

Immigration
Year 1887

(G.O. NO 363-64 P.W.)

(Immigration) dt 9.6.1887

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GOVERNMENT OF MADRAS.

PUBLIC WORKS DEPARTMENT.

9th June 1881, No. 363 I.

Irrigation.

Read the following paper:

No. 21. Report by Major MONTGOMERIE, R.E., on the Coleroon River, dated 14th February 1881.

No. 70 I.

No. 21-A. *Note by the Chief Engineer for Irrigation.*

In June 1880 Major Montgomerie, R.E., was deputed to complete the investigations commenced by Lieutenant Romilly in 1874 as to the capacity of the Coleroon to dispose of the flood waters proposed to be turned into it at the grand anicut, as described in the papers printed in Proceedings of Madras Government, No. 2,116, dated 3rd September 1870.

2. Lieutenant Romilly made a complete survey of the Coleroon and he drew up a report thereon, which will be found in Appendix IX to Major Montgomerie's report. Lieutenant Romilly did all that he was intended to do—i.e., he ascertained the circumstances of the Coleroon and provided most of the data to be used by the more experienced officers under whom he worked. Owing, however, to some discrepancies between the survey and cross sections of the river which might without difficulty have been set right, the information obtained by him was not then turned to account, and, until Major Montgomerie was appointed to complete the long-delayed full examination of the subject required by the letter of the 7th March 1871, No. 81 I., from the Government of India, no officer was available to devote that close attention to the difficult and complex problem the solution of which was desired.

3. Major Montgomerie has arranged all the data available in a manner which admits of its being used, not only for the purpose immediately in view, viz., the settlement of the question of the regulation at the grand anicut of the quantity of flood water to be allowed to traverse the Cauvery and Vennar below this point and of the quantity which may be discharged into the Coleroon, but so as to bring out clearly the material influence of local rainfall draining off the lands south of the Cauvery and north of the Coleroon below the Upper Anicut, on the character and severity of floods in the latter river and throughout the delta. The existence of a considerable amount of local drainage must have been known to the officers who prepared the regulation project, but it must be supposed that they thought the quantities of water due to these to be of little moment compared with those due to the Agunda Cauvery freshes, for the proposals were based only on the fresh levels as registered at the Cauvery dam and on the quantities therefore due to the freshes in the Agunda Cauvery which are there distributed between the Coleroon and the Cauvery. The data then available were materially less extensive and less indicative of the actual circumstances than those which Major Montgomerie has found available, but, had the results then worked out been plotted in diagrams, there can be little doubt but that the importance of the local drainage would have been recognised.

4. Major Montgomerie divides the sources of floods or freshes into two parts termed the upper and the lower valley respectively, the point of division being the upper anicut, and for convenience he has designated the discharge of the Agunda Cauvery in a high fresh a normal flood, while a fresh from above the upper anicut enhanced by local drainage is called an abnormal flood.

5. The information obtained shows that—

(1) The character and behaviour of normal freshes is ascertainable and has been ascertained with all necessary exactness. The quantities and the water levels at all the principal points have been determined, and any questions relating to these can be answered by inspection of the diagrams and tables.

(2) The data for determining the particulars of abnormal freshes of importance, in the past, with even approximate accuracy, are not available. The flood of 1858 was abnormal and was the most severe on record if the flood level at the Cauvery dam which was about 3 inches higher than the great flood of 1818 may be taken as an indication. Of the flood of 1818 no detailed information is to be found. Of that of 1858 the data for estimating quantities are in existence for only a few points and have been made as much use of as was possible. The absence of complete data for abnormal floods is easily explainable. At the upper anicut or Cauvery dam registers of water levels have been maintained for a long series of years, and similarly at the grand anicut, at the other important surplus works, and at the lower anicut the water levels were recorded. On the Agunda Cauvery there was no gauge higher up than that at the upper anicut. On the Coleroon the only points of registration were the upper anicut, the grand anicut, and the lower anicut, or 3 points in 67 miles. Moreover the registers kept were not so detailed anywhere as to admit of the time at which the effects of local drainage began to be felt being ascertained. On the affluents from which the local drainage came there were no registers. All that can be now determined is approximately the maximum discharge at a few points, and the part of this probably due to local drainage, in other words the abnormal factor in the total.

(3) The determination of a probable maximum abnormal flood in the manner requisite to be of use in connection with this discussion is impracticable. It is possible to approximate to the maximum discharge from a given area, but not to that from a certain area with certain other lateral areas over which the rainstorm may pass in a variety of ways, no two of which will produce like results. All that can be said is that the flood of 1858 seems to have been due to a combination of unfavorable circumstances, and that the records of the few years available indicate that it is at least unusual for severe rainstorms to traverse the two sides of the lower valley and the upper valley at the same time, or at such intervals as to produce the most severe results. For 1858 it is not known what the absolute rainfall was. It was recorded in measures the value of which is not now ascertainable. The relative rainfall over

Vide Appendix No. 6.

Portfolio No. 1.

Do. sheets Nos. 2 and 3.

(4) The freshes of the south-west monsoon are normal or nearly so, i.e., they are but little affected by drainage from the lower valley. It is in the north-east monsoon and generally in November that abnormal floods occur. The rainfall is then extremely heavy in parts of the lower valley and also in parts of the upper valley on the left or north side of the Agunda Cauvery.

This rainfall appears to be always cyclonic in character, and it decreases in intensity as the distance from the coast line increases. This seems to be the general rule with exceptions due to local causes such as hills, &c., as in the Iyar Valley in November 1880, when the rainfall was much heavier than would have been expected from its distance from the coast.

(5) The highest normal floods could be disposed of without difficulty by the Coleroon and the Cauvery with its effluents. This will be more fully demonstrated further on, but it may here be mentioned that with 13.3 on the Cauvery dam gauge the total quantity to be disposed of at the head of the Cauvery is ... cubic feet a second 284,000

The Coleroon below the Cauvery present surplus works would dispose of ... cubic feet 230,200

The Cauvery below its surplus works and the Vennar would carry ... cubic feet 53,800

The Coleroon in the abnormal fresh of 1858, in which the Cauvery dam gauge read 13.3 as above conveyed ... cubic feet 285,000

And the Cauvery and Vennar, exclusive of local drainage received by the latter about ... cubic feet 94,600

The total quantity to be disposed of on the meridian of Tanjore was about 400,000 cubic feet a second, of which 284,000 were due to normal and 116,000 to abnormal freshes. Of the latter about 75,000 fell into the Cauvery and Vennar, and only a very small part of this was got rid of by the Cauvery surplus works. For the Vennar there was no possible relief. The water it received had to be carried by it and its branches or spilled over the country. The catchment basin of the Agunda Cauvery (the upper valley) is 27,000 square miles. The basins draining into the Coleroon aggregate just under 1,100 square miles, those into the Cauvery above the Vennar head 868 square miles, and that into the Vennar above Tanjore about 300 square miles. Below Tanjore there is no general drainage into the Vennar. These basins of the lower valley aggregate about 2,270 square miles or say one-twelfth of the upper valley, but the discharge was as 1 to 2.45 nearly.

In 1877 there was a nearly normal fresh of 12.4 on the Cauvery dam gauge. It passed through the delta and did but little damage any-

* Letter, No. 1,464, 7th January 1858, paragraph 3, in Proceedings, Madras Government, 18th March 1868, No. 882.

where. When the Superintending Engineer, Sixth Division, supposed* that the Cauvery and the Vennar with their effluents could dispose safely of only the equivalent of a 10½-feet fresh on the Cauvery dam gauge, he was mistaken as to the quantity represented thereby as entering the Cauvery at that point, for he assumed it to be 109,000 cubic feet a second, whereas the actual discharge is only 78,600 cubic feet, and that due to 12 feet on the gauge is 108,400 cubic feet, of which only 46,900 have to be distributed between the Cauvery and the Vennar, the rest being discharged into the Coleroon by the existing surplus works.

(6) The regulation of the Cauvery at the grand anicut, so far as this means the discharge into the Coleroon of any considerable quantity of water in excess of that which was discharged thence in 1858, is impracticable. The Coleroon, the Cauvery, and the Vennar were all sorely overtaxed in that flood, and, though some slight redistribution might have been possible and beneficial, it is clear that the limitation of the discharge in the Cauvery and Vennar below the regulators to 53,475 cubic feet a second, the quantity to which, by the scheme of 1870, the supply was to be limited, was out of the question. The difference between this quantity and that actually distributed between these two

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rivers would have been about 41,125 cubic feet a second, or more than one-seventh of the discharge of the Coleroon. If moreover the discharge of the Vennár was not to have exceeded 20,175 cubic feet a second, little or no water could have been admitted to this river at its head, seeing that it received from local drainage about this quantity, and the exclusion of its share at the grand anicut would have involved the raising of the discharge of the Coleroon from 285,000 to 346,300 cubic feet a second, a quantity much in excess of its capacity.

(7) The regulation of the discharge of flood water into the Coleroon at the grand anicut and consequently of the water in the Cauvery and Vennár below this point is nevertheless of great importance because though in an extreme flood like that of 1858, accompanied by heavy local drainage, it will not be practicable to do much to prevent excessive discharge in the delta rivers, in floods of less severity the regulators will be of great value as distributors of flood water, and whenever, as in 1880, there is cyclonic rainfall on the south side of the lower valley, the mischief which this is liable to cause may be to a very material extent obviated by shutting off from the Vennár the water coming down from the Agunda Cauvery until the local drainage has been disposed of. In November 1880 the quantity of water in the Vennár might have been reduced one-fourth or one-fifth, and, had this been done, the breaches which occurred would either have been wholly prevented or they would have been slight. The Agunda Cauvery did not reach the maximum level of 11.10 on the Cauvery dam gauge until the evening of the third day after the storm, and when this water came down the Coleroon, having already disposed of its local drainage, would have been able to carry off the water, which was in excess of that which could be conveniently sent down the Vennár. As it was, the Vennár was first breached by local drainage added to the water received from the Cauvery, and then, with a great deal of local drainage still coming in, the uncontrolled admission of its share of the high Agunda Cauvery fresh intensified the damage. Moreover it was shown by Major Oakes that the Vennár cannot be at present adequately supplied with irrigation water until the Cauvery is carrying much more water than is required for the whole delta. The regulators will enable a proper division or distribution to be made at all times. They will not, therefore, be of only occasional value as flood regulators, but will be constantly in use to effect a proper distribution of the irrigation supply. Once in forty or fifty years, or it may be in a century, a flood like that of 1858 will be beyond their capabilities of control, and for this there is no remedy. The rivers generally of the delta must be made as capable as circumstances will permit of disposing of excessive floods, and each must do its own share of this duty. The regulators already constructed at the heads of the principal branches of the Cauvery and Vennár have furnished the means of effecting an approximately suitable distribution of flood waters, as well of the smaller supplies needed for irrigation.

6. To enable the regulation and disposal of flood water (in all but very extreme floods and perhaps partially in these) to be provided for at the Grand Anicut, it will be essential to place the Superintendent in charge of the regulating works in telegraphic or telephonic communication with—

- (1) the Lower Anicut;
- (2) the Vennár-Vetár regulators;
- (3) the Executive Engineer's Office at Tanjore;
- (4) the Upper Anicut.

He will then be in a position to know precisely—

1st, how far the Coleroon can dispose of water in excess of the capacities of the Cauvery and Vennár;

2ndly, what the circumstances of the Vennár may be at the Vetár head and at Tanjore, the lowest point at which drainage of importance is received by the Vennár, and he will know also what to expect from the Agunda Cauvery.

The Executive Engineer will also be able to direct the relief of the Vennár by turning more water into the Vetár should the Vennár be receiving much water from local drainage between the Vetár head and Tanjore.

The following table will serve to illustrate how the Superintendent would proceed to act:—

NORMAL levels of water corresponding to readings on the Cauvery dam gauge (i.e., the levels when there is little or no drainage from the lower valley).

	Readings on Cauvery Dam Gauge Zero of Gauge, 236.16.		Grand Anicut. Crest, 189.11.		Coleroon Gauge near Grand Anicut. Zero 189.53.	Lower Anicut. Crest 51.10 (mean).	
			Upper Gauge.	Lower Gauge.		Upper Gauge.	Lower Gauge.
	FT.	IN.					
	10	0	193.10	189.20	189.60	55.90	53.40
	11	0	193.90	190.60	190.95	57.30	55.30
	12	0	194.85	191.65	191.95	58.75	57.20
	13	0	195.70	192.55	192.80	60.35	59.00
	13	3	196.10	192.80	193.00	60.60	59.30
Abnormal (1858) ...	13	3	202.87	...	197.37	63.10	61.73

• Will be 139.24.

Now supposing the upper gauge grand anicut to read ... 195.70
the Coleroon gauge ... 193.00
the upper gauge lower anicut ... 61.50
the Cauvery dam gauge ... 11.00

the Superintendent would know—1st, that the Cauvery was receiving water from the 868 square miles between the Cauvery dam and Vennár head and that the quantity was approximately 37,600 cubic feet a second; 2nd, that the Coleroon was receiving local drainage from the 1,100 square miles on its north bank and that the quantity was approximately cubic feet a second 72,600. He would have similar information for the Vennár at the Vetár head and at Tanjore, and he would know in each case whether the rivers were falling or rising.

He would have for his guidance fixed maxima which by way of example may be taken to be at the Coleroon gauge pillar ... 196.32
at the lower anicut upper gauge ... 62.50.

and he would not divert water from the Cauvery so as to exceed these limits, which would be somewhat below the levels of 1858. He would further admit to the Cauvery below the regulator anything less than the quantity fixed as the equivalent of the discharge of 1858, if necessary, to prevent the Vennár carrying more water than that of 1858, all which details would be laid down for him. Otherwise he would divide the water to be carried by the Cauvery and Vennár respectively according to their shares which would be tabulated for each foot on the gauge at the Vetár head and on a gauge to be set up at Tanjore. It would not be possible for him to diminish the discharge into the Coleroon by the grand anicut below what would be proper, because that will be a self-regulating work discharging a fixed quantity at each water level unless this be enhanced by the working of the regulators.

7. The only alterations in the design of the regulators for the Cauvery and Vennár found to be necessary are—

- (1) the raising of the bridge roadways from 205.24 to 207.24. The grand anicut bridge was designed to be 207.24, 257 to 259 old datum. and that is high enough.

(2) the modification of the level and arrangement of the shutter platforms to admit of the shutters being raised, if necessary, above future M.F.L., which is calculated to be 200.50 at the upper gauge grand anicut.

8. It is calculated that the alteration of the grand anicut will reduce the F.L. in the Cauvery 2.37 feet, and that the discharge there, instead of a short distance below at the Coviladi and Vadavagudi surplus works, of about 12,000 cubic feet a second, will reduce the F.L. in the Cauvery below the regulator by 1.50 feet or to 199.00. Below Vadavagudi of course in a flood like that of 1858 there will be no material alteration of F.L.

9. Major Montgomerie has recommended the removal of the grand anicut and the construction in lieu of it of a regulator like that to be constructed for the Cauvery and Vennár.

This surplus work is, however, very efficient as is shown by the way in which it has hitherto disposed of vast quantities of flood water, and, as it withstood the greatest flood on record without injury, it must be, whatever the details of its internal construction, a fairly sound work. When the arches have been raised five feet as intended, it will discharge the maximum required, viz., about 85,000 cubic feet a second, with a smaller head than heretofore and therefore with less strain. It has a set of under-sluiques, and though, were a new work to be constructed, it would be desirable to increase materially the waterway at a low level, i.e., at or below the level of the Cauvery bed, and to place it in a different position, viz., nearly at right angles to the direction of discharge, these improvements are not so essential as to make it necessary to abandon this large and powerful weir. Were it necessary that it should discharge 130,000 cubic feet a second, as mentioned by Major Montgomerie, a new work would have to be built, but even he does not suppose that it and the two smaller surplus works below have ever discharged more than 93,500 cubic feet, and as designed it could, if necessary, discharge 100,000 cubic feet with an increase of 0.90 feet to the head or with the M.F.L. raised to 201.40, which would still be 1.47 feet lower than the F.L. of 1858. Should more under-sluiques be hereafter found desirable, they can be introduced into the present work with no more difficulty than was experienced in building those now in use.

10. In paragraph 35 of his report Major Montgomerie has given an estimate of the quantity of flood water which has to be disposed of in 1858 and of its distribution. There is one item in the statement, viz., the drainage from the 868 square miles between the head of the Cauvery and that (present) of the Vennár, which is considered to be excessive—1st, because the discharge attributed to the area mentioned is greater than was probable; 2ndly, because this basin being to the eastward of the country from which the maximum discharge in the Agunda Cauvery was derived, whatever the maximum was, it would have passed before the Agunda Cauvery reached its maximum. Taking these circumstances into consideration, and accepting this officer's estimate of the quantities in the Coleroon and Cauvery respectively, it is believed that the following figures afford a closer approximation to the actuals of that flood: all quantities are in cubic feet a second.

Agunda Cauvery	...	...	...	284,000	
At head of Seringham island	...	...	...	Cauvery.	Coleroon.
Surplused at 150 yards calingulah	...	...	...	135,000	149,000
	...	...	...	10,000	10,000
Local drainage from 868 square miles	...	...	...	125,000	150,000
At Vennár head	...	...	...	54,600	...
Discharge by Grand Anicut Coviladi and Vadavagudi weirs	...	...	...	179,600	159,000
Below the surplus works	...	...	...	85,000	85,000
Local drainage from 1,100 square miles	...	...	...	94,600	214,000
	...	...	...	...	41,000
	...	...	...	94,600	285,000

The Cauvery discharge was then divided somewhat thus:

	Cauvery.	Vennár.
	60,200	34,400
	...	20,600
Local drainage from 300 square miles...	...	...
	60,200	55,000

It of course does not follow that the quantities shown as due to local drainage from the basins of the lower valley were the greatest discharges from the areas named. All that is advanced is that they were probably the maxima at the time the freshes due to Agunda Cauvery water were at their highest. There was a case point in November 1880. The Vennár a short distance east of Tanjore had a high flood on the 22nd due to local drainage chiefly, and again on the 25th due partly to local drainage and partly to Agunda Cauvery water. The water levels were about the same on both occasions, and, as the quantity due to the Agunda Cauvery is approximately known, the difference between the maximum and subsequent quantities of local drainage is deducible. On the 22nd the discharge was about 31,400 cubic feet a second, of which 26,730 were due to local drainage. On the 25th 17,060 were due to local drainage and the rest to water coming from above the Vennár head.

