor and Madacolum channels, which will require no enlargement, the Perryaar water for this tract will be economically conveyed to the several points from which the channels of distribution will draw their supply; of the latter many new ones, with proper sluices and other small masonry works, will have to be constructed, and the principal tanks will have to be repaired and improved. The cost of the works for this tract will be under a lac of Rupees.

41. On the north bank of the

Direction of Perryaar water by old channels on Vigay the breadth of land commanded north bank. by the existing river channels is con-

siderably less than on the other side of the river, not more than 25,000 acres, of which about 14,000 are available for cultivation; of this culturable area, about 6,500 acres are irrigated in the north-east monsoon, and barely 2,000 in the south-west. The old channels on this side will, therefore, be adapted by means of extensions, and new branches to the distribution of Perryaar water for 12,000 acres of first and 7,500 acres of second crop. The cost of this adaptation will be about 24,000 Rs.

42. Without a radical reform of the system of management of irrigation, both on the north and south banks, the works proposed will be ineffective. It is my opinion that it will be essential that the charge of the works and the control of the distribution of water be vested solely in the Engineer Department, as in the Godavary and Kistna deltas.

43. After allotting, as above, as

Area of additional irrigation beyond the reach much water as can be distributed by of the old Vigay channel. them, to the existing channels, there

will still remain Perryaar water enough for the irrigation of 30,000 acres of first and 36,500 of second crop, the land for which will have to be found outside the tract, to which irrigation from the Vigay has hitherto been restricted. Of this additional area, I propose to allot 25,000 and 30,000 acres of first and second crop, respectively, to the Meyloor talook, the remainder to be taken up in the extension of the Nunjah cultivation under tanks in the Tirumungalum talook.

44. To convey the Perryaar water

New channel for Meyloor talook. into the Meyloor talook, an entirely

new channel, with proper branches, will have to be constructed. This channel will draw its supply from above the Peranny anicut by the same head as the old Vada-kurri channel, which will have to be enlarged to enable it to convey the additional volume of water for 2½ miles. Here the separation of the shares for the old Vada-kurri and Sholavundaun irrigation and of the new Meyloor channel will be regulated by a simple masonry structure, and the share of the latter will be conveyed from that point by the new channel (following the line marked by green on the Map No. 5.) into the heart of the Meyloor talook.

45. As it will be carried across the drainage from the southern slopes of the Sirumullays and Aligherry hills, this channel will be an expensive work; including its branches and subsidiary works, it will cost 2½ lacs of Rupees.

Arable area in the tract embraced by the new channel.

46. The whole of the tract bounded on the north by this green line and by the Vigay on the south will be commanded by this channel; its area is 158,000 acres, of which 25,000 have been already disposed of in paragraph 40. Of the remaining 133,000 acres, it appears from a Statement furnished by the Collector that not more than 36,000 acres are cultivated, 16,000 being irrigated, the remainder dry, the ayacut, i.e., assessed arable area, is about double the area of cultivation, say 70,000 acres, 63,000 being set down as occupied by tanks, topes, villages, roads, &c., or as unfit for cultivation.

Land available for the additional paddy crop.

47. These figures, though no doubt not perfectly accurate, as the Revenue Survey has not yet reached the Madura District, are sufficient to show that the unirrigated arable area in the tract commanded by the proposed new channel is, during the south-west monsoon, more than double the area of land required for the Perryaar first crop, and during the north-east monsoon, about one and three-quarter times the proposed area of second crop, and that of the former about 24,000, and of the latter about 13,000 is land already assessed as Nunjah,* there is therefore no doubt about sufficient land fit for paddy cultivation being found in the tract specified for the first crop, the question is whether in the 40,000 acres of arable Punjab land (30—13) 17,000 acres fit for Nunjah, if only water be supplied, will be found for the second crop. From what I know of the country and the soil, I think this question may safely be answered in the affirmative.

* But for which no water is supplied.

48. However, before the channel is completed, the Revenue Department will no doubt be able to decide this point, and any deficiency of Nunjah land could be made good, either by extending the channel a few miles further north, or by embracing a greater breadth (by a branch from the 22nd mile running north of the Nursingapatam hills to Arasaputty and Tombaputty,) or by slightly reducing the share of water allotted to this channel, and giving the difference either to Tirumungalum or to the Soroolllyar.

Water to the Tirumungalum talook.

49. The water for the extension (additional first crop 5,000, second 6,500) of the Nunjah cultivation under tanks and Goondaar channels in the Tirumungalum talook, will be taken from the Tenkurry main duct by a channel through the Vikramungalum gorge, whence it will be distributed by natural drainages, requiring only slight excavation and embanking here and there.

The work of which the project will be compared, and their cost.

50. The complete project will then be made up of the following works and groups of works, the cost of which according to my estimates will be as set opposite each below:—

	Lacs of Rupees.
1. Preliminary (ghaut, roads, buildings.)	0.11½
2. The Perryaar bund and its escape	8.67
3. Cutting through the water-shed	3.12

4. Regulating reservoir and other works between the cutting and in-fall into the Soroolllyaar	0.75
5. Works on the Soroolllyaar	0.80
6. Distribution of water	4.03
* The total estimated cost being	17.49

To this estimated cost, I propose to add a reserve fund of 20 per cent. to be at the disposal of Government to meet deficiencies, if any occur, in my

* If the supply of water turns out to be much more than I have estimated at, the new distribution channel will have to be made bigger and longer.

estimates, or to carry out extensions or additions which may * be found desirable or necessary. The sum to be allotted for the project would then be 21 lacs or £210,000.

Annual value of the water supplied.

51. The water-rate on 149,000 acres of rice crop at four Rupees per acre would be six lacs, all but 4,000 Rupees; and supposing that 26,000 acres of dry cultivation be given up, the net increase of land revenue would be about 5½ lacs of Rupees. For management and repairs I would allow as much as 50,000 Rupees per annum, leaving five lacs as the net profit on the capital expended, which is 28½ per cent. on the estimated cost, or 23¾ per cent. on the 21 lacs which I propose should be assigned for the project.

Allowance for repair and maintenance.

52. The allowance for management and repair will appear high when compared with the Budget grants for that purpose in this Presidency which are, however, notoriously inadequate. The following is a comparison between what is allowed for the Godavery delta works and the proposed allowance:—

	Per million cubic yards of water delivered.	Per acre of the tract commanded by the channels.	Per acre irrigated first crop only.	Per cent. on gross annual profits.
Godavery	RS. 45	AS. 3	AS. 7	8
Perryaar	49	4½	10	9

with due allowance for engineering advantages or disadvantages, the figures in the first and second columns, giving the rates for management and repairs per unit of area over which the channels have to be taken, and per unit of volume of water delivered, are to be taken for comparison.