11. All severe abnormal freshes are caused by rainstorms passing from the eastward to the west. Therefore the lower valley gets the rain before the upper valley and the drainage from the former is at its maximum before the Agunda Cauvery freshes can attain a maximum and travel down to the points in the delta at which the lower valley drainage falls in. This consideration negatives the supposition that the total quantity to be disposed of at one time can be anything like as much as that shown in Appendix 1 to Major Montgomerie's report, viz., 649,223 cubic feet a second. Probably it did not exceed in 1858 somewhat less than two-thirds* of that quantity.

12. Major Montgomerie's estimate of the maximum flood discharges from the basins of the lower valley are based chiefly on the evidence of the quantity draining off the country to the north of the Coleroon between the upper and the lower anicuts, as shown by the discharge over the lower anicut in November 1871, when little or no water was being received by the Coleroon either at the upper anicut or at the Cauvery surplus works. The deduction from the registered water level is indisputable, and all that can be said is that it needs confirmation from other observations. The co-efficient in Ryves' formula for the discharge found is nearly 1,220, while that deduced from an apparently equally heavy rainfall over the area draining into the Vennár in November 1880 is about 670. There is evidence in the damage sustained by the Weyacandan channel near Tripinopoly in 1858 that the flood from part of the basin of 868 square miles above Vennár head was very severe, but hardly that it was of such severity as would result from a co-efficient of 1,200. The valley of the Vennár adjoins the basins which discharge into the Coleroon, and in November 1871 there was a high fresh which was the highest on record prior to that of November 1880, but the co-efficient in the later year did not exceed 600 for the basin of 2,850 square miles above Shatiatope, and for the upper part of the valley 1,600 square miles, where the rainstorm of 1880 was particularly severe, the co-efficient deduced is 621. The highest co-efficient yet met with elsewhere is that for the Tambraparni, the fresh of 1877 at Srivakuntham Anicut, from 1750 square miles, giving a co-efficient of 847, and, as there was some spill on both sides of the river, the actual co-efficient may have been somewhat higher. This river is noted for the severity of its floods, and in the year named many tanks breached and poured their contents into it.

Altogether then, even were the evidence in support of the discharge of the Coleroon in 1871 capable of complete demonstration instead of being dependent upon a single set of entries in the register kept at the anicut, it would not be safe to generalise from this one occurrence and to assume that the maximum discharge from the basins of the lower valley generally may be based thereupon.

13. The following table compares Major Montgomerie's calculations of the discharge of the Cauvery with those which were made in 1866* and used in 1870 in connection with the proposed regulation of the Cauvery:—

Readings on Cauvery Dam Gauge.	MAJOR MONTGOMERIE.		AS CALCULATED IN 1866.	
	Discharges		Discharges	
	At Dam.	Below Sur- plus Works.	At Dam.	Below Sur- plus Works.
FT. IN.	CUBIC FEET A SECOND.	CUBIC FEET A SECOND.	CUBIC FEET A SECOND.	CUBIC FEET A SECOND.
5 0	8,150	8,150	14,340	14,340
5 6	12,100	12,100	19,778	19,695
6 0	16,500	16,050	25,200	24,300
6 6	21,500	19,500	31,613	27,165
7 0	27,230	22,730	38,010	31,192
8 0	33,600	26,650	52,890	37,155
9 0	54,200	31,700	69,900	41,812
10 0	70,000	36,200	88,875	47,040
11 0	87,800	40,900	109,163	53,415
12 0	108,400	46,900	133,122	66,822
13 0	130,200	52,800	...	...
13 3	135,000	53,800	...	...

N.B.—The quantities entered in the column "below surplus works" are distributed between the Cauvery and the Vennar.

The above are the quantities due to normal freshes or those unaffected by local drainage from lower valley. The calculations of 1866 were based on the formula

Appendix A to Captain Mead's Report.—Proceedings of Madras Government, No. 75, 14th March 1867.

$V = 93.3 \sqrt{r.s.}$, which is now known to be incorrect except at much greater hydraulic mean depths than are met with in these rivers. Major Montgomerie's figures have been obtained by Kutler's formula which is that best suited to determine river discharges. The quantities are probably fairly accurate, as the depths and corresponding discharges, when there are more than 5 feet of water in the Cauvery, are close approximations to the proportions obtained from the equation to the parabola. When the river is lower than 5 feet on the dam gauge the irregularities of its bed make the discharges less than the normal. Major Montgomerie has noticed that his calculations show that when the delta has been supposed to be receiving a full supply of water the irrigation has been very indifferently supplied if the quantities used elsewhere be taken as a guide. What has, by local officers in the past, been called the theoretical full supply was 20 cubic yards per veli per hour, equivalent to, in round numbers, 3 cubic yards per acre per hour, or 1 cubic foot a second for 44 acres. The area of irrigation being 822,000 acres, it would follow that 18,682 cubic feet a second would be needed, and this was supposed to be provided with rather less than $5\frac{1}{2}$ feet on the dam gauge though, owing to material inequality of distribution, the Cauvery was well supplied with just under 5 feet on the gauge, and the Vennar not until the reading was 6.4 feet. The revised

calculations indicate that with 5.7 feet on the gauge enough water passes down to afford 1 cubic foot a second for every 66 acres were the Vennar to get its fair share as it will do when its head has been shifted to the grand anicut, and no doubt, as elsewhere, this quantity is sufficient. So far as irrigation water is concerned, the new calculations only show that the quantity of water experimentally known to be sufficient is much less than had been supposed.

14. The effect of the investigations as to the influence of local drainage will be to make it necessary to retain a greater width of waterway in all the rivers of the delta than would have been requisite had the proposals of 1870 been feasible, e.g., the proper normal width for the Cauvery between the grand anicut and the Kodamurti head will be 900 feet. This width was fixed temporarily pending the construction of the regulators, and it will now be the proper width to retain permanently. Some parts are considerably narrower, but generally, except where reformed above the head of the Kodamurti, it is considerably wider.

The following table for the Vennar, in which the entries from Major Oakes' tables have been taken from Proceedings of Madras Government, No. 1,144, dated 29th April 1870, will give a tolerably complete idea of the difference between the requirements as formerly and now determined. It cannot of course at present be concluded that the distribution of flood water will be exactly in the proportions settled by Major Oakes. This will have to be arranged on a more complete examination of the capacities of the several rivers, which examination did not fall within the limits of the investigations undertaken by Major Montgomerie:—

Conditions.	DISTRIBUTION IN CUBIC FEET A SECOND.											
	Vennar.	Vennar.	Vennar.	Korayar.	Pannaiyar.	Small off-takes	Vennar.	Pannaiyar.	Small off-takes	Vennar.	Velliyar.	Small off-takes
12 feet on Cauvery dam gauge	24,676	9,378	15,298	4,680	2,202	1,536	6,880	3,595	405	2,830	1,061	14
Percentages ..	100	38	62	31	14	10	45	55	1	44	37	63
Maximum with Cauvery regulated ..	19,004	7,602	11,402	3,355	1,579	1,634	4,934	1,570	482	2,582	950	14
Percentages ..	100	40	60	30	14	12	43	38	10	52	37	63
13.3 on Cauvery dam gauge ..	*27,500											
Local drainage above Vennar head ..	7,500	(vide para. 24 of Supp. Engr.'s letter in Procs., Madras Govt., No. 417, 20th Feb. 1874.										
Local drainage between Vennar head and Vetar, 200 square miles ..	*10,260											
Percentages ..	45,260	17,200	28,060									
Local drainage below Vetar head, 100 square miles ..			*6,460									
Percentages ..			34,520	10,700	4,833	3,452	15,535	8,544	156	6,835	2,529	35
			100	31	14	10	45	55	1	44	37	63

* Cauvery normal 125,000, of which 22 per cent. to Vennar.

Local drainage 54,600 do. do. but with one-third run off before Cauvery attains its maximum.

† It is supposed that the discharge from these drainages will have been reduced one-half by the time the Cauvery fresh has attained its maximum.

The above figures differ slightly from those deduced in paragraph 10 above as the probable total quantity carried by the Vennar in 1858, but the difference between 51,720 and 55,000 cubic feet a second is not important and results from the former having been estimated in greater detail.

15. In paragraph 12 of his report Major Montgomerie refers to an evident deterioration of those rivers of the delta which act as outlets for the flood waters. So far as is known there is no evidence one way or the other, and it may be added that no conclusive evidence is obtainable because there are no sections of these rivers, which are the lower parts of the numerous branches of the Cauvery and Vennár, for any period prior to or near the year 1858. Investigations which will have to be made in due course will show how far the rivers can carry or can be made capable of carrying off such quantities of flood water as had to be disposed of in 1858, but there are no flood levels at different parts of the delta on record to show what the exact circumstances of the rivers then were. All that is known is that the inundations were very extensive and the damage sustained great, from which it may be inferred that their capacities for the disposal of the flood water then traversing the delta were very inadequate. It may perhaps be concluded that it is not likely to be practicable to make or, even if this be possible, to keep these rivers in a condition suitable to dispose of a flood of great severity occurring once in 40 or 50 years, or it may be in a far short of the demand made upon them at such times. If, however, the flood waters can be carried in safety through the delta to some 15 or 20 miles to the eastward of Tanjore, they will then be so far sub-divided as to make the inundations resulting from spill or breaches in the embankments of much less consequence than would be the case were all control lost, as in 1858 much higher up the delta.

16. Seeing by how much the quantities to be dealt with altogether differ from those given in 1870, the answers which can be given to certain questions asked in the letter from the Government of India are perhaps of little importance apart from the connected circumstances. It may be, however, convenient to give them.

The 1½ millions referred to in paragraph 9 were included in the 26 millions of cubic yards. The point of discharge was alone to be altered, making it slightly higher up the Cauvery, viz., at the grand anicut.

Paragraph 10.—The maximum discharge, or that in the highest known fresh of 13.3, is found to be 284,000 cubic feet a second, or 37.867 millions of cubic yards per hour.

The difference between this and 7.13 millions would be 30.73 millions, or 230,530 cubic feet a second. The Coleroon now carries 230,200 cubic feet in a normal fresh of 13.3 feet on Cauvery dam and it carried 244,000 exclusive of local drainage from the country on the north bank, or 285,000 cubic feet inclusive of that drainage in 1858. Were the off-takes of the Cauvery and Vennár at the grand anicut to be absolutely limited to 7.13 millions of cubic yards, or 50,475 cubic feet, the Coleroon might have to carry 44,125 cubic feet additional, and this it could not do at all events while the differences in the waterway are as considerable as at present. So far as ordinary conservancy operations will secure this, and, if steadily persevered with, they may be expected to effect it, the Coleroon should be made capable of carrying 250,000 cubic feet without strain and perhaps 300,000 on emergency.

Paragraph 11.—The lower anicut could not discharge more than in 1858 without serious risk of damage. In that year the water on the upper gauge was about 2 feet higher than is safe with the arches at their present level. The present length is 2,116 feet. The island between the two branches is 1,285 feet in width, so it would be possible to add 60 per cent. to the capacity of discharge of this weir.

It discharged something under 260,000 cubic feet in 1858.

17. With regard to paragraph 15 of the same letter from the Government of India, it is considered that, as the depth of water to be retained ordinarily by the shutters on the crest of the grand anicut is small, the inexpensive kind of shutters proposed in 1870 will be easily manageable, and it is not necessary to substitute the much more expensive shutters in use on some of the weirs in Cuttack and Midnapoor. The grand anicut is a surplus work, and the circumstances are somewhat different from those of a weir across a river. One modification will be, however, made, viz., the

omission of the horizontal bar for disengaging the hinged shutters, which bar might catch drift and rubbish, and the substitution of a single strut hinged at the lower end and secured at the upper end by a simple locking arrangement which will be released by a small chain to the bridge roadway. As regards the shutters for the regulators, those of the same kind in other regulators are found to work easily without rollers, and probably with 10 feet vents are cheaper than would be larger vents with rolling shutters. The arrangements for working the shutters have, however, been altered to suit the altered conditions as now determined and to admit of the Cauvery and Vennár taking off their full shares of extreme floods when the Coleroon discharge cannot safely be increased.

18. The general conclusions arrived at as a result of the investigations made by Major Montgomerie are—

1st, that the need of regulation of the distribution of irrigation water to the Cauvery and Vennár respectively has been brought out more clearly. The regulators will increase the time during which the delta will be sufficiently supplied by nearly two months, and, as the area interested in the improvement is nearly half that of the total of the delta, or more than 390,000 acres, the importance of the regulating works from this point of view alone is great.

2ndly, that except in abnormally great floods like that of 1858 the value of the regulators for the distribution of flood water will be great, but that the details of the regulation at any given time must be based upon information then obtained as to the water levels in the Coleroon and Vennár.

3rdly, that in an abnormal flood of the severity of that of 1858, but little, if any, relief can be afforded to the delta unless and until—(1) the inequalities in the discharging capacity of the Coleroon are remedied by steadily-continued conservancy operations, having for their object the removal of obstructions now curtailing the waterway of certain parts of this river, and the establishment throughout of normal widths of waterway, proportioned to the requirements, as regards discharge of each part. Below the infall of the last of the land drainages to the lower anicut, a maximum discharge of 260,000 cubic feet for the present and ultimately of 300,000 cubic feet a second should be arranged for. The reformation must be gradually carried out, but it should be continually in progress during the proper season, and care must be taken to secure and maintain the work done up to any given date; (2) the waterway of the lower anicut has been increased; this could be secured by raising the bridge over it, for it is the low level of the bridge which limits the discharging capacity, or by extending the weir across the island, and the relative merits of the two arrangements should be worked out. Apart from the question of the regulation of the Cauvery at the grand anicut it is evidently desirable that there should be a greater margin above F.L. than is the case at present;*

* F.L. 1858	...	63.10
Soffit of arches, south branch	...	63.50
Roadway (about)	...	65.50
Top of parapet	...	68.43

a third way in which more waterway could be obtained would be by lowering the crest wall and using shutters to retain water at the level of the present crest; with however more reliable alternatives, it will be better to adopt one of these unless shutters should be found to be much less expensive with equivalent results.

4thly, that in carrying on the ordinary river conservancy operations in the delta the normal widths of waterway of the several parts of the many rivers by which flood waters are carried to the sea must be based upon the quantities now ascertained as needing disposal. A table of normal widths at each mile for each river should be compiled as soon as the best distribution of the maximum flood discharge has been arrived at.

5thly, that a minimum width between the flood banks of each river will also have to be fixed, and the present flood banks must be retired where found to be too close together.

19. There are some matters noticed in the concluding remarks of Major Montgomerie's report which require brief notice here, though they are for the most part connected rather with the general efficiency of the delta irrigation than with the question of the regulation of the Cauvery at the grand anicut.

(1) *Construction of reservoirs to extend the duration of moderate freshes.*—The subject has engaged attention during many years, and, but for the inability of the Public Works Department to find officers for this special duty, the question whether at all or at any reasonable cost a material proportion of the discharge of the Cauvery and its tributaries when in excess of the current demand for irrigation can be impounded would have been settled long ago. It is thought that the feasibility of forming a reservoir on the Bhowani, referred to in paragraph 70 of the report, has not by any means been as yet established, but further investigation should be made as soon as may be practicable.

(2) *Changes in the river beds (Report paragraph 77).*—Much importance need not attach to the local deposit of sand above the upper anicut. Major Montgomerie thinks that it forms a bank from which 2 or 3 feet of sand are poured into the open head of the Cauvery, but really the presence of the sand above the anicut, which is practically a fixed deposit, indicates that it is not from this source that the sand which enters the Cauvery is derived. As the freshes in the Agunda Cauvery rise and fall, more or less sand is under transport, and the sand deposited there being little when the water is deep and the velocity considerable and much when the circumstances are reversed. That this is the case Major Montgomerie has himself shown. That the upper anicut has diminished the quantity of sand which formerly passed into the Coleroon at that point is certain, but the state of the beds of the Coleroon and Cauvery 4 miles below that anicut indicates that in some 45 years no material change has taken place; and, since the water distribution in heads of the principal branches of the Cauvery and Vennar, no inconvenience from sand in the lower parts of the rivers has been brought to notice. So long as these heads were unregulated, the water-supply to the rivers having a smaller fall than their pairs was necessarily very indifferent, and the regulators have remedied this; while much sand, which would have otherwise remained in the rivers having a comparatively small fall, has been passed on to the sea.

CHEPAUK,
8th April 1881.

(Signed) JOHN MULLINS, Col., R.E.,
Chief Engineer for Irrigation.

STATEMENT showing the Estimates for the Head Sluices for the Cauvery and the Vennar Rivers and the Lock and Basin at Head separately.

Description of Charges.	Rate.	Per.	CAUVERY HEAD SLUICE.		VENNAR HEAD SLUICE.		LOCK AND BASIN.		TOTAL.	
			Quantity.	Amount.	Quantity.	Amount.	Quantity.	Amount.	Quantity.	Amount.
Brick in chunam ..	Rs. 0 2 6	C. ft.	258,985	46,716 6 6	235,865	36,853 14 6	81,244 1/2	12,694 6 9	616,094 1/2	96,264 11 9
Cut stone ..	1 0 0	Do.	36,723 1/2	36,723 4 0	27,868 1/2	27,868 10 0	3,701 1/2	3,701 10 0	68,386 1/2	68,386 8 0
Rough stone in chunam ..	0 6 0	Do.	22,045	8,266 14 0	17,374	6,516 4 0	..	..	39,419	14,782 2 0
Rough stone packed ..	3 8 0	C. yd.	5,003	17,507 0 0	4,632	16,212 0 0	366	1,281 0 0	10,000	35,000 0 0
Plastering ..	3 8 0	Sq. yd.	499	1,225 0 0	385	862 8 0	175	437 8 0	1,050	2,625 0 0
Excavation and filling ..	0 3 0	C. yd.	22,096	4,143 0 0	22,870	4,285 2 0	6,486	1,216 2 0	51,453	9,647 4 0
Making road ..	0 2 0	Do.	7,896	986 14 0	7,627 1/2	940 15 0	13,086 1/2	1,635 13 4	28,509 1/2	3,563 10 4
Graveling ..	1 0 0	Do.	289	289 0 0	227	227 0 0	581 1/2	581 0 2	1,097 1/2	1,097 0 2
Baling ..	2 4 0	Sqr. yd.	4,967 1/2	11,776 14 0	6,730	8,505 0 0	1,828	2,988 0 0	10,576 1/2	22,669 14 0
Iron girders ..	0 2 3	lb.	66,910 2	9,409 3 11	52,572 8	7,392 15 8	..	..	119,482 1/2	16,802 3 7
Teakwood shutters ..	4 0 0	C. ft.	1,785	7,140 0 0	1,403 1/2	6,610 0 0	1,801	643 8 0	3,948 1/2	13,353 8 0
Perrick with winch stays ..	750 0 0	Each.	..	..	..	..	..	..	1	750 0 0
Pair of lock gates 17 1/2 ft. high ..	1,575 0 0	Pair.	..	..	..	..	..	..	1	1,575 0 0
Do. do. 16 ft. ..	1,500 0 0	Pair.	..	..	..	..	..	..	1	1,500 0 0
Teakwood posts and rails ..	1 8 0	R. ft.	159	238 8 0	159	238 8 0	..	..	318	477 0 0
Embankments to protect work while under execution ..	..	..	..	3,650 0 0	..	3,650 0 0	..	..	..	7,300 0 0
Sundries and contingencies ..	..	..	..	11,522 15 7	..	9,537 2 10	..	2,155 15 9	..	23,256 2 2
Total ..	..	..	..	1,59,000 0 0	..	1,28,890 0 0	..	31,200 0 0	..	3,19,090 0 0

CAUVERY DELTA SYSTEM.

CLASSIFIED ABSTRACT of the Estimates for constructing Works for the regulation of the Cauvery and its Branches in the Tanjore District.

Sub-heads.	Names of Works.	Amount of individual Estimates.	Total of each Sub-head.	Total.	Remarks.
1	2	3	4	5	6
	(1) HEAD WORKS.	RS.	RS.	RS.	
C. Works ...	Grand anicut alterations ...	50,600			
	Dam at Vennar head do. ...	11,060			
K. Buildings...	Executive Engineer's bungalow, office and godown. ...	4,360	61,660		
	Superintendent's quarters ...	3,130			
	(2) MAIN CANALS AND BRANCHES.		7,498	69,150	
	Cauvery.				
D. Regulators.	Head sluice ...	1,59,000			
	Screw gearing ...	6,720			
I. Navigation Works.	Lock and basin ...	31,200	1,65,720		
	Lock shed and store ...	770			
K. Buildings...	Shutter shed ...	R.B. 1,610	31,970		
	Do. ...	L.B. 1,780			
	Vennar New Head.		3,390		
B. Land ...	Compensation for land ...	29,100		2,42,080	
D. Regulators.	Head sluice ...	1,28,890	29,100		
	Screw gearing ...	5,280			
F. Other cross (1) drainage works.	Under tunnel ...	R.B. 11,020	1,34,170		
	Tunnel, 2 feet span ...	L.B. 1,230			
K. Buildings...	Shutter shed ...	L.B. 980	12,250		
	Do. ...	R.B. 1,780			
L. Earthwork...	Excavation ...	51,090	2,760		
	Revetment ...	R.B. 17,800			
			68,890		
	Total, (2) Main Canals and Branches.			2,47,170	
	(3) DISTRIBUTARIES.			4,48,250	
	Vennar New Head, Pillay Voikal.				
C. Works ...	Head sluice ...	2,450			
	Sluice ...	410			
			2,860		
	Total for Works ...			2,860	
	Establishment at 25 per cent. ...			5,20,260	
	Tools and Plant at about 5 per cent. ...			1,30,065	
				26,175	
	Total, Direct Charges ...			6,76,500	

CLASSIFIED ABSTRACT of the Estimates for constructing Works for the regulation of the Cauvery and its Branches in the Tanjore District—cont.

Sub-heads.	Names of Works.	Amount of individual Estimates.	Total of each Sub-head.	Total.	Remarks.
1	2	3	4	5	6
	(3) DISTRIBUTARIES—cont.	RS.	RS.	RS.	
	Indirect Charges.				
	Capitalized abatement of land-revenue.			36,375	An approximation arrived at by dividing the amount for compensation for land by 20 to find the annual revenue lost and then capitalizing it (25 times the revenue).
	Leave and pension allowances...			27,639	25 per cent. on the amount for salaries, which is 85 per cent. on the establishment charges.
	Loss by exchange ...				
	Interest during construction ...			60,352	Assuming that the works will be completed in 6 years, the probable outlay being taken as 1,20,260 for the first year and 1,00,000 for each of the subsequent years.
	Total, Indirect Charges ...			1,24,366	
	Total, Direct and Indirect Charges.			8,00,866	

No. 71 I.

No. 21-B. Note by the Acting Chief Engineer for Irrigation.

THE above note was written by Colonel Mullins and left in the office with instructions that when the estimates were received from the Government of India the alterations he proposed should be made before submitting the papers.

2. The estimates have been received and it will take some little time to make the necessary drawings and recast the estimates, but it appears that by a reduction in the masonry and more extended use of concrete than provided for in the original plans, the amount of the estimates will be very slightly altered.

3. As the designs, which are now to be very slightly altered, have been before the Government of India since 1870, it seems desirable, to save delay, to submit the papers at once for consideration of the Government of India leaving the revised estimates to be forwarded when completed.

OOTACAMUND, (Signed) J. O. HASTED, Lieut.-Col., R.E.,
11th May 1881. Acting Chief Engineer for Irrigation.

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

No. 22. ORDER THEREON, 9th June 1881, No. 363 I.

ORDERED that the foregoing papers be submitted to the Government of India with reference to letter from the Officiating Deputy Secretary to the Government of India, No. 81 I, dated 7th March 1871.

2. The plans and estimates which require revision will follow as soon as possible, it being understood that the revised estimate will not differ materially, as regards the amount required for works, from the abstract estimate now forwarded.

(True Extract.)

Ag. Joint Secy. to Govt., P.W.D.,
Irrigation Branch.

To the Chief Engineer for Irrigation.

Exd. J. W. Fischer and E. C. Shunker.
Spare Copies

IRRIGATION.

Genl. of 1881

PUBLIC WORKS.

NOTIFICATION ON RIVER REGULATION.

JUNE

1881

Colony of 1881
Landed to the Government

Appendix to G.O., No. 203 I., dated 6th March 1882.

TRICHINOPOLY,
14th February 1881.

From

Major P. MONTGOMERIE, R.E.,
Executive Engineer, on Special Duty,

To

Colonel JOHN MULLINS, R.E.,
Chief Engineer for Irrigation, Madras.

SIR,—With reference to the Notification in the *Fort St. George Gazette*, No. 50, dated 23rd June 1880, making my services available for special duty in the Tanjore District, and in accordance with your memorandum, No. 26 T.J., dated 30th idem, and

• Report with accompaniments as per annexed statement.

your previous orders, I have the honor to submit my report* on the Coleroon River and its capabilities of relieving the Cauvery Delta of flood waters.

2. As an investigation into the capabilities of so important an affluent of the Cauvery as the Coleroon necessarily embraces the requirements and circumstances of the whole Delta System, the accompaniments to my report are somewhat more numerous than I had anticipated; and, as the facts and data which have become available during the past decade are at variance on some points with the opinions previously expressed by Engineers of very great local experience in the Tanjore District, I have naturally been diffident in submitting the bare facts without some explanations, more especially as these opinions had evidently been accepted by Engineers so eminently practical as the late Colonels Anderson and Orr, and I believe by yourself also to some extent.

3. The extra data which accompanies this report is intended to supplement, and it is hoped will complete, the very valuable information recorded in the Orders of Government marginally noted, the compilation of which must have necessitated great labor and research on the part of the local Engineers. And, should the information now placed before Government be sufficient to enable a practical decision to be arrived at on the complicated subject of the regulation of the waters of the Cauvery, the object of this report will have been attained.

4. As suggested in your memorandum, No. III.-10 T.J., dated 24th May 1880, the working capacity of the Coleroon, or the maximum quantity which it may be called upon to carry, has been taken at a little more than what actually passed into it during the great flood of November 1858, i.e., about 300,000 cubic feet per second, but I need hardly remind you that this was an extreme flood, and that it will not be safe to regulate up to this quantity until the flood-banks have been made up and the masonry works along the river are secured.

5. Lieutenant Romilly's report on the Coleroon is submitted as Appendix No. IX to this report. You are aware that Major Oakes, the late Superintending Engineer of Tanjore, doubted the accuracy of some of Lieutenant Romilly's cross sections, as their

details did not agree with the purposes of the present inquiry like the Coleroon with its shifts and it will be sufficient that the calculated agree with the survey selected are included in a list in Major Oakes' own handwriting.

6. Lieutenant Romilly's assistance in regulating a enable it to carry its maximum Romilly in his report has pointed out the actual state of the streams of the Delta were surveyed of these rivers is even less satisfactory.

7. In my report I have these surplus streams for the exists for the passing of an Act their conservancy is impossible. nity at large will, it is hoped, in the matter.

8. I have also in my report supply of the Delta as brought to Cauvery as calculated by Kut supply of the Delta is only one. This subject is one of equal, flood waters, and will no doubt

on the survey. But it is immaterial, for the each of the 100 cross sections of a large river bed should agree in all respects with the map; sections from which the flood discharges are least two of the sections which have been as said to be available for calculation in a note the others agree very fairly with the survey.

of the Coleroon will be of considerable value in that river to a uniform alignment, and so without danger to its margins. Lieutenant the unsatisfactory state of the bed of the only an examination of his detailed surveys to is. No doubt, if the other surplus rivers and the same detail, it would show that the state than that of the Coleroon.

ured to explain the very great importance of flood waters and the absolute necessity that legislature for their protection, without which tal importance of this subject to the commu- the Government of Madras to take some action

attention to the actual condition of the water- these investigations. If the discharges of the formula are to be accepted, the actual water- what it has hitherto been supposed to be. water, importance than that of the disposal of com you the attention it deserves.

the honor to be,

Sir,

our most obedient servant,

P. MONTGOMERIE, Major, R.E.,
Executive Engineer, on Special Duty.

*Accompaniments to a letter from Major Montgomerie, R.E., Executive Engineer, on Special Duty,
dated 14th February 1881.*

One file containing a Report on the Coleroon with nine appendices and five sub-appendices.
One file of Government Orders and papers connected with the subject of the regulation of the Cauvery as per list.

Portfolio No. 1—containing fourteen maps and sections to illustrate Major Montgomerie's report.

Portfolio No. 2—containing fourteen diagrams to illustrate Major Montgomerie's report.

Portfolio No. 3—containing four sheets of longitudinal and twenty-three sheets of cross sections of the Coleroon and Agunda Cauvery Rivers by Lieutenant Romilly, R.E., and Mr. Paul, Assistant Engineer.

Portfolio No. 4—containing ten sheets of longitudinal sections of the Coleroon Flood Banks.

A Survey of the Coleroon and part of the Agunda Cauvery Rivers by Lieutenant Romilly, R.E., and Mr. Paul, Assistant Engineer, in fifteen sheets. Scale $\frac{1}{25000}$ of the full size.

(Signed) P. MONTGOMERIE, Major, R.E.

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Five sheets longitudinal sections of the Coleroon north bank by Lieut. Romilly, R.E.

Do. do. south bank do. do.

SURVEYS.

Survey of the Coleroon and part of the Agunda Cauvery Rivers by Lieutenant Romilly, R.E., and Mr. Paul, Assistant Engineer, in fifteen sheets. Scale $\frac{1}{25000}$ of the full size.

REPORT ON THE RIVER COLEROON WITH REFERENCE TO ITS CAPABILITIES OF RELIEVING THE CAUVERY DELTA OF FLOOD WATERS.

INTRODUCTORY REMARKS.

THE Coleroon is the largest and (as an outlet for flood-waters) the most important river in the Delta of the Cauvery, and The Coleroon the main effluent of the Cauvery. its utilization for the more or less complete relief of the Delta from flood-waters has been suggested by almost every Irrigation Engineer who has ever been connected with the Delta.

2. How long the Coleroon has been the main effluent of the Cauvery, or if it has always been so, is a disputed question. Comparative capacities of the Coleroon and the other rivers of the Delta. which need not be taken into consideration here. It is sufficient, for the present inquiry, to know that under the existing régime of the Delta the Coleroon below the Grand Anicut has a capacity sufficient to take one-half of the maximum discharge, which has to pass through the Delta into the sea at any one time (*vide* table on Sheet No. I or Appendices Nos. I and II). Its maximum discharge is almost the same as that of the Agunda Cauvery at the head of the Seringam Island, and is consequently about double that through the Cauvery Dam, or over the Upper Anicuts.

3. The Coleroon having, as stated above, a capacity equivalent to that of all the other rivers of the Delta put together, Coleroon capable of carrying its own share of flood waters. may, and ought to, be required to carry its own fair share of flood waters to the sea. but it cannot possibly do more without altering the existing régime of the Delta system.

4. A brief history of the several proposals which have been made, or actually carried out, for the regulation of the Cauvery, and the improvement of the irrigation of its Delta, up to that time, is given by Captain Mead, R.E., in his report dated 3rd December 1866, and a more detailed description of these works, and of a few others since constructed, is given in Major Oakes' memorandum, printed with the Proceedings of the Madras Government, No. 417, dated 20th February 1874.

5. In this report, it is not proposed, nor is it possible with the limited data at present available, to attempt the investigation of all the circumstances connected with the detailed reticulation of the rivers and channels within the Delta proper, but merely to examine into the causes and effects of the floods of the Cauvery and its Delta, and to state the broad principles which must guide the manipulation of these floods, whether at the head of the Delta or at any point within its limits.

6. Captain Mead's proposals for the regulation of the Cauvery floods, which were finally submitted to the Government of India with the Proceedings of the Madras Government, Nos. 2116 and 2117, dated 3rd September 1870, so far as they can be understood from the file of papers accompanying this report, of which a list is given in Appendix No. VIII,

were as follows:—To prevent all ingress into the Delta proper, below the Vennar Head, of floods exceeding the equivalent to a $10\frac{1}{2}$ feet flood on the Cauvery Dam Gauge; this was to be accomplished by the construction of a vented dam across the Cauvery about 200 feet below the Grand Anicut, by blocking up the existing head of the Vennar and, in lieu thereof, supplying a head sluice to the Vennar adjacent to the proposed Cauvery Vented Dam, and by raising the existing level of the Grand Anicut $\frac{7}{10}$ ths of a foot, and by these means forcing into the Coleroon all flood waters in excess of the equivalent to a $10\frac{1}{2}$ feet flood at Cauvery Dam. The Covilady Kalin-gulah was to be blocked up to prevent water returning into the Delta below the Grand Anicut.

7. The result of these proposals, as estimated by the Local Engineers, would be to augment the volume of the Coleroon, east of the Covilady Kalin-gulah, by the difference between 22,300,000 cubic yards discharge of the Coleroon, and 26,216,000, the expected maximum discharge; or by 3,916,000 cubic yards per hour, which is equal to 29,370 cubic feet per second. These results were apparently based upon the statement made at paragraph 82 of Captain Mead's report that in a 12 feet 3 inches fresh—"I roughly calculate the water passing down the Coleroon below gives 167,287 cubic feet per second, and agrees very fairly with the calculations by Kutter's formula now submitted, and which make the discharge at the Lower Anicut, during the flood of 1877, (12 feet 4 inches on Cauvery Dam Gauge) 183,000 cubic feet per second.

8. But the expected results from his proposals are somewhat differently expressed by Captain Mead himself, for at paragraph 77 of his report he says: "a 12 feet 3 inches fresh will discharge 8,195,000 cubic yards per hour over the Grand Anicut." And again at paragraph 81, in sketching the probable result of a flood similar to those of 1818 and 1858, he says:—"the Grand Anicut, with a head of 2.8 feet, would discharge 9,563,000 cubic yards, that is, 71,722 cubic feet per second.

9. In reviewing these somewhat indefinite proposals, the Government of India were naturally anxious, before sanctioning the estimates, to have before them some more precise proof of what the results of the scheme would actually be, and the Madras Government were called upon, in letter No. 81 I, dated 7th March 1871, to submit detailed surveys and sections of the Coleroon, in order to ascertain if that river could carry what their Inspector-General considered would be the results of the scheme, viz., an increase of 6 millions of cubic yards per hour, above a maximum flood of 23 millions of cubic yards per hour, or in all 29 millions of cubic yards per hour, which is the same as 217,000 cubic feet per second.

10. Had the real circumstances of the Cauvery Delta been correctly understood, General remarks as to the actual circumstances of the Cauvery Delta and nature of maximum floods, by the local Engineers, this question might have been easily answered without an elaborate survey and sections of the Coleroon, which have taken nearly ten years to complete and dispose of, for, in the flood of November 1858, the Coleroon actually carried 285,000 cubic feet per second, which exceeds the supposed maximum by $2\frac{1}{2}$ times the 6 millions of cubic yards per hour. But in making this admission it would have been necessary for the Local Engineer to allow—

1st.—that 12 feet 3 inches on the Cauvery Dam Gauge is not a maximum flood in the Agunda Cauvery;

- 2nd.—that a maximum flood in the Agunda Cauvery at the head of the Seringam Island is only half of the total maximum discharge, which may have to pass through the Delta to the Sea at one time;
- 3rd.—that the normal equivalent to a maximum flood at the Cauvery Dam is not the same as the maximum discharge of the Cauvery at the Vennar Head, and that the latter may exceed the former by 100,000 cubic feet per second; and
- 4th.—that the discharge at the Lower Anicut is not limited by the discharge over the Upper Anicut plus the discharge over the Cauvery Surplus Works, but that it may, and has been augmented by at least 129,900 cubic feet per second.