53. The relative advantages and disadvantages with respect to the cost of maintenance and management of the Godavery delta works and the works proposed for Madura, are about as follow:—

(1.) The Godavery head works are exposed to far greater wear and tear, than will be those of the Perryaar project.

(2.) The cross drainage per acre of area commanded by the channels is as five in the Godavery to three in the Perryaar case.

(3.) In consequence of the greater hydraulic slope of the Madura channels, erosion by current will be greater than in the Godavery channels.

(4.) This greater fall will, on the other hand, give them the advantage in size, number, and aggregate length of channels, which will be considerably less *per unit of area* than is the case in the Godavery delta.

(5.) The numerous tanks required for the Madura irrigation, and which per acre of irrigation cost considerably more to keep in repair than channels for direct irrigation, is a disadvantage.

(6.) The Godavery maintenance has the advantage of water-carriage for its material, and of a slightly lower rate of wages.

(7.) The expensive river works, annually required to keep a deltaic river in its course (the Godavery divides into three such rivers, aggregating 150 miles in length within the Δ below the anicut besides 25 miles above), is an extra and very heavy charge, from which the maintenance of the Madura works will be free.

(8.) In the Godavery the irrigation is charged with the maintenance of the locks (thirty-five in number).

54. A careful consideration of the above shows that the charge for maintenance and repair of the proposed Madura works, should be rather less (rateably for area and volume of water delivered) than the *proper* charge, (after deducting the extra charges for river works and repair of locks) for the same purpose in the Godavery delta. But the annual grants for the repair and maintenance of the Godavery works have during the last few years, been so inadequate, that unless in future they are very largely augmented, the works will get seriously deteriorated in value and usefulness. The Godavery experience can, therefore, be only used as a warning and as giving us a minimum rate (for works of the same kind with similar conditions) which the charge for maintenance, &c., should not be allowed to fall to. I therefore assume that the annual charge for repair and maintenance of the Perryaar irrigation works will be, as stated in paragraph 49, 50,000 Rupees.

55. Of course, the anticipated increase of revenue will not take place immediately after the completion of the works, considering the large extent of ayacut Nunjah, for which at present there is no water, I think that one-fourth of the full profits, or seven per cent., may be expected in the second year, rising to fifteen per cent. in perhaps six or eight years, and subsequently gradually rising to the full amount.

Ability of the ryots in the Madura and Meyloor talooks to bring under cultivation the additional area of paddy, and to pay the estimated increase of land revenue.

The area which will be under the command of the channels is about 375 square-miles; this may be conveniently taken in two blocks: one, which will be the richest, being the tract already partially irrigated by river-channels and tanks, the other, the outside tract noticed in paragraphs 37 and 43. The first contains about 135 square-miles, in which the annual extent of rice *crop* will be raised from about 24,000 acres to 80,000, and the land revenue from 1.45 lacs to 4.75 lacs of Rupees;

56. There need be no doubt about the ability of the ryots to bring under cultivation the additional area, and to pay the additional revenue; the following remarks on this point may be useful.

the second has an area of 240 square-miles, and the proposed works will, it is expected, raise the area of paddy cultivation from 27 to 69,000 acres of *crop*, and the land revenue, from 1½ to 3½ lacs. In the richer tract the land revenue will then be at the rate of about 3,500 Rupees

* Every square-mile within the ring fence the block includes town, topes, dry and wet, uncultivable waste, roads, &c., &c.

† For instance, the tract between the Peruvelli and Wyacondam in the Trichinopoly talook.

per square-mile,* by no means an unprecedented rate for blocks of similar extent. In the Cauvery delta† there are blocks of similar and even considerably greater extent, where the rate per square-mile is as much as 4,000 Rupees.

Taking the whole of the habitable‡ country of the three talooks, Tirumungalum, Madura, and Meyloor, the population is about 400 per square-mile; the population of the 375 miles in the richest and most densely peopled part of the

	Sq. M.
‡ Total area	1,597
Uninhabited mountain and jungles...	397
	1,200
Population...	486,000

district may, I think, be fairly assumed to be at the rate of 450 per square-mile, or 170,000 people, and supposing the full increase of revenue take place so soon as fifteen years hence, and the population to have increased by only 30,000 in that period, the rate per head would be 4½ Rupees.§

§ Land Revenue ...	8½ lacs Rupees.
Population ...	200,000

|| For the year 1865-66.

Land Revenue ...	35 lacs Rupees.
Population ...	700,000

The land revenue|| collected last year in the Godavery delta was at the rate of 5 Rupees per head of its population. From the above it appears that the amount to which it is expected that the Perryaar

works will raise the land revenue in Madura proper, whether considered with reference to extent of country or population will not be more than experience shows may be expected.

(Signed) J. G. RYVES, Captain; R. E.,
Supg. Engr. on Special Duty.

CHINNAMANOR,
7th August 1867.

PERRYAAR PROJECT ESTIMATE.

	Rate.	Amount.	Total.	Total of each work or group of works.
	RS.	RS.	RS.	RS.
1.—Ghaut, 25 feet wide, gradient 1 in 20.				
8,000 Running yard, excavation and formation at 1½ Rupees per running yard ...	1½	10,000		
6 small bridges at 250 Rupees each ...	250	1,500		
Metalling with broken stone ...	3	3,000		
Revetments and contingencies ...		1,500		
Improving road from Chinnamanoor to the foot of the ghaut, 18 miles at per mile ...	500	9,000		
3 small bridges across deep hill streams ...		6,000		
Clearing jungle and levelling tracks through the hills above the ghaut, 10 miles at 500 Rupees + 25 at 100 ...		7,500		
Felling and trimming for transport valuable timber and bamboos within the water spread of the lake ...		6,000		
Carriage of do. to Chinnamanoor 1,500 bandies, 25 miles ...		4,500		
Total for ghaut, roads, and clearing jungle ..			49,000	
Deduct value of timber, 1,500 bandy loads at 25 Rupees ...			37,500	
2.—Cutting through Water-shed.				11,500
227,787 Cubic yards of Rock, 52,133 cubic yard Earth.				
6,100 Miners, months, at per mensem ...	17½	1,06,750		
2,000 Coolies ...	12	24,000		
Total labor in Quarry...			1,30,750	
120,000 lbs. of Gun-powder ...		21,000		
375,000 yards of Match ...		4,688		
15,250 lbs. of Steel ...		7,625		
244,000 lbs. of Iron ...		30,500		
146 months' work of a forge ...	50	7,300		
Total Materials...			71,113	
114 Carpenters, months, at per mensem ...	25	2,850		
1,225 Coolies ...	11	13,475		
968 Waggonmen ...	15	14,520		
3,950 Bullocks ...	12½	49,375		
Total for Transport...		80,220		
Of which ¾rds to be charged to bund, leaving against cutting ...			26,740	
Non-effective 10 per cent., of working strength on ¾ pay = 7½ per 100 on 1,57,490 Rupees ...		11,812		
Hutting at ¾ Rupee per man x month (11,610) ...		8,708		
Maistries and share of Hospital Establishment ...		9,000		
Incidental charges at 2½ per cent., on 2,31,603 Rupees ...		5,750		
Share of estimated cost of plant, tools, and machinery ...		45,238	80,548	
Total estimated cost of the cutting...				3,12,151

PERRYAAR PROJECT ESTIMATE.

	Rate.	Amount.	Total.	Total of each work or group of works.
	RS.	RS.	RS.	RS.
3.—The Escape.				
37,650 cubic feet of cut-stone work in large masses for crests at ...	7/16	26,355		
50,430 " dressed work in faces ...	1/2	25,215		
294,797½ " coursed rubble ...	1/3	98,266		
84,000 " excavation in rock for foundation ...	1/16	8,400		
Incidental charges at 5 per cent. ...		7,912	1,58,236	
Share of cost of plant, tools, machinery ...		5,852		
Total estimated cost of the Escape...			13,764	1,72,000
4.—Bund.				
1,293,018 Cubic yards ... 192,824 cubic yards Puddle, 4,94 cubic yards Stone Wave Screens.				
19,320 Coolies, months, at per mensem ...	10½	2,02,860		
177 Elephants " " " ...	50	8,850		
478 Carpenters " " " ...	25	11,950		
4,780 Coolies " " " ...	11	52,580		
1,260 Waggonmen " " " ...	15	18,900		
3,806 Bullocks " " " ...	13½	50,747		
288 Boats' crews " " " ...	80	23,040		
Total for Earth, Puddle, and building Wave Screens.			3,68,927	
Stone for dam and Wave Screens, &c., 227,787 cubic yards at two-thirds of the cost of transport from cutting = ¾ x 80,220 ...			53,480	
Non-effective 10 per cent of working strength on ¾rds pay = ¾ x 321,141 ...		21,609		
Hutting at ¾ Rupees per man x month = ¾ x 27,905 ...		20,929		
Maistries and Hospital Subordinate Establishment ...		24,000		
Incidental charges, including working Pumps and Syphons ...		13,300		
Share of estimated cost of Tools, plant, and machinery ...		1,93,047	2,72,885	
Total estimated cost of Bund...				6,95,292
Total for the Head Works at the Perryaar...				11,90,943
5.—(Regulating reservoir above the in-fall into the Sooroollyaar ...			80,000	
Remains to Ancients across the Sooroollyaar ...			75,000	1,55,000
6.—Distribution north of the Vigay.				
Excavation of main channels ...		74,718		
Do. of branches ...		23,200		
Total Excavation...			97,918	
Masonry for cross { under Tunnels 63,850 } drainage { Escapes ... 45,000 } ...		1,08,850		
Do. in Sluices ...		32,160		
Do. in Bridges ...		10,800		
Total Masonry...			1,51,750	

PERRYARR PROJECT ESTIMATE.

PERRYARR PROJECT ESTIMATE.					
	Rate.	Amount.	Total.	Total of each work or group of works.	
	RS.	RS.	RS.	RS.	
Purchase of Land and Contingencies...	...		32,261		
Repairing Tanks	...		25,000		
Total Distribution north of the Vigay...				3,06,932	
7.—Distribution south of the Vigay.					
Excavation of main channels	...	21,602			
Do. „ branches	...	28,697	50,299		
Masonry for cross drainage to Escapes	...	7,500			
Do. in Sluices	...	17,430			
Do. in Bridges	...	2,500	37,430		
Purchase of Land and Contingencies... ..	...		8,796		
Total Distribution south of the Vigay...				96,525	
Grand Total of Estimate...				17,49,400	
Add 20 per cent., for a Reserve Fund...				2,50,600	
Total to be assigned for the Project...				21,00,000	

	RS.	RS.
Ghaut roads and clearing Jungle	11,500	
Cutting through the Water-shed... ..	3,12,151	
Masonry Escape	1,72,000	
Bund	6,95,292	11,90,913
Total for the Head-Works at the Perryaar		1,55,000
Regulating reservoir and works on the Soroollyaar		
Distribution { North of the Vigay.	3,06,932	} 4,03,457
..... { South of the Vigay.	96,525	
Estimated cost of the Project...		17,49,400
Add for Reserve Fund...		2,50,600
Total to be assigned for the Project...		21,00,000

CAMP CHINNAMANOOR,
7th August 1867.

(Signed) J. G. RYVES, Captain, R. E.,
Supg. Engr. on Special Duty.

No. 2.

Level of Rock surface.	Length, yards.	Depth, Feet.	Middle width $\times \frac{\text{width}}{2}$	Sides. base $\times \frac{\text{base}}{2}$ $\times \text{height.}$
125	200	1½	300	450
128	850	7½	6,475	48,567½
137	500	14	7,000	98,000
141	50	19	950	18,050
147	375	29	10,875	315,375
160				479,115
165	315	39	12,285	
160	160	30	4,800	144,000
148	50	17½	875	15,812½
134	360	7½	2,790	21,622½
125	60	1	60	60
			46,410	1,140,552

46,410 $\times \frac{1}{2} =$ 206,666

1,140,552 $\times \frac{1}{4} =$ 21,211

Total Rock = 227,877 C. yards.

Top Earth.			
Length, yards.	Width feet.	Depth feet.	$9 \times C.$ yards.
300	20	3	18,000
1,050	25	6	157,500
550	30	6	99,000
375	50	2	37,500
315	45	4	56,700
200	40	6	48,000
500	35	3	52,500
Total Earth =			469,200
			$\times \frac{1}{9}$
			52,133 $\frac{1}{3}$ C. yds.

CAMP CHINNAMANLOOR,
7th August 1867.