GENERAL DESCRIPTION OF THE VALLEY OF THE CAUVERY AND ITS DELTA.

11. Before attempting to explain the above facts, it will be necessary to give a brief description of the physical features of the country, comprising the Upper and Lower Valleys of the Cauvery.

12. A graphic and very interesting description of the river itself, and parts of its delta, is given in Colonel D. Sim's report, dated 16th July 1839, and although the state of the rivers distributing the supply through the Delta have been greatly improved since then, by the construction of the minor regulators, and by the systematic training of their upper reaches, those rivers which act as outlets for the flood waters have evidently deteriorated, and the sound principles which were then inculcated, viz., to make "the river itself the principal agent in discharging the mud and sand which its waters brought down," and which has effected so much for the distributaries above, are even more applicable for the conservancy of the outlets below.

13. Throughout this report, for the sake of convenience, the lands which drain into the Cauvery, above the Upper Anicut, are called the Upper Valley of the Cauvery, and the floods from these lands are termed normal floods, while the Delta and all lands draining into it below the Upper Anicuts are called the Lower Valley of the Cauvery, and the floods from it are termed abnormal floods.

14. The Upper Valley of the Cauvery drains an area of 27,705 square miles, and a map illustrating the average annual rainfall over it is shown on Sheet I accompanying the Preliminary Report on the Bhavani Regulation scheme. The area of the Lower Valley of the Cauvery is 5,131 square miles, and a general map of this portion, showing the drainage areas affecting abnormal floods, with a table of maximum flood discharges, is given on Sheet I accompanying this report.

15. Although there is a considerable portion of the Upper Valley within the Coimbatore District and in the Dindigul Taluk of the Madura District, in which the average annual rainfall during the north-east monsoon exceeds that during the south-west monsoon, the main portion of it is principally affected by the south-west monsoon rains; on the other hand the greater portion of the Lower Valley is principally affected by the north-east monsoon rains, and a line drawn north and south through Lalgudi, or about ten miles to the east of Trichinopoly, would indicate, as nearly as possible, the limit to the eastward of which the north-east monsoon rains, and to the west of which the south-west monsoon rains, preponderate in the Lower Valley.

16. The south-west monsoon where it affects the Cauvery is seldom, if ever, accompanied by any great meteorological disturbances, and, as the rains during this monsoon are almost unfailling along the portions of the western mountains draining into

the Cauvery, the floods (or freshes as they are called) during this period are usually good and sufficient, and hardly ever excessive, as may be seen by an examination of the general diagram of floods from 1845 to 1880 (Sheets Nos. XVIII and XIX).

17. The north-east monsoon, which is much more uncertain in its results than the south-west monsoon, is periodically (about once in ten or eleven years) accompanied by very considerable meteorological disturbances, often accompanied by a cyclone with excessive falls of rain. The whole Lower Valley of the Cauvery is subject to the effects of these periodical cyclones, which travel from south-east to north-west, deluging whole tracts of country and sometimes influencing, to an alarming extent, the rainfall in the Upper Valley.

18. The very uncertain nature of the floods at the Upper and Lower Anicuts, during the north-east monsoon period, will at once be apparent from the general diagram of floods accompanying this report. The floods during this monsoon, although not so frequent as during the south-west monsoon, are often much higher, and what have been termed abnormal floods have only happened during this period, at least for the years for which the registers have been maintained. These occurred in January 1845, November 1858, November 1861, October 1864, November 1871, and November and December 1880.

19. Two of these abnormal floods, viz., November 1871 and November 1880, abnormal floods of 1871 and 1880 effects of cyclonic rainfall. have been taken to illustrate the subject; they were both the effects of heavy cyclonic rainfall.

20. On the former occasion the heavy rainfall was confined to the northern parts of the delta, and the cyclone which caused it, having struck the delta at about Tranquebar, appears to have gone northwards along the Coast. The heavy rainfall which accompanied the cyclone of 21st November 1880 was principally confined to the southern portions of the Delta and the lands draining into it from the south. This latter cyclone appears to have passed through the Delta in a north-westerly direction between Tanjore and Negapatam, and, having split on the Puchamali Hills, the rain clouds of the southern portion were carried well up the valley of the Cauvery, probably as far as Ootacamund on the Nilgiri Mountains, causing a high flood of 11 feet 10 inches at Cauvery Dam on the night of the 24th idem.

21. Rainfall maps for these two cyclones are given at Sheets Nos. II and III. Maps of the cyclonic rainfall of 1871 and 1880, and the abstract statements of the rainfall are given in Appendices Nos. VI and VII.

22. The Madras Irrigation Chief Engineer, Colonel Mullins, R.E., has himself had ocular demonstration of the effects on the flood banks of the Vennar and Vetar Rivers of the meteorological disturbance of the 21st November last. The floods which succeeded this disturbance happened on the 22nd, the morning following, and were caused almost entirely by the drainage from little over 200 square miles between Trichinopoly and Tanjore (*vide* General Map Sheet No. I). The water register at the head of the Vennar shows that there was only 3 feet 3 inches on the 21st and 4 feet 6 inches on the 22nd at the regulator above, and it is considered that, even if the Vennar head had been closed entirely, the catastrophe which happened could not have been avoided with the flood banks in their present condition, although, if the banks had been sufficiently high and the outlets below clear, the regulation of the water at the head of the Vennar would have materially helped in preventing the damage, and would have been of the greatest assistance after it had occurred, when the high flood of the 24th idem came down the river from above.

23. The abnormal flood of the 7th November 1871, although it did very considerable damage in the taluks of Mayavaram and Shiyali, is principally referred to in this report for the accurate data as to maximum flood discharges in Lower Valley obtained from abnormal flood of November 1871.

the Lower Valley of the Cauvery, which the records at the Lower Anicut enable us to deduce from it. On this occasion the flood rose to 6 feet 6 inches on Lower Anicut, and, as little or no water was passing over the Upper Anicuts (*vide* general diagram of floods) and none whatever from the Cauvery Surplus Works at the time, the estimated discharge of 129,900 cubic feet per second was clearly caused by the drainage from the Coleroon and the country on its north bank, between Upper and Lower Anicuts, an area of about 1,100 square miles; this gives a co-efficient of 1,200 for the formula $D = C.M.^{\frac{2}{3}}$. This flood was witnessed by the writer of this report from the right bank of the Coleroon somewhere opposite the Coodamooty Head. The Coleroon was at that point more than half full and covered with foam, a striking contrast to the Cauvery a mile or two to the southwards.

24. These two local floods of November 1871 and November 1880 have not been selected as examples of maximum floods in the Cauvery, but to illustrate the causes and effects of abnormal floods in its Lower Valley, and to give some idea of the effect of a general heavy rainfall over the Lower Valley of the river, occurring simultaneously with a maximum flood from the Upper Valley, such as must have been the case in the great floods of 1818 and 1858. The sudden, and abnormally great, rise of the river throughout the Delta during the flood of November 1858 is graphically illustrated by the Comparative Diagram Sheet No. XX.

25. With this brief description of the physical features of the Upper and Lower Valleys of the Cauvery River, and with the assistance of the accompanying maps, diagrams, and tables of discharges which have been prepared from the more precise data available, and from the experience which has been acquired during the past decade, it is hoped that a satisfactory explanation of most of the valuable records of the flood of November 1858, which have hitherto been considered quite unaccountable, may be arrived at, and we shall now proceed to investigate.

THE MAXIMUM FLOOD DISCHARGES OF THE CAUVERY AND ITS EFFLUENTS, THEIR CAUSES AND EFFECTS.

26. The great flood of November 1858 is the highest flood in the Cauvery river of which there are any actual records; although there are traditions of still higher floods having occurred at the beginning of the present century, the actual records of floods do not go further back than to 1843.

27. From the records of the flood of November 1858, it would appear that the water rose on the 21st of the month suddenly from 5 feet 2 inches to 13 feet 3 inches at the Cauvery dam, from 0 to 9 feet 6 inches on the north branch, and from 2 inches to 7 feet 3 inches on the south branch, of the Upper Anicut, and simultaneously on the same date to 14 feet 4 inches on the Grand Anicut to 10 feet 11 inches on the Covilady Kalingulah, and from 3 feet 1 inch to 17 feet 10 inches on the Coleroon guage pillar opposite the Grand Anicut. And on the succeeding day, the 22nd, the water at the Lower Anicut is shown to have risen from 4 feet 9 inches to 11 feet 6 inches on the north branch, and from 5 feet to 12 feet on the south branch.

28. This flood, which was essentially normal at the south branch gauge Upper Anicut, was abnormal at the north branch of that Anicut and throughout the Delta below, especially at the Grand Anicut and Covilady Kalingulah, where the abnormal differences were so great that they have hitherto been considered inexplicable, and almost all the valuable records of this flood, maintained at different parts of the Delta, by different and independent observers, have

been considered as more or less unreliable and untrustworthy, and have been either discarded or altered to what must now appear a dangerous extent.

29. As the value of all calculations and statements of maximum flood discharges depend entirely on the accuracy and sufficiency of the records and data on which they are based, it will be necessary to explain the circumstances and incidence of the great flood of November 1858 at the several parts of the Delta at which registers have been maintained, discarding those the accuracy of which is not corroborated by concurrent evidence. And the most convenient way to do this will be to refer, in detail, to each objection which has been raised.

30. The first great difficulty which appears to have presented itself to the mind of the local Engineer was to account for the considerable variations in the recorded afflux at the different works, in some cases the recorded afflux of the flood of 1858 being very much greater than during lesser floods, and in hardly any case approaching the limits prescribed by a certain School of Engineers, who affirm that during the highest floods the afflux at any ordinary weir must be very small if it does not actually disappear.

31. In order to ascertain the actual state of the case, it has been necessary to carefully examine *ab initio* all the records of floods, and to plot on separate diagrams (Sheets Nos. XXI to XXVIII) the relative heights above M.S.L. of the water above, and below, each work or every flood with reference to differing depths on Cauvery Dam. And by this means, as is explained on the diagram, for the south branch Upper Anicut, the normal equivalent heights of water and afflux (or head) corresponding to differing depths at Cauvery Dam has been arrived at for each work.

32. By dividing the floods into the two categories, normal and abnormal,—the former passing through the Delta without any accession from local drainage, and the latter receiving augmentations in accordance with the intensity and incidence of local rainfalls,—we are at once able to compare the heights of water during similar abnormal floods, and thus indicate and explain their causes.

33. In order to insure accuracy in arriving at the relative heights of the water, it has been necessary in the first place to ascertain the values above M.S.L. of the zero of each gauge, and these have been carefully selected from the values given to them in Captain Mead's and Lieutenant Romilly's Appendix No. IV. In fixing the new iron gauges throughout the Delta, great care should be taken that the original values are given to the zeros; otherwise the past records cannot be utilized.

Actual afflux at Upper and Lower Anicuts three times the afflux estimated by Local Engineer.

34. We shall now proceed to consider *seriatim* the several difficulties which have presented themselves:

(a) At paragraph 3 of his letter, No. 1464, dated 7th January 1868, Proceedings of Madras Government, No. 882, dated 18th March 1868, the Superintendent Engineer, Sixth Division (Captain Cakes), says in reference to the Upper Anicuts:

"In a 12-foot flood the difference of level between the water above and below the anicut is as per margin, and as the waterway of the anicut inclusive of sluices is 2,129 feet, while the waterway of the Cauvery is 1,950 feet, were the anicut removed entirely, the water level in the Cauvery and Coleroon would only be reduced by about 4 of a foot."

And again at paragraph 73 of his memorandum printed with Proceedings of Madras Government, No. 417, dated 20th February 1874, the same officer states in reference to the Lower Anicuts:

"In the flood of 1858 the water rose to 12 feet above the crown of the south branch; this may be relied upon as correct; the water level below the dam was not marked, but the difference of level was probably inappreciable; the level to which the water rose on the north branch was not marked, and the water returns are not to be relied upon."

Now, as regards the Upper Anicut, it will be seen by a reference to Diagram Sheet No. XXI that the normal afflux with a 12-foot flood is 1.50 of a foot, or nearly three times that allowed by the Superintending Engineer. The accuracy of this diagram was very carefully tested by the results of the last high flood of 24th November 1880, which was a particularly favorable one, having gauged 11 feet 10 inches at both ends of the Cauvery Dam. The actual heights of the water above and below the anicut were taken, with a levelling instrument from the marks left by the flood, immediately afterwards. The relative heights of these marks, which were very clear and well defined, giving an afflux of 1.55 of a foot, have been plotted on the diagram and agree with it absolutely.

The writer of this report is not prepared to say that the Superintending Engineer may not be theoretically correct in stating that the afflux at the southern branch Upper Anicut, during a 12-foot flood, is

only .60 of a foot; but, if so, the only way to account for the difference is to assume that the bed of the Coleroon for some distance below the anicut has been deepened out by the difference, or by $1.50 - .60 = .90$, or by nearly one foot. That the bed of the Coleroon has been deepened out to a greater depth than this, opposite the Vadavagoody and Perimalcovil surpluses, is evident from the cross sections given on Sheets Nos. XI and XII, and the Superintending Engineer himself, at paragraph 21 of his letter, No. 1464, dated 7th January 1868, shows that the Coleroon has become deepened by 64 of a foot at the 150 yards kalingulab, 3 miles below the Upper Anicut. So it is not improbable that there has been some deepening of the bed below the anicuts, but it must have happened before 1858, as the recorded afflux of that year agrees with the diagram.

The same cause may also account in some measure for the considerable afflux at the Lower Anicuts, as shown on the diagrams. It must, however, be stated here that the data on which the Lower Anicut diagrams have been prepared is not so precise as at the Upper Anicuts, and they are possibly not so correct.

(b) In referring to the gauge readings at the Upper Anicuts, the Superintending Engineer says, at paragraphs 15 and 16 of his memorandum, printed with Proceedings of Madras Government, No. 417, dated 20th February 1874:

"Much reliance cannot be placed on the high-water gauge readings of the flood of November 1858, when the damage done in the Delta was very great, and the natives were seeking safety for themselves and their families by flight from the neighbourhood of the rivers."

"16. As stated above the high-water level over south bank of the anicut was 7 feet 3 inches, and that over the Cauvery Dam must have been from 13 feet 3 inches to 13 feet 6 inches, or to within from 3 to 6 inches of the top of the parapet. The gauge reading is given at 15 feet 6 inches, which is certainly inaccurate, as the parapet was not submerged, and the level is altogether inconsistent with that shown as the level over the anicut; the latter was accessible, and the reading of its gauge is probably correct."

The Superintending Engineer's deductions regarding the height of water on the Cauvery Dam are manifestly correct. But, as the gauge readings for the south branch, when plotted, agree perfectly with the accompanying diagram, and as the abnormality of those for the north branch are fully explained by the almost precisely similar occurrence which happened on the 22nd November last, and which

* The height of the water may not have been marked on the work, but the heights given in the register have been plotted on the accompanying diagram, and the increased afflux is quite explained by the obstruction caused by the arches; the level of the water at the south branch, which the Superintending Engineer states may be relied upon, rose to within 50 of a foot of the crown of the arches of the bridge (vide Diagram Sheet No. XXVII).

are fully explained on the diagram for the north branch, there does not appear to be any reason whatever to doubt the accuracy of the high-water gauge readings of either of the branches of the Upper Anicut for the 21st November 1858.

(c) And, in reference to the Vennar Head Works, the Superintending Engineer, at paragraph 26 of his memorandum above referred, says. "The register of the flood of 1858 is absurd; it shows water 3 feet over the parapets and a difference of 10 feet here on the 21st and 22nd November, when the difference at the Cauvery Head was only 1 foot 10 inches."

And in regard to the Grand Anicut he says at paragraph 31: "The register of flood of 1858 cannot be relied upon, but the water probably rose to 8-1 on gauge."

And at paragraph 33, when referring to the Covilady Kalingulah: "The water register shows that the water rose to 10 feet 11 inches above the dam during the flood of November 1858, or a foot above the level of the roadway of the bridge; no reliance can be placed upon it."

From these remarks it would appear that, because the abnormal flood of 1858 subsided faster at the Vennar Head and Grand Anicut than it did at the Cauvery Dam, the registers are to be considered "absurd" and "unreliable," and that the record of the highest water at the Grand Anicut on the 21st May 1858 may safely be reduced by over 6 feet, that is, from 14-33 to 8-10 of a foot on the gauge, and which would reduce the height of the water on the 21st to 65 of a foot less than it was actually registered at on the succeeding day. The simple reply to this is that the same cause which made water in the Cauvery abnormally high at Vennar head being removed or exhausted caused the water to fall abnormally quickly. From the experience gained during the cyclonic rainfalls of 1871 and 1880, it is perfectly clear that the discharge from the 860 square miles which drain into the Cauvery between the Cauvery Dam and the Vennar Head (see General Map Sheet No. 1) after a continued heavy fall of rain such as the registers* would indicate would be more than sufficient to account for the abnormal rise of 14 feet 4 inches over Grand Anicut on the 21st November 1858. The great contraction of the rivers immediately below the Vennar Head no doubt was the cause of the water piling above; of course, if the water had been so very high at Vennar bridge, the height of the water could not have been gauged, and no entry should have been made for it. The longitudinal sections on the map of the River Sheet No. IV will explain this, and it will be seen, from the longitudinal Diagram Sheet No. XIII, on which have been plotted the recorded heights of the water at Vennar Head Grand Anicut and Covilady Kalingulah on the 21st, 22nd, and 23rd November 1858, with those of the 6th November 1877 and 3rd December 1880, that the recorded surface fall in the Cauvery during the flood of 1858 coincides very closely with other floods, and it would appear only reasonable to accept the records of the flood of 1858 except for the Vennar Head on the 21st November 1858 where it is manifestly wrong. In fact, with the evidence of the damage and loss of life caused by the local rainfall of the 21st November 1880, it would be scarcely prudent to base any proposals for the regulation of the floods above so populous and valuable a Delta as that of the Cauvery upon flood levels which have been depreciated to one-half of the original records.