Estimate of the Labor, Materials, and Transport for the cutting through Water-shed and Stone dam.																		
Quarry.														Transport.				
Season.	Quantity, cubic yards to be done in the season.	Cubic yards per diem.	Months.	Labor.			Materials.					No. of waggons.	Running yard at one time.	Do. laid and relaid.	Carpenters, &c., months.	Coolies, months.	Waggonmen, months.	Bulletins, months.
				Miners.	Miners months.	Coolies months.	Gunpowder, lbs.	Match, yards.	Steel, lbs.	Iron, lbs.	Forges months.							
1st	47,787	319	3	73	150	200	5,000	7,500	375	6,000	4	0	9,600	40	600	200	750	
				225	1,350	360	25,000	75,000	3,375	54,000	30	56	2,400	10	75	384	1,600	
2nd	90,000	450	8	325	2,600	720	50,000	160,000	6,500	104,000	64	92	10,000	34	300	384	1,600	
3rd	93,000	450	8	250	2,000	720	40,000	132,500	5,000	80,000	48	92	10,000	30	250	384	1,600	
	227,787				6,100	2,000	120,000	375,000	15,250	244,000	146		10,500	114	1,225	968	3,950	

(Signed) J. G. RYVES, Captain, R. E.,

(Signed) J. G. RYVES, Captain, R. E.,
C. S. 1000

Quantity of Masonry, &c., in the Escape.

Drop Walls.

Wing Wall.

Total in Wing Wall	875	24,587
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Total Masonry... 352,877½ Cubic Feet.

Crests of Dropwalls—Best cut-stone work carefully fitted and in large masses	37,650
Faces of do. and front face of wing wall dressed beds and joints in Hydraulic cement	50,430
Remainder—Coursed rubble in mortar.....	294,797½
Trench for foundation 84,000 cubic feet, out of rock.	

Quantities of Earth and Puddle Work in the Bund.

$(1,110 \times 138\frac{1}{2} + 7,520 \times 281\frac{1}{2} + 69,274) \times 10 \dots$	=	30,485,300	
$(36 \times 704 + 90 \times 2,531\frac{1}{2} + 90 \times 4,916\frac{1}{2} + 70 \times 4,916\frac{1}{2}) \dots$	=	993,542	
$1\frac{1}{2} \times \left\{ \begin{array}{l} 75 \times 9,100 + 75 \times 6,100 + 70 \times 3,700 + 65 \times 1,900 \\ + 60 \times 700 \times 40 + 100 \dots \end{array} \right\}$	=	849,603	
Total below the 120 feet level.....		32,328,445	
$(1,110 \times 272\frac{1}{2} + 7,520 \times 5) \times \frac{1}{2} \dots$	=	7,141,575	
$(210 \times 56\frac{1}{2} + 347 \times 59 + 33\frac{1}{2}) \times 10 + 40 \times 35 \times 2 + 45 \times 60 \times 12 + 73 \times 85 \times 22 + 52 \times 110 \times 32 \dots$	=	647,700	
Total above the 120 feet Level ...		7,789,275	
Puddle = $\frac{5}{8} \times 3 \times (17 \times 161^2 + 16 \times 151^2 + \frac{1}{2} \sqrt{c} -) + (1^2 + 1^2 + \sqrt{c})$		40,117,720	
= $\frac{5}{8} \times (3 \times 166,170 + 1,290) = \frac{5}{8} \times 499,800 =$	Puddle...	5,206,250	= 192,824 C. yds.
	Earth...	34,911,470	= 1,293,018 "
Stone wave screens - $(1,280 + 1,240 + 1,240) \times 5 \times 10 = \dots$		188,000	= 6,963 "

No. 4.—(Continued)
Estimate of Labor and Draft for the Earth, Puddle, and Stone Screen Work in the Bund.

ESTIMATE OF LABOR AND DRAFT FOR THE EARTH, PUDDLE, AND STONE SCREEN WORK IN THE DUND.																																									
Season.	Earth, Puddle, or Stone.	Quantity, Cubic yards, in the sea.	Cubic yards per Mouth.	EXCAVATING, LOADING, SPREADING, AND RUNNING.							TRANSPORT TO BUND.																														
				Excavating.	Clearing debris of stones, etc.	Loading.	Unloading, spreading, and leveling.	Masons at 2X Coolies' hire	Men.	Men X months.	Elephants X months.	No. of wagons in use together.	Running yards Railway in use at one time.	Running yards and re-laid Railway laid.	Carpenters X months.	Coolies X months.	Wagon men X months.	Bullocks X months.	Boats' Crews X months.																						
1st	Earth	230,000	1,315	7	165	55	110	80	2X2	414	2,893	23	41	12,500	50	500	160	406	20																						
	Puddle	18,000	144	5	20	..	14	15	..	49	245	4½	6	3,000	12	120	40	55	4																						
	Puddle	32,000	640	2	90	..	64	70	3X2	230	460	8	25	6,000	24	240	40	94	8																						
2nd	Earth	300,000	1,500	8	187	63	125	90	2X2	469	3,752	30	47	15,000	60	600	200	592	51																						
	Puddle	20,000	140	5½	19	..	14	14	..	47	264½	5	7	5,000	20	200	40	70	5																						
	Puddle	30,000	533	5½	75	..	53	54	3X2	188	423	7½	24	6,000	24	240	40	106	8																						
3rd	Earth	335,000	1,675	8	209	70	140	100	2X2	523	4,184	33½	61	18,000	72	720	250	816	50																						
	Puddle	20,000	145	5½	20	..	14	12	..	46	253½	5	8	6,000	24	240	40	82	6																						
	Puddle	27,000	432	2½	60	..	43	43	3X2	152	380	6½	22	6,000	24	240	40	108	8																						
4th	Earth	335,000	1,675	8	209	70	140	96	2X2	519	4,152	33½	71	20,000	80	800	280	1,066	51																						
	Puddle	15,000	112½	5½	15	..	12	8	..	35	186½	3½	7	6,000	24	240	40	69	5																						
	Puddle	25,000	375	2½	50	..	39	23	3X2	123	328	6½	22	6,000	24	240	40	118	8																						
5th	Earth	83,018	415	8	51	17	35	30	4X2	141	1,128	8½	13	10,000	40	400	50	224	50																						
	Puddle	5,824	39	6	5	..	3	3	..	11	66	1½	..	..	..	..	..	..	6																						
	Stone	6,963	70	4	..	..	..	90	30X2	159	600	..	..	..	..	..	..	..	8																						
Total for Earth, Puddle, and Stone-wave-Screens.....				19,320											197											93		12,000		119,500		478		4,780		1,260		3,806		288	

Estimate of cost of Plant, Tools, Machinery, and Buildings.

	RS.	RS.	RS.
<i>Railway Material and Wagons.</i>			
Rails, 57,500 yards of 2½" x ¾" 9 lbs. per yard, 232 tons, at 175 Rupees ...	40,000		
Sleepers, 265,625 Running feet, at 30 Rupees per 100	79,688		
Nails, 23,125 dozens (2½ lbs. per dozen) at 3 dozens per Rupee ...	7,708		
		1,27,996	
Deduct for value after use—			
232 tons of bar iron, at 105 Rupees per ton ...	24,360		
17 tons of nails, at 120 Rupees per ton ...	2,040		
167,083 Running feet of sleepers, at 25 Rupees per 100.	44,246		
		70,646	
Net charge for Railway Material...			
Wagons, 200, at 360 Rupees each ...	72,000		57,350
For maintenance the several parts of 40 wagons, at Rupees 300 per set ...	12,000		
Do. Carpenters' and Smiths' hire ...	4,000	88,000	
Deduct for value after use—			
160 tons of cast-iron, at 90 Rupees per ton ...	14,400		
36 tons of wrought iron, at 120 Rupees per ton ...	4,320		
6,720 Cubic feet teak-wood, at ½ Rupee per cubic foot	3,360		
		22,080	
Net charge for Wagons...			
Boats—sheet iron 10, complete with tackle, &c., at Rupees 3,500 ...	35,000		65,920
Maintenance, at 5 per cent., for 5 years...	8,750	43,750	
Deduct for value after use, at 1,400 Rupees each...	..	14,000	
Net charge for Boats...			
Tools for rock-cutting, tamping charging, and forges.	3,000		29,750
Tools for earth and puddle and rail laying, at ½ Rupee per man, month ...	6,830		
Tools for Carpenters', Smiths' &c., and Shop fittings.	4,500	14,330	
		5,530	8,800
Deduct for value after use ...	..		
Lifting and hauling Tackle.			
6 one-ton Cranes at 600 Rs...	3,600		
3 two do. do. at 900 Rs...	2,700		
1 three do. do. at 1,350 Rs...	1,350		
8 single and double crabs at 200 Rs...	1,600		
5 five-ton do. at 500 Rs...	2,500		
Chain—(400 fms. ½ in., 200 fms. ¾ in.)—Rope (600 fms. 1½ in., 400 fms. 3 in., 200 fms. 4½ in., 100 fms. 6 in.)	2,000		
Sundry—(posts, rollers, beams, &c.)...	750		
		14,000	
Deduct half for value after use ...	..	7,000	
Net charge for lifting and hauling Tackle			
Syphons.—840 ft. 48 in. pipe—210 tons, at £6-10 per ton	13,650		7,000
144 ,, ,, bends 36 ,, ,, £11 do.	3,960		
5 No. Sluice valves, complete, £88 each ...	4,400		
10 ,, filling cupolas do. £12 do. ...	1,200		
Freight and charges from England to Negapatam ...	11,700		
Carriage from Negapatam to the Perryaur.	10,400	45,310	
Deduct value of 260 tons cast iron pipes, at 100 Rs. per ton	..	26,000	
Net charge for Syphons...			
	..	..	19,310

Estimate of cost of Plant, Tools, Machinery, and Buildings.

	RS.	RS.	RS.
Pumps—1 centrifugal (24" x 4½") 10" disch. pipe 24 feet and gearing	3,000		
2 double action Fire Engine pattern with 100 feet tubing	1,500		
Steam Engine 6 H.-P. portable	3,000		
Deduct half for value after use ...	...	7,500	
Net charge for Pumps and Steam Engine...	...	3,750	
Total estimated cost of Plant, Tools, and Machinery..	...	...	3,750
			1,91,880
Buildings.			
Officers' and Overseers' quarters 8,800 Sq. ft. covered.	10,500		
Workshops, Forges, Store-sheds, Sawpits, &c.,	4,500	do.	do...
Barracks for one Company, Sap- pers, and 40 Police... ..	13,500	do.	do...
Hospitals. { 1 for 45 Men } { 1 " 10 Women } { 1 " 25 Convicts }	8,000	do.	do...
Jail for 250 Convicts... ..	10,000	do.	do...
Lines for Maistries and skilled men... ..	3,000	do.	do...
Total for iron roofed buildings...	...	48,200	
Two Powder Magazines, each for 250 barrels...	...	3,000	
Deduct for value of materials, as follows:—			
62,666 Sq. ft. of corrugated iron at ½ Rupee ...	7,833		
19½ tons of cast iron at 75 " ...	1,462		
9½ " of wrought iron at 105 " ...	998		
1,950 C. ft. of teak and vengay at 1 " ...	1,950		
6,000 Sq. ft. of doors and windows at ½ " ...	2,000		
Total deductions...	...	14,243	
Net charge for buildings...	...	...	36,957
Warm clothing at 6 Annas per month for each man = ½ x 40,800 men, month	...	...	15,300
Total for Plant, Tools, Machinery, Buildings, and Warm clothing...	...	...	2,44,137

Of which to be charged to cutting Rupees 45,238
Do. " " Bund " 1,93,047
Do. " " Escape " 5,852

CAMP CHINNAMANOOR,
7th August 1867.

(Signed) J. G. RYVES, Captain, R. E.,
Superintending Engineer, on Special Duty.

A.

Method of working in the Bed of the River.—See Drawings on Sheet No. 6.

The working season in the Perryaar tract will consist of 200 days between the 1st of June and the 15th February, but for work in the bed of the river it would be limited to the period after the north-east monsoon freshes are over, and before the 15th February, besides, perhaps, twenty-five or thirty working days in August and September.

The first season's operations in the bed of the river will be commenced as soon as the north-east monsoon rains having ceased, the river discharge has fallen to about 100,000 cubic yards per hour.

During the previous months of this season the stone-dam (D) in rear will have been well advanced, and will now be at the 32 feet level, but with a clear opening of

45 feet wide left, through which the river will flow with a current of about 5 feet per second or 3½ miles per hour.

* Captain Payne's B. M. on rock at the Mool-
lyaar Junction being =0.

The mean bed of the river at the site for the bund being* 6 feet, the water surface will now be 3 feet. This surface having been raised to + 12 feet by the temporary dam (d) across the 45 feet gap in the stone-dam, the earthen bund (B) will be raised (from boats in almost still-water) till its top is about 4 feet under water; and the current over its top therefore about half a mile per hour. The syphons, of which there will be four each 4 feet D^r will then be filled, and the temporary dam (d) having been removed, the water surface in front of B will fall to the + 8 feet level leaving the top† of the bund dry. The rear bund (b) will then be completed, and the water in the inclosed space pumped out.

In this inclosed space the bottom layers of the puddle lining and of the earth bund will then be carried on, and at the same time the front and rear bunds (B) and (b) and the stone-dam (D) will be raised. When B and b have reached the + 20 feet and + 15 feet levels, two of the syphons will be raised to their corresponding level, and as soon as they are at work will be followed by the other two, and B and b made good across the spot formerly occupied by the syphons.

Thus the work will be gradually raised (except the corner XYZ in Plan which, for the present, must be left open for the water) in layers about 2 feet thick, the two bunds B and b being always 5 to 10 feet higher, and the stone-dam D about 15 feet higher than the work.