35. Having explained the cause of the abnormal height of the great flood of Discharges of the flood of November 1858, 21st November 1858 within the Delta, we shall now trace its condition and volume from the Head of Seringam Island to the Lower Anicuts, placing in parallel columns what were the approximate discharges in the Cauvery and Coleroon Rivers at each point of importance, the discharges being taken from the accompanying tables and diagrams all shown in cubic feet per second.

	Cauvery.	Coleroon.
Total Discharge of Agunda Cauvery ...	284,000	
At Head of Seringam Island normal equivalents to 13 feet 3 inches on C.D. ...	135,000	141,000
Extra discharge from Iyar River over north branch Upper Anicut ...	...	8000
Total at Head of Seringam Island ...	135,000	149,000
At 150 yards Kalingulah Surplus from Cauvery into Coleroon ...	10,000	10,000
Total at 150 yards Kalingulah ...	125,000	159,000
At Vennar Head abnormal discharge from 860 square miles local drainage on south bank Cauvery between Cauvery Dam and Vennar Head ...	100,000	...
Total at Vennar Head ...	225,000	159,000
At Grant Anicut Surplus from Cauvery into Coleroon ...	93,500	93,500
Total at Grand Anicut including Vennar ...	131,500	252,500
At Lower Anicut Surplus from cauvery below Grand Anicut and discharge from North Bank of Coleroon 1,077 square miles less spill over right bank Coleroon which may have been considerable ...	...	32,500
Total Discharge of Coleroon at Lower Anicuts ...	...	285,000

It is difficult, if not impossible, to approximate very closely to the actual volume of water that entered the Delta proper at the Vennar Head, and by Cauvery below the Grand Anicut, during the flood of November 1858, but it was probably not more than 131,500 cubic feet per second. Now, to have reduced this amount to 50,000 cubic feet per second (which is apparently the maximum that was intended by Captain Mead) might not have aggravated very much the actual damage which occurred to the Coleroon in November 1858. But, if we examine the above statement with the statement of possible maximum discharges given on the General Map Sheet No. I, it will at once be evident that, had the circumstances of the flood of November 1858 been somewhat different, and had a maximum flood of 129,000 cubic feet per second from the country drained on the north bank of the Coleroon supervened, there can be little doubt that the Lower Anicut would have been destroyed and the damage to the country between it and the sea would have surpassed even that, which happened in 1818 and which is referred to in Colonel D. Sim's report, and in this case the reverse of Captain Mead's proposals might then have been advantageous. This will explain the statement made by Colonel D. Sim that "some modification therefore in the distribution of the water by which a larger quantity may be thrown into the Cauvery even during the highest inundations would, judging from past experience, seem to be rather an advantage than an evil."

THE REGULATION OF THE FLOODS OF THE CAUVERY AND ITS EFFLUENTS.

36. From what has already been said on the subject it must be sufficiently clear that, owing to the extent and geographical position of the Delta and the country draining directly into it, no scheme for the complete exclusion from the Delta proper below the Grand Anicuts of all Cauvery floods except what is required for irrigation is either practicable or advisable, and that any intermediate scheme, by which any fixed portion of these floods would be

permanently turned down any particular effluent of the Delta, would be only less objectionable. The only portion of the Delta which it might be possible to protect in an efficient manner from all upper floods is the central section of the Delta under the minor Cauvery and some of its effluents; but, if this were done, the northern and southern portions of the Delta, besides being subject to an enhanced share of the upper floods, would always be as subject as ever to the effects of the local abnormal floods during the north-east monsoon, which after all are the principal, if not the entire, cause of damage to the Delta.

37. These abnormal floods cannot be kept out of any one river without destruction to its neighbour. And, as we cannot possibly prevent these local nuisances, the next best thing to do is to get rid of them as soon as possible, and that is by having proper surplus outlets and by seeing that these outlets are not misappropriated for other purposes. Flood embankments may be raised to an indefinite height and the upper waters may be regulated with the utmost nicety; but, unless outlets below exist and are in proper order, there can be no protection from the floods.

38. From the general map of the Delta Sheet No. I and the statement printed on it, some idea of the capacities to be given to these surplus outlets may be arrived at. They must in any case (to carry off local floods alone) have a combined capacity more than sufficient to carry off the whole of a possible maximum flood of 14 feet on the Cauvery Dam gauge; and, as a maximum flood of 14 feet on the Cauvery Dam gauge occurs only once in about 50 years, and then probably in conjunction with a local abnormal flood in only one section of the Delta, the extra capacity to be given to these outlets to take off the total discharge will depend upon the precision and accuracy with which the upper floods are distributed and regulated among them. If this is properly done as it ought to be, the distributing rivers of the Delta and their outlets will not be required to be increased in capacity and protected by flood banks very much more than will be absolutely necessary to withstand local floods alone. On the other hand, if the upper floods are not regulated, but merely distributed between each effluent in proportion to its capacity, it evidently follows that the distributaries and their outlets must have nearly twice the capacity which is required for local floods. Fortunately for the Delta the contracted state of the Cauvery and Vennar Rivers at the Head of the Delta places a limit on the floods that can enter it, and this quantity is probably not more than 131,000 cubic feet per second.

39. The very great importance to the community at large of the proper maintenance and conservancy of the surplus rivers and channels, which, owing to the peculiar circumstances of the Cauvery Delta, not infrequently remain for several consecutive years without being required to perform their own particular functions, has been repeatedly brought to notice. Colonel D. Sim in his report already alluded to said:

"Before concluding this report, there is a subject to which, though not immediately connected with the anicuts, I would beseech the particular attention of the Collectors of Tanjore and South Arcot and the Civil Engineers Department of the division. It is the great importance of preventing the formation of islands in the Coleroon which has been too much neglected of late years. The banks of the river are planted with durbah grass to protect them from the effects of the current, the seeds of which are blown into the bed of the river, and young plants are seen springing up in all directions. Every plant becomes a nucleus around which sand and soil collect to obstruct and impede the free passage of the stream and prevent it exercising that influence on the bed which is requisite to preserve its proper level. In time, if the accumulation is allowed to proceed, a small island is formed, which diminishes the capacity of the channel and forces the current on the banks, which are thereby undermined and often destroyed. To this cause I attribute the frequency of breaches in the Coleroon Banks and the extensive destruction occasioned in inundations."

This process, which Colonel Sim appears to attribute entirely to nature, is often done purposely by the ryots to acquire land, and when once acquired, whether the

accretion is natural or artificial, it is almost beyond the power of the local Engineer, under the present state of the law, without a legal process in each case to remove it, and the difficulty becomes all the greater when the accretion has been made in some out-of-the-way surplus which has not been used for years. So long as the rivers are used principally for the purpose of supply, the Engineer has been able to enlist the sympathy and assistance of the cultivators, and with them the influence of the Collector of the Revenue, in conserving the beds of the streams. But in the conservancy of the surplus streams, and even in some instances in the proper maintenance of the flood banks above, the exertions of the Engineer have been paralyzed through the cupidity of the ryot, and the apparent antipathy of Government to the introduction of any legislative measures, without which the necessary conservancy is impossible. In this matter, viz., the conservancy of the beds of the flood outlets lies, the fundamental difficulty in the control and disposal of the flood waters throughout the Delta.

40. Major Oakes, the late Superintending Engineer of the Sixth Division, who has had more experience in the Tanjore District and is probably better acquainted with the peculiarities of its inhabitants than probably any other Engineer, has forcibly brought to the notice of Government the necessity of some legislative enactment for the Tanjore irrigation works. The Irrigation Committee of the last Famine Commission, of which Mr. Webster, the present Collector of Tanjore, was a Member, have also strongly recommended an Irrigation Act, and it may be hoped that, with the recent disastrous experiences in the Tanjore District, something will now be done to place the irrigation under the Cauvery on a proper footing.

41. Although any special report on the capabilities of the Coleroon of relieving the Cauvery Delta of flood waters must naturally embrace the general subject of the control and regulation of the flood waters throughout the Delta, it would be out of place here to enter into the details required for the different regulators. But a few remarks on the duty that will be required from the regulators at the head of the Delta and the method of performing it will be necessary.

42. From what has been said above, it will be seen that, owing to the contraction of the Cauvery and Vennar Rivers at the Grand Anicut, the volume of water which can enter the Delta is limited to about 131,000 cubic feet per second, and that the balance of any flood in the Cauvery at the Vennar Head above this quantity must go down the Coleroon, whether that river can hold it or not. So that, with a possible maximum flood of 11 feet on the Cauvery Dam Gauge and maximum abnormal floods from the north bank of the Coleroon and from the south bank of the Cauvery about Trichinopoly occurring simultaneously, the destruction of the Lower Anicut and the wreck of the Coleroon below it would be complete. From the evidence before us, however, it would appear that, although such a combination may be possible, there is no actual record of such an occurrence. In any case it would be an extremely difficult combination to deal with, and one that could be very slightly influenced by the regulation of the Cauvery at the Grand Anicut. We may, therefore, proceed to detail the duty to be performed by the regulators at the Grand Anicut under one or two possible circumstances:

1st.—When a high flood of, say, 11 feet on Cauvery Dam occurs simultaneously with an abnormal discharge of say 100,000 cubic feet per second from the lands draining into the Cauvery from the south between the Cauvery Dam and Vennar Head and no abnormal flood enters the Coleroon from the north. Such an event would probably be accompanied by a very high local flood in the Vennar and perhaps also in the Cauvery, and the necessity for regulation at the Grand Anicut would be of

the utmost importance for the safety of the Delta. In this case the discharge of the Cauvery at the Vennar Head would be—

Normal discharge at Cauvery Dam	...	...	...	87,800
Less surplus at 150 yards Kalingulah	...	...	...	5,000
Abnormal accession from south bank about Trichinopoly	...	...	...	82,800
Remaining in Cauvery	...	...	...	100,000
Total volume in the Cauvery at the Vennar Head	...	...	...	182,800
And the discharge of the Coleroon would be—	...	...	...	...
Discharge Upper Anicuts	...	...	...	83,000
Plus surplus at 150 yards Kalingulah	...	...	...	5,000
Total volume in Coleroon at the Grand Anicut	...	...	...	88,000

Now, if we take the maximum capacity of the Coleroon to be 300,000 cubic feet per second, it will be evident that the whole of the water in the Cauvery, viz., 182,800 cubic feet per second, could in this case be turned into the Coleroon. And, so long as the normal discharge from the Upper Valley does not exceed 11 feet on the Cauvery Dam gauge and there is no abnormal discharge into the Coleroon from the north, the Coleroon can take all, and the quantity which the Coleroon can take when the flood from the Upper Valley exceeds 11 feet on the Cauvery Dam Gauge will *ceteris paribus* be reduced in proportion to the volume which passes the head of the island.

2nd—When a possible maximum flood, say, of 14 feet on the Cauvery Dam receives no abnormal augmentations to the Coleroon or to the Cauvery above the proposed regulators at the Grand Anicut. Under existing circumstances there would be in—

Cauvery at head of Island	...	...	...	Cubic Feet Per Second.
Discharged by all surplus works as per synoptical table	...	...	...	152,000
Remainder entering into Delta	...	...	...	93,000
Now the normal equivalent to a 14-foot flood on Cauvery Dam at the Lower Anicut is	...	...	...	59,000
And as maximum capacity of Coleroon is	...	...	...	254,000
The quantity by which the Cauvery might be further reduced is	...	...	...	300,000
	...	...	...	46,000

43. From these two examples it will be seen that any number of complicated combinations will occur in practice, and the difficulty in regulating the flood-waters will be much greater than even Major Oakes anticipated when he recommended the permanent location of an Executive Engineer at the head works. In fact, it will be absolutely necessary for the officer in charge to be in telegraphic or telephonic communication with the Upper and Lower Anicuts and with the other Vennar regulators. The responsibility that will be placed in the hands of this Executive Engineer will be great, and it will be churlish not to furnish him with the appliances which modern science provides. No third-rate railway, whether it pays a dividend or not, is permitted to be run without the telegraph wire accompanying it. Even the Upper Godavari works, which were never supposed to pay, were placed in telegraphic communication with each other almost as soon as they were commenced.

44. If the regulation of the flood-waters of so important and valuable a Delta as that of the Cauvery is worthwhile undertaking at all, it is worth doing well. The site for the regulators selected by Captain Mead is by all agreed to be the only proper site. And there is no doubt that, had that officer been in possession of the further data now available, he would have seen the impossibility of passing over the Grand Anicut, with its low flat arches

of 6 feet rise, and a clear waterway of only 2.75 feet between tops of dam stones and haunches, the very great bodies of water which must occasionally be dealt with, and which may be as much as 180,000 cubic feet per second into the Coleroon, *vide* paragraph 42. To discharge this quantity would require nearly 1,000 running feet of open vents with between 2 and 3 feet head of water, and as the present Grand Anicut is an old native work built with stone and mud in the heart of it, it would be useless to try and do anything further with it. A vented dam, similar to those to be provided to the Cauvery and Vennar head, should undoubtedly be built in the place of the Grand Anicut.

Superintending Engineer's memorandum, paragraph 28, printed with Proceedings, Madras Government, No. 417, dated 20th February 1874.

45. The position of such a dam, with the most suitable alignment to be given to the Cauvery at the head of the Delta, is shown on Sheet No. XIV. It will be observed that Captain Mead's proposal, to make the regulator at the Grand Anicut the real head of the Delta, has been adhered to in marking out this alignment. Probably the most important benefit to be derived from these regulators would be lost by leaving the Vennar head open or partly so; in fact, whether the outlets into the Cauvery and Coleroon are to be completely closeable or not, the complete closing of the Vennar head should at any time be possible; for the necessity for this we have only to consider the circumstances of the Vennar during the flood of 22nd November 1880 and the succeeding days.

46. The rectification of the alignment of the Cauvery, as shown on the plan Sheet No. XIV, may seem a heavy work to a stranger, but any one acquainted with the Panjore rivers, and who has seen what has actually been done in this way in the Cauvery itself, between the Covilady Calingula and the Coodamoorthy head within late years will understand the circumstances of the case; in the training of the portion of the river above referred to extensive islands and promontories have been removed, and many acres of the river bed permanently reclaimed at a very moderate cost. Two cross sections of the actual reclamations which have been made in one of the bends are given on Sheet No. XI. The principal portion of the land to be removed is the strip between the Cauvery and Vennar Rivers below the Vennar head, and should it be considered advisable to allow this part of the work to remain until a more convenient season, and there should happen to be any misplaced sentimentalism in regard to the work of our immediate predecessors, the bridge at the Vennar head may be allowed to stand, and the strip of land may remain as an island without reducing the existing waterway as shown by the alignment marked in red, until a less conservative and more practical generation shall remove both bridge and island. But in any case the Grand Anicut must be removed to allow surplus flood-waters to pass freely into the Coleroon. This grand old work has probably coined more money than all the other irrigation works of India put together, but at the same time it cannot be denied that it has been the principal cause of the complaints as to the excessive quantities of sand silt and upper floods which have been forced down into the Delta, and which, were it not for the grand anicut, would be shared by the Coleroon.

47. From a consideration of all the facts of the case now before us, we arrive at the following general conclusions with reference to the control and regulation of flood-waters throughout the Delta of the Cauvery:—

- I. That owing to the extent and geographical position of the Delta and the lands draining directly into it, the complete exclusion of upper flood-waters from the Delta or from any portion of it is not practicable or advisable.
- II. That for the same reasons to fix or limit the flood discharge down any one river is equally inadmissible.
- III. That regulation of floods, in the proper sense of the term, is imperatively necessary, especially at the head of the Delta, *i.e.*, at the Grand Anicut.

- IV. That the regulation of floods of magnitude, at least at the head of the Delta, becomes dangerous, if not absolutely impossible, without telegraphic communication with the Upper and Lower Anicuts and the Yennair and other regulators.
- V. That flood outlets of sufficient capacity, to take off all local floods, and a fair proportion of the upper floods, are absolutely necessary for each section of the Delta, and that without them all regulation above is useless.
- VI. That an Act of the legislature is of primary importance for the protection and conservancy of surplus streams, great and small, which, from the peculiar circumstances of the Cauvery Delta, frequently remain several consecutive years without being required to perform fully their own legitimate functions. And that without such an Act there can be no real conservancy, and consequently, no complete protection from floods.

CALCULATION OF DISCHARGES.

48. The calculations of the discharges referred to in this report have been based upon the results of the recent investigations by Ganguillet and Kutter* into the flow of the water in river and canals. These investigations have shown the necessity for applying co-efficient which shall vary, not only for each depth of water, but for different classes and descriptions of rivers and channels.

49. The following is the formula of Kutter, as applied to English feet:—

$$\text{Kutter's Formula and Higham's Tables. } D = \left\{ \frac{1.811}{N} + 416 + \frac{0.00281}{S} \right\} \times A \times \sqrt{RS}$$

and this may be reduced to the simple formula $D = A \times C \times \sqrt{RS}$ and applied to different values of (N) as has been done by Mr. Higham in the preparation and arrangement of his tables, by which all the calculations of river discharges have been made for this report.

50. The following are the different values of (N) for the three recognised classes of rivers and canals in earthen channels:—

I. Perfect order, perfectly free from stones and weeds	...	(Values of N.)
II. Moderately good order, free from stones and weeds	...	025
III. Bad order, over-grown or impeded by detritus	...	030
	...	035

It will be observed that the above classes refer only to rivers and canals in earthen channels with permanent sides and bottoms; and to make the formula perfectly applicable to the rivers of Southern India, whose sandy beds are known to be more or less scoured out and deepened during floods, it would be necessary either to know the actual section of the river during the flood, or to apply an extra co-efficient to an already complicated formula.