By the middle of February, when work will be stopped, the earth and puddle will have reached the + 25 feet level, and the stone-dam, now carried completely across the river, the + 42 feet level.

In this state the water in the bed of the river will be left till work can be commenced again in the next season, the rear bund (b^r) being protected from erosion by a casing of halved bamboos lashed together and loaded on the slopes with stone, the current over (b^r) when a big fresh of 1½ millions cubic yard per hour is flowing down the river, will be only a foot and a half per second or just over one mile per hour and over the crest of the stone dam the water's velocity would, according to my calculations, be about 6½ feet per second. The earth and puddle would not suffer to any serious extent under such a flood, and the stone-dam, though no doubt the stones in its rear slope, would be a good deal disturbed and many of them carried down to the bed of the river in rear, would not, in the few hours that a flood of this magnitude would last, lose any thing to signify in its height.

For nine days out of ten during the six months June to November the whole of stream will pass through, none of it over, the stone-dam (D), so that there will be nothing to prevent steady progress in its construction throughout the whole of the working season; and the earth and puddle work on the north flank of the river will also be carried on during all the two hundred days.

In the second season the operations in the bed of river would be as follows—
(see 2nd Section Sheet No. 6.)

20th Aug.	{ River 150,000 cubic yards Surface + 45 feet.	Commence raising B earth from boats in practically still water.
30th Aug.	{ River 125,000 cubic yards Surface + 40 feet.	Top of B now at + 37 feet finish off with stone faced with clay, and at the same time fix the syphons in their places completely submerged.
5th Sept.	{ River 100,000 cubic yards Surface { + 40½ in front + 34½ in rear.	Syphons now discharging 70,000 cubic yards per hour. 30,000 cubic yards passing over the stone top of B with a velocity of 1 mile per hour.

8th Sept. {River 87,500 cubic yards
Surface { + 40 in front.
 { + 31½ in rear. } The whole stream now taken by the syphons.

Pump out the water in the inclosed space below the 31½ feet level, and go on with the work till the north-east monsoon freshes set in which will prevent any work being carried on in the river from about the middle of October till the end of November, when work will re-commence and go on till the 15th February.

The third section on Sheet No. 6 shows the state of the work as it is expected to be at the commencement and close of the third season.

In the fourth season the bund would be raised to the + 135 feet level throughout after the front of the work has reached the 110 feet level, the ordinary stream of the river will pass over the saddle E and the syphons be no longer required for the bund; they will then be transferred to the escape which (the foundations having been laid and wing-wall completed in the previous seasons) would in this season be raised to the + 115 feet level.

In the fifth season the bund and escape would be completed, and the stone screens built.

The whole might easily be done in four seasons, or indeed in three, if they happened to be moderately dry years; but it will be better to give the great mass of earth below the + 120 feet level time to settle before the top and the stone screens are finished off.

Of course the dates and surface levels given above as corresponding to certain states of the river are only approximations, the best I can make, and I believe, very near the truth, the surface levels depend on the permeability of the stone-dam, if the experience of the first season shows that the water surface on the up-stream side of the dam (D) corresponding to a certain discharge is much higher than I expect, an arched (dry stone) opening (or two, or three if necessary) will be left in the stone-dam at about the 30 feet level to ensure the fall of the river surface to a sufficiently low level on the cessation of freshets in the subsequent seasons.

B.

Table of the average Monthly and Annual Rain-fall at seven stations in the Districts, adjacent to the catchment basins of the Perryaar.

	Cochin, 13 years' average.	Trevan- drum, 10 years' average.	August- ermully, 5 years' average.	Tencan- shee, 10 years' average.	Trimun- galum, 5 years' average.	Madura, 5 years' average.	Meyloor, 5 years' average.	Perryaar catch- ment es- timated.
January ...	·34	·56	6·23	1·75	·13	·10	·70	1·52
February ...	·65	·39	2·28	·87	·13	·50	·72	·96
March ...	1·93	1·91	3·18	2·19	·56	1·12	1·19	1·80
April ...	5·30	5·48	7·41	6·36	3·75	2·92	2·70	4·53
May ...	13·34	8·87	30·66	2·92	2·09	2·82	2·59	9·82
June ...	28·05	11·84	28·64	3·82	·88	2·09	1·47	11·94
July ...	22·47	8·28	30·96	2·48	2·37	2·33	3·97	11·21
August ...	12·77	6·11	21·86	1·93	4·72	6·01	3·80	8·12
September ...	8·48	4·44	16·46	1·06	2·68	4·07	4·55	6·03
October ...	12·63	10·05	26·04	6·93	5·96	9·11	7·76	11·56
November ...	4·32	5·56	15·58	8·66	6·99	9·21	5·93	8·46
December ...	·88	1·52	9·72	2·61	1·32	2·21	2·21	3·03
The year ...	111·16	65·01	199·02	41·05	31·58	42·49	37·59	78·98

7th August 1867.

(Signed) J. G. RYVES, Captain, R. E.,
On Special duty

C. (PERRYAAR PROJECT.)

Table showing the Discharge through the cutting and rise of the Lake surface, corresponding to different states of the river.

Period, days.	Discharge of river into the lake Million Cubic yards.	Outflow through the cutting Million Cubic yards.	Outflow over the escape Million Cubic yards.	Stored in lake above the 133 feet level.	Level of the lake surface.	Rate of inflow per hour, 1,000 cubic yards.	Rate of outflow through cutting, 1,000 cubic yards per hour.	
5	20	18·1		1·9	133	167	151	Dig Fresh.
½	4	2·1		3·8	133½	333	175	
½	6	2·3		7·5	134	500	192	
½	9	3		13·5	135	750	250	
½	12	4		21·5	136½	1,000	333	
½	16	5·6		31·9	138½	1,333	467	
½	12	7·5		36·4	141	1,000	625	
1	10½	14·9		32	142½	437	622	
2	15	23·8		23·2	141	313	496	
3	18	26·2		15	138½	250	364	
6	30	37·4		7·6	136½	208	260	Extraordinary Fresh. Excess above cuttings safe rate of discharge = 17·1 million cubic yards.
½	10	3·1		14·5	135	833	258	
½	18	4·9		27·6	136½	1,500	408	
½	20	7·4		40·2	140	1,666	633	
½	25	10·2	6·2	48·7	143	2,083	850	
½	32	12	16·3	52·4	145	2,667	1,000	
½	40	13·2	23·2	56	145½	3,333	1,100	
1	50	24·7	35	46·3	146½	2,083	1,060	
1	25	20	10·6	40·7	144½	833	833	
3	40	48	·8	31·9	143½	555	666	
4	40	47·8		24·1	141	417	500	
5	36	44·7		15·4	139½	300	375	
6	30	37·8		8·6	137	208	262	
					135			

Table showing the Discharge through the cutting and rise, &c.—(Concluded.)

Period, days.	Discharge of river into the lake Mn. Cubic yards.	Outflow through the cutting Mn. Cubic yards.	Outflow over the escape Mn. Cubic yards.	Stored in lake above the 133 feet level.	Level of the lake surface.	Rate of inflow per hour, 1,000 Cubic yards.	Rate of outflow through cutting, 1,000 Cubic yards per hour.	
$\frac{1}{2}$	9	1.5		15.1	136 $\frac{1}{2}$	1,500	250	Great Flood. Excess above cuttings safe rate of discharge = 35.2 million cubic yards.
$\frac{1}{2}$	15	2.5		27.6	140	2,500	416	
$\frac{1}{2}$	22 $\frac{1}{2}$	4	4	45.7	144 $\frac{1}{8}$	3,667	667	
$\frac{1}{2}$	30	6.4	9.4	59.8	147 $\frac{1}{2}$	5,000	1,067	
$\frac{1}{2}$	40	8	22	69.8	149 $\frac{3}{8}$	6,667	1,333	
$\frac{1}{2}$	45	9.4	31.6	73.8	150	7,500	1,567	
$\frac{1}{2}$	48	10	35.5	76.3	150 $\frac{1}{2}$	8,000	1,667	
$\frac{1}{2}$	44	10.1	35.8	74.4	150 $\frac{3}{8}$	7,333	1,683	
$\frac{1}{2}$	35	9.4	31.4	68.6	149 $\frac{1}{8}$	5,833	1,567	
$\frac{1}{2}$	24	8.2	23.3	61.1	147 $\frac{1}{2}$	4,000	1,367	
$\frac{1}{2}$	15	7	14.6	54.5	146 $\frac{1}{2}$	2,500	1,167	
$\frac{1}{2}$	15	11.5	13.5	44.5	143 $\frac{1}{2}$	1,250	958	
1	15	18.2	3.7	37.6	142 $\frac{3}{8}$	625	758	
3	30	42		25.6	139 $\frac{1}{2}$	417	583	
5	30	43.8		11.8	136 $\frac{1}{2}$	250	365	
7	30	38.6		3.2	133 $\frac{1}{2}$	179	250	
21	75	78.2			133	149	155	

(Signed) J. G. RYVES, Captain, R. E.,
On Special duty.

7th August 1867.

Proceedings of the Madras Government, Public Works Department,
14th November 1867.

No. 279. Read the following letter from the Superintending Engineer of the 1st Division :—
(Here enter 7th August 1867)

No. 280. ORDER THEREON, 14th November 1867, No. 3,521.

IRRIGATION, No. 14.

1. The report now before the Government contains a sketch of the operations which Captain Ryves considers necessary for conveying the waters of the Perriar river to the low lands of Madura.

2. The project is in two sections :—

First.—The construction of a dam across the Perriar to raise the water to such a height, as, with the addition of a moderate amount of cutting through a rocky saddle, to allow of its being turned into the Scoroolly, and thence into the Vigay river.

Second.—The distribution of the supply thus thrown into the Vigay for the irrigation of three talooks in Madura, partly by means of existing channels and tanks, and partly by new channels.

3. Captain Ryves furnishes a tolerably complete account of the present state of the Madura district, of the insufficiency of water for the irrigation of the land under the channels leading from the Vigay, and of the extensive field available to the north of that river for the increase of wet cultivation. No argument seems to be required to prove either that the present supply of water in the Madura district is insufficient for the wants of the people, or that any addition to it would not be eagerly appropriated. It is estimated that a supply may be obtained from the Perriar competent to the irrigation of 149,000 acres of paddy, of which 78,000 acres would be first, and 71,000 second crop, and that the water rate yielded to Government would amount to 6 lacs of Rupees.

4. These figures may be relied on as approximately correct, seeing that they are the result of an intimate knowledge of the Madura district on the part of Captain Ryves. It has then to be decided whether the proposed works are practicable, and if the outlay required for their execution would be remunerative to the extent anticipated by the author of the project.

5. The project, as explained by Captain Ryves, is an old one. The people of Madura have long looked to it as the solution of their difficulties in regard to supplying their fields with water, and the Engineers of the district have been quite alive to its importance. It is only now, however, that it has been submitted in such a comprehensive manner as to allow the Government to form any opinion as to its general soundness.

6. Captain Ryves has conclusively shown that an excellent site can be obtained for the construction of a dam across the Perriar. The width of the river is less than 200 feet at the bed, and the banks rise rapidly to the height of 150 feet and upwards. At the height of 104 feet above the bed, a depression or saddle is available for conversion into an escape. The dam would intercept the drainage of 250 square miles of country which draws a supply from both monsoons. There have been no means of ascertaining with any degree of accuracy what amount of

rain actually falls over this tract, and Captain Ryves had therefore no alternative but to estimate it from the known rain-fall in the adjacent districts. The result he has thus arrived at is that the rain-fall may be estimated at 78.98 inches per annum, as the minimum, and that the average is more likely to be 100 inches.

7. Captain Ryves' estimate of the quantity of water discharged by the river at the site of the proposed work must also necessarily be but a very rough approximation at best. The maximum rate of

Appendix C.

discharge he estimates at 34 millions of cubic yards per hour, or about 25,000 cubic feet per second, which quantity is equivalent to a fall of 3.7 inches of rain in 24 hours over the drainage basin of 250 square miles.

8. At the close of the north-east monsoon the supply falls to 100,000 cubic yards per hour, or 750 cubic feet per second, and a still further diminution must take place with the continuance of dry weather for several months in succession.

9. A knowledge of the actual rain-fall over the drainage in question is doubtless of the highest importance both for a determination of the quantity of water which can confidently be calculated on for the supply of the Madura district, and for the control of the floods of the river during the construction of the dam. It would, however, be difficult if not impossible to ascertain with any high degree of accuracy the amount of rain-fall on the tract comprised within the present project. It can only be judged of by analogy, and the Government, taking into consideration the unfavourable character of the south-west monsoon on the western ghats and the abundant rain-fall along them at all points to which observation has extended, are satisfied that Captain Ryves' estimate of the supply available from the basin of the Perriar for distribution in Madura is extremely moderate.

10. From the site of the proposed dam to the water-shed of the drainages leading to the eastern and western coast the distance is only three and a half miles, and the highest point of the ridge is 165 feet above the bed of the river at the site of the dam.