51. The rivers of the Cauvery Delta are, however, so very broad in proportion to their depth, that the extra depth scoured, and consequently the extra discharge due to enlargement of section during floods, must be small; it is probably not more

* Die neuen Formeln für die Bestimmung der mittlern Geschwindigkeit des Wassers in Canälen und Flüssen.
 † The greatest hydraulic mean depth of the Coleroon River, with a maximum discharge of 285,000 cubic feet per second, does not exceed 15 feet, and that of the Cauvery, with a maximum discharge of 152,000 cubic feet per second, does not exceed 10½ feet. The possible maximum depth of water on Cauvery dam, which is taken at 14 feet as shown on Synoptical Table, Sheet No. XV, does not represent the actual working hydraulic mean depth of the Cauvery, as although the Cauvery dam is perhaps clear of sand with this depth of water on it, the velocity through it is reduced, for the discharge at dam must equal the discharges at the other sections below. The Cauvery dam is only a few feet wide, so that the surface fall over it becomes practically immeasurable; besides which, the assumption that the Cauvery dam is at any time perfectly clear of sand has yet to be established. This assumption has been based on the sections of sand deposits made by Supervisor Mahadaya Iyer, shown on Sheet No. VII, and has been made merely to complete the Synoptical Table of Discharges, as explained in the note at foot of table, for the purpose of obtaining the theoretical velocity through the dam; the actual discharges of the Cauvery having been calculated at sections, 1 mile and 2 miles below the dam as hereafter explained.

than 8 or 10 per cent., or less than the difference that would be caused by taking $N = 030$ and $N = 035$; and taking into consideration, moreover, the friction caused by the broad sandy surface of the river bed, and the resistance and loss of power which must be sustained in setting in motion the sand itself, it is considered that very fair approximations to the actual discharges of the rivers of the Cauvery Delta will be arrived at by taking $N = 035$ for those sections where the sandy beds are broader than the average; and $N = 030$ where they are narrower than the average. So that $N = 0325$ may be taken as the co-efficient of roughness and irregularity to be applied to uniform sections of the average width.

52. Having indicated the most suitable value to be given to (N), the co-efficient of roughness and irregularity for calculating the discharges of the rivers of the Cauvery Delta by Kutter's formula, it will be necessary to explain the process by which the discharges over the anicuts and surplus works entered in the Synoptical Table of discharges have been arrived at.

53. The normal heights of water on the crests, with the afflux at each work corresponding to differing depths of water on the Cauvery dam, have been obtained by means of the Diagram Sheets Nos. XXI to XXVIII. These diagrams, which have been prepared from the recorded readings of the gauges, fully explain themselves, and are probably the only means by which the normal equivalents could be accurately found.

54. Where possible, the discharges of the river channels themselves, calculated by Kutter's formula, have been taken as the quantities passing over anicuts the actual discharges over the masonry works above.

55. Advantage has been taken of the very distinct marks of the flood of the 24th November 1880, which rose to 11 feet 10 inches on the Cauvery dam gauges, to ascertain the precise surface* falls of the Cauvery and Coleroon Rivers at each of the sections between the head of the Seringam Island and the 150 yards calingula. These sections with the flood levels are shown on Sheets Nos. VIII and IX, and the means of the calculated discharges at these sections have been taken as the actual discharges through the Cauvery dam and over the Upper Anicuts; the proportionate discharge over each branch of the anicut being settled by the sections at 381 feet below the works. An abstract of these calculations are given in Appendix No. III.

56. The means of the surface falls, above and below each section, have been taken as the correct surface falls for calculating the velocities at each section. In irregularly margined rivers, like the Cauvery and Coleroon, it is absolutely necessary to know the exact surface fall through each section. It is manifestly erroneous to take the mean surface fall between three or more miles of river, as some have done in calculating the discharges; for, not only is this surface fall not exactly that to which the velocity through any particular section is due, but the sectional area or waterway is materially vitiated by taking the surface fall as a straight line for any great length of the river at one time.

57. Having established the actual discharges over both branches of the Upper Co-efficients of discharge over anicuts and Anicuts, the next point is to ascertain the velocities of approach to Upper Anicuts. correct co-efficients to be applied to the ordinary formulae of Dubnats for discharges over weirs, in order that these co-efficients may be applied to the other anicuts and surplus works when the discharges cannot be calculated by the river formula. But

* Lieutenant Romilly's Flood Levels for his sections of the Coleroon between Upper Anicut and 150 yards kalingula have apparently been taken by assuming a uniform slope of surface in this distance between the tail waters of the anicut and kalingula; this is both wrong in detail, and makes the flood levels of Coleroon too high at 100 yards kalingula; for although there is hardly any difference between the water above and below the kalingula there is always a rapid fall, down to the Coleroon, even in maximum floods.

before this can be done it is necessary to know the mean velocities of approach; these are manifestly the velocities with which the actual discharges pass through the sections of approach. The nearest sections that were available for this purpose at the Upper Anicuts were the sections 25 feet above the anicuts. These sections are shown on Sheet No. VIII; the velocities obtained have been entered in the Synoptical Table, and the co-efficients to be applied are given on the Diagram Sheet No. XVI and Appendix No. II.

58. As explained by the note at the foot of the Synoptical Table, the velocities of approach to Cauvery surplus works and to Cauvery dam. of approach to the Cauvery surplus works have been taken at about two-thirds of the velocities in the Cauvery; and the velocities through the Cauvery dam are merely the theoretic velocities, assuming the dam to be clear of sand as indicated on the Synoptical Table.

59. The discharges through the separate branches of the Lower Anicut are merely approximate, for no precise data as to the surface falls, &c., of each branch is available. But the total normal discharges at the Lower Anicuts, as shown in the table, are the sums of the discharges at the Upper Anicuts + the discharges from the Cauvery surplus works, and these agree very closely with the calculated discharges of the river Coleroon at Lieutenant Romilly's Sections, Nos. 34, 35, 36, 49, 50 and 63, an abstract of which is given in Appendix No. III. These sections have been selected both because they are well defined and because the record of the flood levels of the 16th July 1874, taken by Lieutenant Romilly, agree with those of the 6th November 1877, taken by Serjeant Ward and Sub-Overseer Veerasawmy Iyengar, the only correction necessary having been to discard the Sub-Overseer's flood levels of the 6th November 1877 at Section No. 36, and to allow a uniform surface slope between Sections Nos. 35 and 37, as given by Lieutenant Romilly's flood levels. Sections 34, 35, 36, and 50 are shown at Sheet No. XII. Sections 49 and 60 have not been copied, as the calculations at them were only taken as a final check, but the abstract of the calculations at each section are given in Appendix No. III.

60. Before tabulating the calculated discharges in the Synoptical Table, they have been plotted on the two diagrams which accompany this table for the purpose of check and to prevent errors of magnitude. On these diagrams have also been plotted in red the discharges at the several works as given by Captain Mead, R.E., in his report dated 3rd December 1866, and in yellow the discharges of the Coleroon as calculated by Lieutenant Romilly, R.E., entered on diagram in red. Discharges by Captain Mead, R.E., entered on diagram in red. Discharges by Lieutenant Romilly, R.E., entered on diagram in yellow. Discharges by Lieutenant Romilly agrees exactly with the discharge as calculated by the Mississippi formula by Lieutenant Romilly agrees exactly with the discharge as calculated by Kutter's formula, when there is the equivalent to 10 feet on the Cauvery dam in the Coleroon, and with greater depths of water the Mississippi formula gives a somewhat less discharge, probably about 30,000 cubic feet per second less, during a maximum flood.

61. The discharges as given by Captain Mead, R.E., naturally cannot agree with those calculated by the more recent formula, for it will be observed from Appendix A to his report, dated 3rd December 1866, that he has taken uniform instead of varying co-efficients. In calculating "the quantity of water passing through any section of a river" he has taken

$$\text{"Velocity feet per second} = 0.2 \times \sqrt{\text{r.s.}}$$

This is very much higher than any co-efficient which Kutter's formula allows for rivers with a regimen similar to those in the Cauvery Delta; and in calculating the discharge of the Coleroon, Captain Mead has apparently taken the discharge over the Upper Anicuts by the ordinary formulae of Dubuats with a uniform co-efficient of $\frac{2}{3} = .75$, instead of co-efficients varying from .35 to .875, which are the equivalents to the variable co-efficients of Kutter.

The results are, that while Captain Mead's discharges at the Cauvery dam are altogether greater than those arrived at by Kutter's formula, about double the latter in the lower stages of the river before the water begins to pass over the anicut, the discharges over the anicuts, as calculated by Captain Mead, become less than those now submitted after the water has risen to 11 feet on Cauvery dam, but are very much greater (in some instances four times as much) during the lower stages of the river.

And if we take the sum of the discharges through the Cauvery dam and those over the Upper Anicuts as the total discharge of the Agunda Cauvery, we have by Kutter's formula less than half the discharge allowed by Captain Mead, when the water on Cauvery dam is between 5 and 8 feet, and exactly the same discharge when the water is at 13 feet (or almost a maximum flood) on the Cauvery dam.

The irregularities of Captain Mead's discharges over the Upper Anicuts cannot easily be accounted for, even by taking into consideration the extra waterway of the tamboghie (or depression in crest of anicut), which was not closed until 1871 after his calculations were made. But his discharge through the Cauvery dam was no doubt augmented by taking the mean depth of water in the dam as the working hydraulic mean depth of the Cauvery.

Captain Mead's discharges at the Grand Anicut agree fairly with those now submitted up to a depth of 11 feet on Cauvery dam.

Discharges over Cauvery surplus works. The discharges over the other surplus works are inconsiderable, and need not be referred to here.

62. In making these comparisons it must be borne in mind that Captain Mead, in his report above referred to, has distinctly stated that the calculations submitted by him in 1866 were merely approximations, and when we take into consideration the more complete data which has been collected during the past decade, and the radical changes in the method of calculating discharges which have been suggested by the results of recent investigations, it is a matter for surprise that the approximate discharges now submitted should agree at all with those submitted by Captain Mead nearly 15 years ago.

63. No attempt has been made to gauge accurately the quantities of water passing through the Cauvery dam, as it is considered that the approximations now submitted are sufficiently near the truth to dispose of the subject now under consideration, viz: the regulation of the flood-waters of the Cauvery. It would, however, be satisfactory if these calculations were verified by accurate gaugings of the Cauvery at the Cauvery dam; and, in fact, it is absolutely necessary, for the economic management of the irrigation of the Delta, that this should be done for the lower stages of the river. But to do this, more efficient appliances than those at present available on the Cauvery will be necessary, and at least one or two steam launches will be required.

64. Should any operations of the sort be decided upon, the writer of this report knows of no one more capable in every way to superintend the operations than Mr. Hughes, Executive Engineer, most suitable person to superintend gauging operations. the intelligent and energetic Executive

Engineer of Tanjore, Mr. W. Hughes, who has afforded every assistance in procuring data for, and in some instances suggesting and verifying, the calculations now submitted.

CONCLUDING REMARKS.

The condition of the Water-supply of the Delta and the present state of the River beds.

65. In no scheme for irrigation is it possible to consider independently of each other the two most important subjects, viz., the condition of the water-supply and the disposal of flood-waters; nor is the irrigation of the Cauvery Delta, which is in some respects peculiar, an exception to this general rule.

66. From the foregoing observations, however, it is plain that, owing to the conditions of the Delta of the Cauvery, each river must, under any circumstances, carry a fair share of flood-waters, and the more accurately and carefully these floods are controlled and regulated at the head of each river, the less will be the work required to place them in a state of safety below. And it follows that if the arrangements for the control and regulation of the flood-waters are complete, they will be more than ample for the distribution of the water-supply, and consequently may be put in hand without further reference to the present or future condition of the water-supply.

67. But as the financial aspects of an irrigation project cannot be fully considered without a proper knowledge of the conditions of its water-supply, it will not be out of place here to make a few concluding remarks on the several points connected with the water-supply of the Cauvery Delta, which have been brought to light by these investigations.

68. If the calculations of the discharges by Kutter's formula, which are now submitted, are accepted as correct, it follows that, while the maximum flood discharges are greater than those which have hitherto been considered the maxima, the actual water-supply of the Delta is only about one-half what has usually been thought to be the case; and that, instead of the Delta receiving an abundant supply of 3 cubic yards per hour per acre, when there is 5 feet on the Cauvery dam gauge, it only receives $1\frac{1}{2}$ cubic yards, or less than what is considered a sufficient supply for the other irrigated Deltas of this Presidency.

69. This would at once account for the apparent waste of water in the Delta, and the persistent avidity with which the cultivators keep their sluices fully open even during high floods; and when we read the sagacious observations made by Major Oakes, R.E., at the 7th paragraph of his letter, No. 1464, dated 7th January 1868, with the light now before us, we will at once see the correctness and force of his remarks, to the effect that it would probably be the ruin of the Delta to limit the supply entering it to 3 or 5 cubic yards per hour per acre, or to any other specified quantity; and that, in fact, the proper supply of the Cauvery Delta cannot be estimated by the small intermittent quantities entering it during the lower stages of the river, and that in reality the Delta is not receiving a proper supply until the rivers are actually in "good flood" as any native of Tanjore would express it.

70. The actual water-supply of the Delta, being only one-half that which has hitherto been considered the case, the storing of the surplus water in the upper valley of the river becomes doubly necessary; and the very strong views which have from time to time been expressed by the Government of Madras are now applicable with double force. That the construction of reservoirs is feasible may be seen by a perusal of the Preliminary Report on the Bhavani Regulation Scheme, dated 3rd May 1880, and which was recorded with Proceedings of the Madras Government, No. 1196, dated 6th idem. The figures in that report were based on those which are now considered to have been excessive, and the probable supply from the Bhavani becomes proportionately lessened. The margin of the actual supply of the Bhavani over the quantity used will still, however, be very great; and the average annual supply from that river will, in any case, probably be not less than 40,000 millions of cubic feet.

71. As the average annual supply of the Cauvery is only one-half what has hitherto been estimated, the statement made in the Bhavani Report of the percentage of the rainfall in the valley of the Cauvery which can be utilized for irrigation will necessarily be materially modified, and if we take 10 inches of rain as the least annual average sufficient to cause water to run off the land, and if we allow that the percentage run off is in proportion to the total annual rainfall, the following rough rule, if applied to the upper basin of the Cauvery, gives the quantity run off equal to the estimated quantity that passes the head of the Seringam Island, and is as follows:—"The percentage of rainfall run off in a year is one-half the annual fall in inches above ten." That is, if the annual rainfall over a particular tract is 110 inches, the percentage of the rain that has fallen which runs off may be taken at 50 per cent., and if the annual rainfall is 40 inches, the percentage run off is only 15. Of course, as explained in the report on the Bhavani, no rule can possibly apply to every locality; the above statement has been made not with a view to laying down a general rule for guidance, but merely to show what a small proportion of the actual rainfall is usually available for irrigation purposes.

72. The only other subject which it will be necessary to refer to in this report is the state of the sandy beds of the deltaic rivers, which must always affect the question of the control of the waters. This no doubt is a very important point in the economic management of the irrigation of the Cauvery Delta; but the difficulty in the treatment of sand deposits is by no means so grave or so insurmountable as the tone and tenor of Colonel R. Strachey's memorandum, dated from Simla, 22nd October 1867, would lead one to believe. Had the Inspector-General for Irrigation Works possessed the experience of the local Executive, he would have known that the volumes of sand, which are the natural products of all the rivers of Southern India, are as easily manipulated as the floods which bring them down, and that the principle which was inculcated by Col. Caldwell, of the Madras Engineers, at the beginning of the century, which was endorsed by Colonel D. Sim, also of that corps, in his report of 1839, and which has since been successfully followed by the local Executive, viz., "to make the river itself the principal agent in discharging the mud and sand which its waters brought down," is quite sufficient, if carried out, to maintain the beds of the rivers in an efficient working state. An example of the changes, which can be effected in the sandy bed

of a river by the simple process of training with Nanel* grass and other plants, is given on Sections Nos. XXV and XXVI, Sheet No. XI, and of course the changes which are effected by the masonry regulators are still more permanent and complete at the heads of the different rivers.

73. The excessively gloomy views of the Inspector-General of Irrigation Works, were no doubt induced by a consideration of the novel, and somewhat expensive proposals, of the Revenue authorities for the removal of sand, from the rivers of the Cauvery Delta, by manual labor, as the only possible remedy for their then condition, and by the fact that these proposals were actually embodied in paragraph 3 of the Secretary of State's Despatch, No. 27, dated 14th September 1867.

74. The effects of the gigantic struggles of the Revenue authorities with the sand at the several bifurcations of the Lower Cauvery were plainly visible, some ten years ago, in the shape of huge, unsightly mounds of sand which poured their destructive contents over the adjoining fields by the strong winds prevailing during certain seasons of the year. If these mounds have not disappeared by this time, the simplest method of getting rid of them would be to return the sand to its proper place, viz., the river beds and let it move on.

75. As the control and manipulation of the sand along the river beds is effected with so much facility, the only possible objections to its entering the rivers of the Delta are—

1st.—The diminution of the waterway of the Cauvery at the head of the Seringam Island, by which the supply of water which enters the Delta in low freshes may be somewhat diminished.

2nd.—The silting up of some of the irrigation channels, especially those in the lower parts of the Delta, by the influx of sand through their head sluices.

The first objection is more apparent than real as will presently be explained. But the second is one that cannot be altogether avoided; it will, however, be greatly mitigated by the proposed open dam in lieu of the Grand Anicut; and it is believed that with a free passage from the Cauvery into the Coleroon at the Grand Anicut during floods the normal condition of the Cauvery would be established.

76. An examination of the corresponding cross sections, Sheets Nos. VIII to XII, will give a fairly accurate idea of the relative changes which have taken place in the beds of the Coleroon and Cauvery Rivers since 1833 before the anicuts were

* The method of using Nanel grass, &c., for the training and regulation of the rivers of the Cauvery Delta is given in a memorandum by the Chief Engineer for Irrigation, printed with Proceedings, Madras Government, No. 1194, dated 1st May 1874, and the following description of the plants used in the training of the rivers is taken from Ainslie's *Materna Medica of Hindoostan*:—

"Nanel (Nānil) (Tamil). Casia (Hindoole).

"Bello (Tulu). Saccharum spontaneum.