11. The ridge would have to be cut through, and it becomes a matter of calculation to what height it would be best to raise the dam in order to save cutting, or conversely, to what depth it would be expedient to carry the cutting in order to save height in the dam.

12. Captain Ryves has given the approximate relative cost of dam and cutting at the different levels at which it would be economically practicable to draw off the required supply of water to Madura. As rock is encountered at a short depth below the surface, and as the length of the cutting would increase as the depth increased, there must be a limit beyond which it becomes more economical to raise the water artificially than to continue the excavation of a channel. The details of Captain Ryves' computation of the relative cost of dam and cutting at different levels are not furnished, and before any design could be finally approved by Government they would require a detailed calculation, with a complete record of the levels of the ground, in support of the conclusion arrived at, that one particular level for draining off the supply of water is better than any other that could be proposed.

13. Assuming for the present that Captain Ryves' figures are approximately correct, the Government learn that if the water were drawn off towards Madura at a level of 105 feet above the bed of the river at the site of the dam, or in other words, if a dam of that height, plus the height at which the crest of such a work must be above the water level, were constructed, the cutting through the rock would reach a maximum depth of 75 feet, and would cost upwards of 14 lacs of Rupees, and is computed to occupy fourteen years in execution; while the dam and escape would only cost 4 lacs. The other extreme given by Captain Ryves is at the 155 feet level, which would reduce the cost of cutting to half a lac of Rupees, and swell that of the dam and escape to 13½ lacs. The level selected is at the height of 133 feet above the bed of the river at the dam, which gives a maximum cutting of about 45 feet. The level of 133 feet represents the computed normal water level. The crest of the escape is fixed at the 142½ feet level, or about 40 feet above the lowest point of the saddle adjoining the dam, and the extreme level to which an extraordinary flood is computed to rise would be 7½ feet higher.

14. The proposed dam would thus have to withstand a depth of 150 feet of water. There is no similar work in existence which retains a body of water much exceeding 100 feet in depth, and, considering the difficulties under which it would have to be raised in a tract of

The reservoir of St. Ferréol holds a depth of water of 106 6 feet. country covered with dense forest and elephant grass, and possessing a character for extreme unhealthiness in certain months which would doubtless deter workmen from giving their services, excepting under greatly enhanced rates. Looking also to the stoppage of the work during the unhealthy season, and to other causes of delay which cannot fail to arise, the Government are well aware that nothing short of a well founded conviction of the final success of the undertaking would justify them in supporting it.

15. Captain Ryves has clearly shown that the diversion of the Perriar waters into Madura would be an inestimable boon to the inhabitants of that district, and he has also satisfied the Government that a large outlay might be incurred for this purpose with great advantage to the revenue. What the Government still require is an assurance that the mode of bunding the Perriar proposed by Captain Ryves, and the height which he has determined upon as the most suitable for the delivery of the water across the water-shed, are really the best that can be devised. The construction of a dam to retain 150 feet depth of water is a formidable undertaking. It must be therefore a matter for careful consideration whether security should not be purchased by a larger outlay in the first instance than Captain Ryves contemplates, viz., by a reduction of the height of the dam and an addition to the rock cutting through the water-shed, even though the period occupied in carrying the work to completion may be materially extended in consequence.

16. These papers will therefore be returned to Captain Ryves in order that he may, taking the above remarks into consideration, re-submit his proposal for the construction of the dam. Although Captain Ryves' mode of carrying out that difficult work appears to have been thoroughly considered by him, the Government

*Proceedings of the Madras Government, Public Works Department,
14th November 1867.*

fear that it is too complicated to prove practically successful, and are of opinion that some other manner of procedure which, combining simplicity with rapidity of execution would give a better assurance of a completely satisfactory result, should be adopted.

17. It seems to Government that there would be great danger in allowing any portion of the flood-water of the river to pass over the crest of the dam during its construction, and that the arrangements for conveying the water from the front to the rear of the work while in progress are open to serious objections. Not only would the transport from the coast of the massive portions of the iron syphons which Captain Ryves proposes to make use of be a matter of great difficulty, but the working of them, involving not simply erection in one spot, but removal from a lower to a higher level as the work proceeded, would require the command of a much greater amount of skilled labor than could be counted on. It has further to be observed that, if by any accident, the free discharge of the syphons were checked the water in the pool above the dam would rise and threaten the destruction of the work.

18. As the stone to be obtained from the cutting through the saddle will, it is believed, be for the most part got out in much smaller pieces than will be suitable for the construction of the dam, the expediency of obtaining stone from that source seems doubtful, and it will probably be preferable to procure all that may be required for the dam from the adjoining hills, throwing it in in large masses.

19. The project has not been submitted in the full, detailed, and comprehensive manner in which the Government of India now direct that all schemes requiring their sanction should be laid before them, and Captain Ryves will therefore report at once his views as to the measures that should be taken for completing the necessary surveys and levelling operations, as well as for collecting the additional information that is necessary to enable him to devise and complete the whole of the designs and estimates connected with the project, and to furnish the definite and copious explanations which the Government of India will expect to receive with it.

20. On the receipt of his report, which will be submitted through the Chief Engineer for Irrigation, the Government will endeavour to place at Captain Ryves' disposal for employment in Madura such establishment as may be requisite for the thorough preparation of the data he may require, and on its being ready, His Excellency in Council will authorize his return to Madura to finally put the project into a shape for submission to the Government of India.

21. The Government are determined that this ancient and interesting project on which so much intelligent and courageous labor has been expended by Captain Payne and Captain Ryves, and on which the welfare of a great district of country depends shall be finally and completely sifted. They will devote to it all the amount of inquiry and analysis which may be requisite to put it into the completest shape, in the earnest hope that the result may justify them in submit-

*Proceedings of the Madras Government, Public Works Department,
14th November 1867.*

ing the scheme for the approval of the Government of India supported by the official sanction of those professional advisers whose opinion in a matter of this nature is so indispensable.

(True Extract.)



Colonel, R. E.,

Secretary to Government.

To Captain Ryves, R. E.

To the Superintending Engineer, 8th Division.

„ Controller of Public Works Accounts.

„ Revenue Department.

Exd. S. T. Augustin.

Revenue 1867 ~~W. H. H.~~
No. of Govt. on hand
7. 3123.

Proceedings of the
J. W. H. H. H.

Noted 14th 3 Nov.
Received 15th 1867.

8th 3521.

8th 2731.

Comm. Fed. to the
Revenue Board

18th Nov. 1867.

in & out of the office with on on on 35-21 2000

Passing orders
on Report of the oper-
ations necessary for
conveying the nature of
the Persian river to the
low lands of Chalman

20 2731-18 Nov.

With order &

No. 326-327