"This very beautiful grass, Sir William Jones tells us, is often described with praise by the Hindoo poets for the whiteness of its blossoms, which give a plain, at a distance the appearance of a broad river; the culm is made into mats for passing rivers; it is also much used in the Southern Provinces for thatching houses. Some of the larger stalks are occasionally used as pens for writing. Page 183.

"Sagareale, Hindoo name.

"Pay Kārunboe (Tamil). Dattā Gūra (Dak).

"Sor (Hind). Saccharum panicum Kōnig.

"With this very lofty grass the natives make roofs for their houses, rafts for crossing rivers, railings for their enclosures, and hies to carry dead bodies. Page 204.

"Three-leaved grass tree of Indian forest.

"Yeer Nāchle (Tamil).

"Pānki-Shārbū (Dak). Nāindā (Hind).

"Nān-vāli (Tulu).

"Vīlax Trāla.

"... takes its Tamil name from growing near water" Page 83.

constructed. The old cross sections, taken in November and December 1833, which are shown on these sheets, are unfortunately not complete; but although the portion containing the signature of the person who took them is not to be found, the sections were evidently taken with great care, and give a reliable idea of the relative levels of the two rivers in 1833. The reduced levels in red shown on the old cross sections at the Vadavagoody and Perimalecovil surplus works have been taken from the levels given on Captain Mead's sections of the Cauvery; and the details of the vents, with the cross stones and dam stones of the Vadavagoody surplus, have also been added without altering the original section. No reduced levels can be shown on the old sections in the vicinity of the Upper Anicut, as the masonry works were not then in existence.

77. From the cross sections it would appear that, while the bed of the Coleroon has deepened throughout, probably about 50 of a foot below Upper Anicuts, 64 of a foot at the 150 yards valingula, 1-96 feet at the Vadavagoody surplus, and 3-58 feet at the Perimalecovil surplus, the Agunda Cauvery in front of the Upper Anicut has sanded up about 5 feet, from which accumulation a mean depth of from 2 to 3 feet of sand is poured into the open head of the Cauvery. At 4 miles below the Upper Anicuts the mean bed levels of the Coleroon and Cauvery are shown to be nearly the same. Below this there is no evidence of any material change in the bed of the Cauvery until we come to the Perimalecovil surplus, where the sand appears to have increased by 1-21 of a foot. At this last point it will be observed that the Cauvery is diminished to about 300 or 400 feet in width.

78. We shall now, before concluding, make a few observations on the supposed evil effects caused by the accumulation of sand at the head of the Cauvery. evil caused by the sanding up of the head of the Cauvery at the Upper Anicuts, and give some suggestions for its remedy, which might be necessary, should the evil complained of be found to actually exist.

It will be seen from the Synoptical Table of discharges accompanying this report that although the volume of water which enters the Delta by the Cauvery dam is only 8,150 cubic feet per second when there is 5 feet on the gauge, the volume is increased to 16,500 cubic feet per second when there is 6 feet on the gauge. This latter quantity would give 2-67 cubic yards per hour per acre for the 800,000 acres irrigated, and when there is 6 feet on the Cauvery dam gauge only 1,100 cubic feet per second escape over the Upper Anicuts, so that the Delta receives very nearly a full theoretic supply of 3 cubic yards per hour per acre, before there is any great waste over the Upper Anicuts.

But under the present conditions, under which the Delta receives its water-supply, the question really is, not what is a theoretic continual supply, but what would be the quantity which the Delta could fully utilize in the event of a low fresh of, say, 8 or 9 feet on the Cauvery dam gauge during a precarious season when every cubic foot of water would be of great value for the cultivation.

79. The actual state of the river bed at the Cauvery dam during floods is not positively known, and what would be the extra discharge through the Cauvery dam, if it and the river bed below were perfectly clear of sand, is quite uncertain, and cannot be arrived at without careful sections and diagrams of the river in different stages, together with accurate gaugings of the stream.

80. Should further investigations prove that the evil exists, and that there would be any positive advantage gained by keeping the dam and the river below it clear of extra sand, it may be safely assumed that nothing in the way of a head sluice to the river could prevent the sand entering it, unless accompanied by most powerful scouring sluices in the anicut, with a waterway in some appreciable proportion to the waterway of the Cauvery itself. Such works, it need not be explained, would be very expensive.

81. Possibly a more efficient and less expensive method of keeping the sand from rolling into the Delta, and which has sometimes been suggested, might be the construction of a sand wall or low weir placed obliquely across the head of the Cauvery, with its crest a few feet lower than the crest of the anicut, and of such a length that the discharge over it, when the water in the river is on a level with the crest of the anicut, would, with a small head of water, be equal to the discharge through the Cauvery dam, if clear of sand. The depth of water on the Cauvery dam being of course diminished by this head. In this case also scouring sluices would be required in the anicut at the tail end of the sand wall, but they would not necessarily be so large as those that would be required, if a head sluice were constructed.

82. But as has already been said, this evil is more apparent than real. In the first place it is not known positively to exist; in the second, if it does exist, it affects the condition of the water-supply only—

(a. when there happens to be a drought caused by a failure of the north-east monsoon, and

(b) when a moderate flood happens to occur during the drought.

And the presumption is that if there is a drought caused by the failure of the north-east monsoon, there is not likely to be any flood in the river.

83. Should, however, it be found necessary at any time to increase the supply entering the Delta during low floods, crest planks worked from the bridge over the Upper Anicut will do every thing that is wanted. It is perfectly immaterial how much sand enters at the head of the Cauvery, provided it is allowed to pass back into the Coleroon at the Grand Anicut or at any other convenient point; it cannot possibly make the slightest difference to anybody or anything, whether a portion of the sand which has to be carried to the sea by the Coleroon is carried via Trichinopoly and Vennar head, or by the other side of the Seringam Island.

84. Prevention is, however, always better than cure, and as nothing should or need be left to chance either in the regulation and control of the floods, or in the supply of the water to the Delta of the Cauvery, the subject of the construction of storage reservoirs which has been so frequently brought to the notice of Government, and which would not only prevent all evil which may be apprehended from the existence of sand accumulations at the Cauvery head, but would insure the safety of the crops of the Delta during all droughts, "should not be lost sight of."

TRICHINOPOLY,
14th February 1881.

(Signed) P. MONTGOMERIE, Major, R.E.,
Executive Engineer on Special Duty.

*Received by the
6/3/81*

N^o 70-J

Note by the Chief Engineer for Irrigation

In June 1880 Major Montgomerie R.E. was deputed to complete the investigations commenced by Lt. Romilly in 1874, as to the Capacity of the Coleroon to dispose of the flood waters proposed to be turned into it at the Grand Anicut, as described in the papers printed in P. M. G. N^o 2116 dated 3rd September 1870.

2. Lt. Romilly made a complete survey of the Coleroon and he drew up a Report thereon which will be found in Appendix II to Major Montgomerie's Report. Lt. Romilly did all that he was intended to do i.e. he ascertained the circumstances of the Coleroon and provided most of the data to be used by the

the more experienced officers under whom he worked. Owing however to some discrepancies between the survey and cross sections of the river which might without difficulty have been set right, the information obtained by him was not then turned to account and until Major Montgomery was appointed to complete the long delayed full examination of the subject required by the letter of the 7th March 1871. N^o 81. S. from the Government of India, no officer was available to devote that close attention to the difficult and complex problems the solution of which was desired.

3. Major Montgomery has arranged all the data available in a manner which admits of its being used not only for the purpose immediately in view, viz. the settlement of the question of the regulation at the Grand Anicut of the quantity of

P.M.G.
28th March 1871
N^o 916.

flood water to be allowed to pass the Cauvery and Vennar below this point, and of the quantity which may be discharged into the Coleroon, but so as to bring out clearly the material influence of local rainfall draining off the lands South of the Cauvery and North of the Coleroon below the Upper Anicut, on the character and severity of floods in the latter river and throughout the Delta. The existence of a considerable amount of local drainage must have been known to the officers who prepared the regulation paper, but it must be supposed that they thought the quantities of water due to these to be of little moment compared with those due to the Agunda fairies freshes, for the proposals were based only on the fresh levels as registered at the Cauvery Dam and on the quantities therefore due to the freshes in the Agunda fairies which are

are there distributed between the Cooleroom and the Caucary. The data then available were materially less extensive, and less indicative of the actual circumstances than those which Major Montgomery has found available, but had the results then worked out been plotted in diagrams there can be little doubt but that the importance of the local drainage would have been recognized.

4. Major Montgomery divides the sources of floods or freshes into two parts termed the Upper and the Lower valley respectively the point of division being the upper Anicut, and for convenience he has designated the discharge of the Agunda Caucary in a high fresh a normal flood while a fresh from above the upper anicut enhanced by local drainage is called an abnormal

2
flood.

5. The information obtained shows that

(1) the character and behaviour of normal freshes is ascertainable, and has been ascertained with all necessary exactness. The quantities and the water levels at all the principal points have been determined, and any questions relating to these can be answered by inspection of the diagrams and tables.

(2) The data for determining the particulars of abnormal freshes of importance, in the past, with even approximate accuracy, are not available. The flood of 1858 was abnormal, and was the most severe on record, if the flood level at the Caucary dam which was about 3 inches higher than the great flood of 1818

may

may be taken, as an indication of the flood of 1818 no detailed information is to be found. Of that of 1858 the data for estimating quantities are in existence for only a few points, and have been made as much use of as was possible. The absence of complete data for abnormal floods is easily explainable. At the Upper Anicut or Fairway Dam registers of water levels have been maintained for a long series of years, and similarly at the Grand Anicut, at the other important surplus works, and at the Lower Anicut the water levels were recorded. On the Agunda Fairway there was no gauge higher up than that at the Upper Anicut. On the following the only points of registration were the Upper Anicut, the Grand Anicut and

the Lower Anicut or 3 points in 60 miles. Moreover the registers kept were not so detailed any where as to admit of the time at which the effects of local drainage began to be felt being ascertained. On the affluents from which the local drainage came there were no registers. All that can be now determined is approximately the maximum discharge at a few points, and the part of this probably due to local drainage, in other words the abnormal factor in the total.

(B) the determination of a probable maximum abnormal flood in the manner requisite to be of use in connection with this discussion is impracticable. It is possible to approximate to the maximum discharge from a given area, but not to that from a certain area with certain other

other lateral areas over which the rainstorm may pass in a variety of ways, no two of which will produce like results. All that can be said is that the flood of 1858 seems to have been due to a combination of unfavorable circumstances, and that the records of the few years available indicate that it is at least unusual for severe rainstorms to traverse the two sides of the lower valley, and the Upper Valley, at the same time, or at such intervals as to produce the most severe results. For 1858 it is not known what the absolute rainfall was. It was recorded in measures the value of which is not now ascertainable. The relative rain-

fall over most of the lower valley and over part of the Upper valley has been ascertained.

Vide Appendix
p. 6.

Portfolio No 1.
-do- sheets
No 2 & 3.

3
There are no records for the rest of the Upper Valley. For November 1871 and 1880 the actual rainfall has been shown.

(11) the fresher of the South West monsoon are normal or nearly so i.e. they are but little affected by drainage from the lower valley.

It is in the North East monsoon and generally in November that abnormal floods occur. The rainfall is then extremely heavy in parts of the lower valley, and also in parts of the Upper valley on the left or North side of the Azunda Cañon.

This rainfall appears to be a strong cyclonic in character, and it decreases in intensity as the distance from the Coast line increases. This seems to be the general rule with exceptions due to local causes such as hills

hills &c. as in the Nayar valley in November 1880, when the rain fall was much heavier than would have been expected from its distance from the Coast.

(5) the highest normal floods could be disposed of without difficulty by the Coleroon and the Cauvery with its effluents. This will be more fully demonstrated further on, but it may here be mentioned that with 13.3 on the Cauvery dam gauge the total quantity to be disposed of at the head of the Cauvery is cubic feet a second. 284,000

The Coleroon below the Cauvery present surplus works would dispose of cubic feet - 230,200

The Cauvery below its surplus works and the Vennar would carry cubic feet - 53,800

Coleroon in the abnormal 1880, in which the

Cauvery dam gauge read 13.3 as above conveyed - C.F. 284,000 and the Cauvery and Vennar, exclusive of local drainage received by the latter about C.F. 94,600 The total quantity to be disposed of on the meridian of Tanjore was about 400,000 cubic feet a second, of which 284,000 were due to normal and 116,000 to abnormal freshes. Of the latter about 75,000 fell into the Cauvery and Vennar, and only a very small part of this was got rid of by the Cauvery surplus works. For the Vennar there was no possible relief. The water it received had to be carried by it and its branches or spilled over the country. The Catchment basin of the Agnada Cauvery (the Upper Valley) is 27,000 square miles. The basins draining into the Coleroon aggregate

aggregate just under 1100 square miles; those into the Cauvery above the Vennar head 868 $\frac{1}{2}$ miles and that into the Vennar above Tanjore about 300 square miles. Below Tanjore there is no general drainage into the Vennar. These basins of the lower valley aggregate about 2270 square miles or say one-twelfth of the upper valley but the discharge was as 1 to 2.45 nearly.

In 1877 there was a nearly normal fresh of 12.4 on the Cauvery dam gauge. It passed through the Delta and did but little damage anywhere. When the Supp. Engineer 6th Division supposed that the Cauvery and the Vennar with their effluents could dispose safely of only the equivalent of a 10 $\frac{1}{2}$ feet fresh on the Cauvery dam gauge, he was mistaken as to the quantity

* Letter No 14644 - 7 Aug
1868 para 3 in
P.M. G. 18th March
1868. 4 $\frac{1}{2}$ 882.

represented thereby as entering the Cauvery at that point, for he assumed it to be 109000 whereas the actual discharge is only 78,600 cubic feet cubic feet a second, and that due to 12 feet on the gauge is 108,400 cubic feet of which only 46,900 have to be distributed between the Cauvery and the Vennar, the rest being discharged into the Coleroon by the existing surplus work.

(6) the regulation of the Cauvery at the Grand Anicut, so far as this means the discharge into the Coleroon of any considerable quantity of water in excess of that which was discharged therein in 1858 is impracticable. The Coleroon the Cauvery and the Vennar were all sorely overtaxed in that flood, and though some slight redistribution might have been possible and beneficial,

it

it is clear that the limitation of the discharge in the Cauvery and Vennar below the Regulators to 53,475 cubic feet a second, the quantity to which by the scheme of 1870 the supply was to be limited was out of the question. The difference between this quantity and that actually distributed between these two rivers would have been about 41,125 cubic feet a second, or more than one seventh of the discharge of the Coleroon. If moreover the discharge of the Vennar was not to have exceeded 20,175 cubic feet a second little or no water could have been admitted to this river at its head, seeing that it received from local drainage, about this quantity and the exclusion of its share at the Grand Ancient would have involved

the raising of the discharge of the Coleroon from 280,000 to 346,300 cubic feet a second, a quantity much in excess of its capacity.

- (7) the regulation of the discharge of flood water into the Coleroon at the Grand Ancient, and consequently of the water in the Cauvery and Vennar below this point is nevertheless of great importance because though in an extreme flood like that of 1858, accompanied by heavy local drainage it will not be practicable to do much to prevent excessive discharge in the Delta rivers, in floods of less severity the regulators will be of great value as distributors of flood water, and whenever, as in 1880, there is cyclonic rainfall on the South side of the lower valley, the mischief which

which this is liable to cause may be to a very material extent. It is obviated by shutting off from the Vennar the water coming down from the Agunda Cauvery until the local drainage has been disposed of. In November 1880 the quantity of water in the Vennar might have been reduced one fourth or one fifth, and had this been done the breaches which occurred would either have been wholly prevented, or they would have been slight. The Agunda Cauvery did not reach the maximum level of 11.10 on the Cauvery dam gauge until the evening of the 3rd day after the storm, and when this water came down the Coleroon having already disposed of its local drainage would have been able to carry off the water, which was in excess of that which could be conveniently sent down the Vennar. As it was the Vennar was first breached by local drainage

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added to the water received from the Cauvery, and then with a great deal of local drainage still coming in, the uncontrolled admission of its share of the high Agunda Cauvery fresh intensified the damage. Moreover it was shown by Major Oakes that the Vennar cannot be at present adequately supplied with irrigation water until the Cauvery is carrying much more water than is required for the whole Delta. The regulation will enable a proper division or distribution to be made at all times. They will not therefore be of only occasional value as flood regulators, but will be constantly in use to effect a proper distribution of the irrigation supply. Once in 40 or 50 years or it may be in a century, a flood like that of 1858 will be beyond their capabilities of control, and for this there is no remedy. The rivers generally

generally of the Delta must be made as capable as circumstances will permit of disposing of excessive floods, and each must do its own share of this duty. The regulators already constructed at the heads of the principal branches of the Cauvery and Vennar have furnished the means of effecting an approximately suitable distribution of flood waters, as well of the smaller supplies needed for irrigation.

6. To enable the regulation and disposal of flood water (in all but very extreme floods and perhaps partially in these) to be provided for at the Grand Anicut, it will be essential to place the Supt in charge of the regulating works in telegraphic or telephonic communication with

(1) the Lower Anicut

(2) the Vennar-Vettar regulators

(3) the Executive Engineer's office at Tanjore,

(4) the Upper Anicut. He will then be in a position to know precisely

1st how far the Coleroon can dispose of water in excess of the capacities of the Cauvery and Vennar;

2nd what the circumstances of the Vennar may be at the Vettar head, and at Tanjore, the lowest point at which drainage of importance is received by the Vennar, and he will know also what to expect from the Aqueduct Cauvery.

The Executive Engineer will also be able to direct the relief of the Vennar by turning more water into the Vettar, should the Vennar be receiving much water from local drainage between the Vettar head and Tanjore.

The following table will serve to illustrate how the Superintendent would proceed to act.

Normal levels of water corresponding to

to readings on the Cauvery Dam gauge
(i.e. the levels when there is little
or no drainage from the lower valley)

* Will be 189.24

Readings on Cauvery Dam Gauge	Grand ancient Crest 189.14		Coleroon gauge near Grand ancient Zero	Lower ancient Crest 57.10 (mean)	
Zero of gauge 236.16	Upper gauge	Lower gauge	Zero 189.63	Upper gauge	Lower gauge
10.0	193.10	189.20	189.60	55.90	53.40
11.0	193.90	190.60	190.95	57.30	55.30
12.0	194.65	191.65	191.95	58.75	57.20
13.0	195.70	192.55	192.80	60.35	59.00
13.3	196.10	192.80	193.00	60.60	59.30
Abnormal (1858) 13.3	202.87	—	197.37	63.10	61.78

Now supposing the upper gauge.
Grand Ancient to read 195.70
the Coleroon Gauge 193.00
the upper gauge lower ancient 61.50
" Cauvery Dam gauge 11.00
the Superintendent would know
1st that the Cauvery was receiving
water from the 868 square miles
between the Cauvery Dam and
Vennar head and that the quantity
was approximately 37600 cubic
feet a second; 2nd that the Coleroon
was receiving local drainage
from the 1100 square miles on its

North bank, and that the quantity
was approximately cubic feet
a second 72600. He would have
similar information for the
Vennar at the Vettar head and
at Tanjore, and he would know
in each case whether the rivers
were falling or rising.

He would have for his guidance
fixed maxima which by way of
example may be taken to be
at the Coleroon gauge pillar 196.32

" Lower ancient upper gauge 62.50
and he would not divert water
from the Cauvery so as to exceed
these limits, which would be
somewhat below the levels of
1858. He would further admit
to the Cauvery below the regulator
anything less than the quantity
fixed as the equivalent of the
discharge of 1858, if necessary
to prevent the Vennar carrying
more water than that of 1858,
all which details would be
laid down for him. Otherwise

he

he would divide the water to be carried by the Cauvery and Vennar respectively according to their shares which would be tabulated for each foot on the gauge at the Vellar head, and on a gauge to be set up at Tanjore.

It ^{would} not be possible for him to diminish the discharge into the Coleroon by the Grand Anicut below what would be proper, because that will be a self regulating work discharging a fixed quantity at each water level unless this be enhanced by the working of the regulators.

7. The only alterations in the design of the regulators for the Cauvery and Vennar, found to be necessary are

(1) the raising of the bridge roadway from 205.24 to 207.24. The Grand Anicut bridge was designed to be 207.24, and that is high enough.

(2) the modification of the level

and arrangement of the shutter platforms to admit of the shutters being raised, if necessary above future M. F. I., which is calculated to be 200.50 at the Upper gauge Grand Anicut.

8. It is calculated that the alteration of the Grand Anicut will reduce the F. I. in the Cauvery 2.37 feet, and that the discharge there, instead of a short distance below it, the Koviladi and Vadavagudi surplus works, of about 12,000 cubic feet, a second well reduce the F. I. in the Cauvery below the regulator by 1.50 feet or to 199.00. Below Vadavagudi of course, in a flood like that of 1858 there will be no material alteration of F. I.

9. Major Montgomerie has recommended the removal of the Grand Anicut and the construction in lieu of it of a regulator like that

Report
para 44.

to be constructed for the fauvry
and Vennar. This surplus work
is however very efficient as is
shown by the way in which it
has hitherto disposed of vast
quantities of flood water, and
as it withstood the greatest
flood on record without injury
it must be whatever the details
of its internal construction,
a fairly sound work. When
the arches have been raised
5 feet, as intended, it will
discharge the maximum required
viz about 85,000 cubic feet a
second with a smaller head than
heretofore, and therefore with
less strain. It has a set of
undersluices, and though were
a new work to be constructed
it would be desirable to increase
materially the waterway at a
low level i.e. at or below the
level of the fauvry bed, and

to place it in a different position
viz nearly at right angles to the
direction of discharge, these
improvements are not so essen-
tial as to make it necessary to
abandon this large and powerful
weir. Were it necessary that it
should discharge 18,000 cubic
feet a second as mentioned
by Major Montgomery a new
work would have to be built,
but even he does not suppose
that it and the two smaller
surplus works below have
ever discharged more than
93,500 cubic feet, and as designed
it could, if necessary discharge
100,000 cubic feet with an increase
of 0.90 feet to the head or with
the M.F.L. raised to 201.40 which
would still be 1.47 feet lower
than the F.L. of 1858. Should
more undersluices be hereafter
found desirable they can be

introduced

introduced into the present work with no more difficulty than was experienced in building those now in use.

10. In para 35 of his Report Major Montgomerie has given an estimate of the quantity of flood water which had to be disposed of in 1858 and of its distribution. There is one item in the statement viz the drainage from the 868 square miles between the head of the Cauvery and that (present) of the Vennar which is considered to be excessive 1st because the discharge attributed to the area mentioned is greater than was probable, 2nd because this basin being to the Eastward of the Country from which the maximum discharge in the Agunda Cauvery was derived, whatever the maximum was

it would have passed before the Agunda Cauvery reached its maximum. Taking these circumstances into consideration and accepting this officer's estimate of the quantities in the Plerow and Cauvery respectively it is believed that the following figures afford a closer approximation to the actuals of that flood. all quantities are in cubic feet a second.

Agunda Cauvery	284,000	
	Cauvery	Cobron
At head of Seringham island	135,000	149,000
Surplus at 150 yds Calinga tal.	10,000	10,000
	125,000	159,000
Local drainage from 868 square miles	54,600	
at Vennar head -	179,600	159,000
Discharge by Grand ancient Coviladi & Vadavanasu weirs.	85,000	85,000
Below the surplus works -	94,600	244,000
Local drainage from 1100 square miles		11,000
	94,600	255,000

The Cauvery discharge was then divided somewhat thus

	Cauvery	Vennar
	60,200	34,400
Local drainage from 300 square miles.	-	20,600
	<u>60,200</u>	<u>55,000</u>

It of course does not follow that the quantities shown as due to local drainage from the basins of the lower valley were the greatest discharges from the areas named. All that is advanced is that they were probably the maxima at the time the freshes due to Agumda ^{water} Cauvery were at their highest.

There was a case in point in November 1880. The Vennar a short distance East of Tanjore had a high flood on the 22nd due to local drainage chiefly and again on the 25th due partly to local drainage and partly to Agumda

Cauvery water. The water levels were about the same on both occasions and as the quantity due to the Agumda Cauvery is approximately the same the difference between the maximum and subsequent quantities of local drainage is deducible. On the 22nd the discharge was about 31,400 cubic feet a second of which 26,730 were due to local drainage. On the 25th 17,060 were due to local drainage, and the rest of water coming from above the Vennar head.

11. All severe abnormal freshes are caused by rain storms passing from the Eastward to the West. Therefore the lower valley gets the rain before the upper valley and the drainage from the former is at its maximum before the Agumda Cauvery freshes can attain a maximum and travel down to the points in the Delta

at which the lower ^{valley} drainage valley falls in. This consideration negatives the supposition that the total quantity to be disposed of at one time can be any thing like as much as that shown in Appendix 1. to Major Montgomery's report, viz 640,228 cubic feet a second. Probably it did not exceed, in 1880, somewhat less than two thirds of that quantity.

Coleroon 285,000
 Cauvery below
 surplus works 94,600
 Vennar
 local drainage 25,600
* 405,200

12. Major Montgomery's estimate of the maximum flood discharges from the basins of the lower valley are based chiefly on the evidence of the quantity draining off the country to the North of the Coleroon ^{between} the Upper and the Lower Anicuts, as shown by the discharge over the lower anicut in November 1871, when little or no water was being received by the Coleroon either at the upper Anicut or at the Cauvery surplus works. The deduction from the registered water level is indisputable, and all that can be said is that it needs confirmation from other

Report
 para 23.

observations. The coefficient in Ryves' formula for the discharge found is nearly 1220, while that deduced from an apparently equally heavy rainfall over the area draining into the Vennar in November 1880 is about 670. There is evidence in the damage sustained by the Weyaccondan channel near Trichinopoly in 1858 that the flood from part of the basin of 868 square miles above Vennar head was very severe but hardly that it was of such severity as would result from a coefficient of 1200. The valley of the Vellar adjoins the basins which discharge into the Coleroon, and in November 1871 there was a high fresh which was the highest on record prior to that of November 1880, but the coefficient in the latter year did not exceed 600 for the basin of 2850 square miles above Shattalpe and for the upper part of the Valley 1600 square miles where the rainstorm of 1880 was particularly severe

severe the coefficient deduced is 621. The highest coefficient yet met with elsewhere is that for the Tamharaparni, the fresh of 1877 at Sivachumtham amount, from 1750 square miles, giving a coefficient of 847 and as there was some spill on both sides of the river the actual coefficient may have been somewhat higher. This river is noted for the severity of its floods and in the year named many tanks breached and poured their contents into it.

Altogether then even were the evidence in support of the discharge of the flood in 1871 - 72 capable of complete demonstration instead of being dependent upon a single set of entries in the register kept at the Anicut, it would not be safe to generalize from this one occurrence, and to assume that the maximum

discharge from the basins of the lower valley generally may be based thereupon.

13. The following table compares Major Montgomerie's Calculations of the discharge of the Cauvery with those which were made in 1866 and used in 1870 in connection with the proposed regulation of the Cauvery.

* Vide statement
F in P.M.G. No.
775- 14 March
1867.

	Readings on Cauvery Dam Gauge	Major Montgomerie		As calculated in 1866.	
		Discharges at Dam	Below surplus works	Discharges at Dam	Below surplus works
N.B. The quantities entered in the column "Below surplus works" are distributed between the Cauvery and Vempar.	Feet. inches	C.f. a second	C.f. a second	C.f. a second	C.f. a second
	5 . 0	8150	8150	14,340	14,340
	5 . 6	12,100	12,100	19,778	19,695
	6 . 0	16,500	16,500	25,200	24,300
	6 . 6	21,500	19,500	31,613	27,165
	7 . 0	27,230	22,730	38,010	31,192
	8 . 0	39,600	26,650	52,890	37,155
	9 . 0	54,200	31,700	69,900	41,812
	10 . 0	70,000	36,200	88,875	47,040
	11 . 0	87,800	40,900	109,163	53,415
	12 . 0	108,400	46,900	133,122	66,822
	13 . 0	130,200	52,800		
	13 . 3	135,000	53,800		

The

The above are the quantities due to normal freshes or those unaffected by local drainage from lower valley. The calculations of 1866 were based on the formula $V = 93.3 \sqrt{r.s}$ which is now known to be incorrect except at much greater hydraulic mean depths than are met with in these rivers. Major Montgomery's figures have been obtained by Kutter's formula which is that best suited to determine river discharges. The quantities are probably fairly accurate as the depths and corresponding discharges, when there are more than 5 feet of water in the fanny, are close approximations to the proportions obtained from the equation to the parabola. When the river is lower than 5 feet on the Dam gauge the irregularities of its bed make the discharges less than the normal. Major Montgomery has noticed that his calculations show

Appendix A,
to Capt Meads
report M.M.
No 775-14 June
1867.

that when the Delta has been supposed to be receiving a full supply of water the irrigation has been very indifferently supplied if the quantities used elsewhere be taken as a guide. What has, by local officers in the past, been called the theoretical full supply was 20 cubic yards per acre per hour, equivalent to in round numbers 3 cubic yards per acre per hour or 1 cubic foot a second for 44 acres. The area of irrigation being 822,000 acres it would follow that 4,682 cubic feet a second would be needed, and this ^{was} supposed to be provided with rather less than $5\frac{1}{2}$ feet on the Dam gauge though, owing to material inequality of distribution the fanny was well supplied with just under 5 feet on the gauge, and the Vennar not until the reading was 6.4 feet. The present calculations indicate that with 5.7 feet on the gauge, enough water

Table A.
P.M.G.
20th July 1874.
No 417.

water passes down to afford
1 cubic foot a second for every
66 acres, were the Venmar to get
its fair share as it will do
when its head has been shifted
to the Grand Anicut, and no
doubt as elsewhere this quantity
is sufficient. So far as irrigation
water is concerned, the meir
calculations only show that
the quantity of water experimentally
known to be sufficient is much
less than had been supposed.

14. The effect of the investigation
as to the influence of local
drainage will be to make it
necessary to retain a greater
width of waterway in all the rivers
of the Delta than would
have been requisite had the
proposals of 1870 been feasible.
e.g. the proper normal width
for the conveyance between the
Grand Anicut & the Kodamurti

70
head will be 900 feet. This width was
fixed temporarily pending the construc-
tion of the regulators and it will now
be the proper width to retain permanently.
Some parts are considerably narrower
but generally except where reformed
above the head of the Kodamurti
it is considerably wider.

The following table for the Venmar,
in which the entries from Major
Oakes' tables have been taken from
P.M. G. et al. 1144 dated 29 April 1870, will
give a tolerably complete idea of the
difference between the requirements
as formerly and now determined. It
cannot of course at present be
concluded that the distribution
of flood water will be exactly in the
proportions settled by Major
Oakes. This will have to be arranged
on a more complete examination of
the Capacities of the several rivers
which examination did not fall
within the limits of the investigations
undertaken by Major Montgomery.

Distribution

on record to show what the exact circumstances of the rivers then were. All that is known is that the inundations were very extensive and the damage sustained great, from which it may be inferred that their capacities for the disposal of the flood water then traversing the Delta were very inadequate. It may perhaps be concluded that it is not likely to be practicable to make or, even if this be possible, to keep these rivers in a condition suitable to dispose of a flood of great severity occurring once in 40 or 50 years or it may be in a century. It will be possible to make the most of the rivers, but this most may fall far short of the demand made upon them at such times. If however the flood waters can be carried in safety through the Delta to some 15 or 20 miles to the Eastward of Tanjore, they will then be so far subdivided as to make the inundations

resulting from spill or breaches in the embankments of much less consequence than would be the case were all control lost as in 1858, much higher up the Delta.

16. Seeing by how much the quantities to be dealt with altogether differ from those given in 1870, the answers which can be given to certain questions asked in the letter from the Government of India are perhaps of little importance apart from the connected circumstances. It may be however convenient to give them.

The $1\frac{1}{2}$ millions referred to in para were included in the 26 millions of cubic yards. The point of discharge was alone to be altered, making it slightly higher up the Cauvery viz at the Grand Arcot.

Para 10 - The maximum discharge or that in the highest known fresh of 13.3 is found to be 284,000 cubic feet a second or 37.867 millions of cubic yards per hour.

The

The difference between this and 7.13 millions would be 30.73 millions or 230,530 cubic feet a second. The Coleroon now carries 230,200 cubic feet in a normal fresh of 13.3 feet on Cauvery Dam and it carries 244,000 exclusive of local drainage from the country on the North bank, or 285,000 cubic feet inclusive of that drainage in 1858. Were the offtakes of the Cauvery and Vennar at the Grand Anicut to be absolutely limited to 7.13 millions of cubic yards or 50,475 cubic feet, the Coleroon might have to carry 44,125 cubic feet additional, and this it could not do, at all events while the differences in the waterway are as considerable as at present. So far as ordinary Conservancy operations will secure this and if steadily persevered with they may be expected to effect it, the Coleroon should be made

Capable of carrying 250,000 cubic feet without strain, and perhaps 300,000 on emergency.

Para 11 - The Lower Anicut could not discharge more than in 1858 without serious risk of damage. In that year the water on the Upper gang was about 2 feet higher than is safe with the arches at their present level. The present length is 2116 feet. The island between the two Branches is 1285 feet in width, so it would be possible to add 60 per cent to the capacity of discharge of this weir. It discharged something under 260,000 cubic feet in 1858.

North Branch 1048
South - do - 1068
2116

17. With regard to para 15 of the same letter from the Government of India it is considered that as the depth of water to be retained ordinarily by the shutters on the crest of the Grand Anicut is small the inexpensive kind of shutters proposed in 1870 will be easily manageable and it is

not

not necessary to substitute the
much more expensive shutters
in use on some of the weirs in
Cuttack and Midnapoor. The
Grand Aricut is a simple
work and the circumstances
are somewhat different from
those of a weir across a river.
One modification will be however
made viz. the omission of the
horizontal bar for disengaging
the hinged shutters, which bar
might catch drift and rubbish,
and the substitution of a single
stud hinged at the lower end
and secured at the upper end
by a simple locking arrange-
ment which will be released by
a small chain to the bridge
roadway. As regards the shutters
same kind as other regulators
are found to work easily without
rollers, and probably with 10 feet
vents are cheaper than would
be larger vents with rolling

shutters. The arrangements for
working the shutters have how-
ever been altered to suit the
altered conditions as now deter-
mined and to admit of the
fauvery and Vennar taking off
their full shares of extreme floods
when the Coleroon discharge
cannot safely be increased.

18. The general conclusions arrived
at as a result of the investigations
made by Major Montgomery
are:-

1st that the need of regulation of
the distribution of irrigation
water to the fauvery & Vennar
respectively has been brought
out more clearly. The regulator
will increase the time during
which the Delta will be
sufficiently supplied by nearly
2 months, and as the area
interested in the improvement
is nearly half that of the
total of the Delta, or more

than 390,000 acres, the importance of the regulating works from this point of view alone is great.

2nd that except in abnormally great floods like that of 1858 the value of the regulators for the distribution of flood water will be great, but that the details of the regulation at any given time must be based upon information then obtained as to the water levels in the Coleroon & Vennar.

3rd that in an abnormal flood of the severity of that of 1858, but little if any relief can be afforded to the Delta unless and until (1) the inequalities in the discharging capacity of the Coleroon are remedied by steadily continued Conservancy operations, having for their object

the removal of obstructions now curtailing the waterway of certain parts of this river, and the establishment throughout of normal widths of waterway, proportioned to the requirements, as regards discharge of each part. Below the infall of the last of the bank drainages to the Lower Anicut, a maximum discharge of 260,000 cubic feet for the present and ultimately of 300,000 cubic feet a second should be arranged for. The reformation must be gradually carried out, but it should be continually in progress during the proper season, and care must be taken to secure and maintain the work done up to any given date; (2) the waterway of the Lower Anicut has been increased, this could be secured by raising

raising the bridge over it, for
it is the low level of the bridge
which limits the discharging
capacity; or by extending the
weir across the island, and
the relative merits of the
two arrangements should be
worked out. Apart from the
question of regulation of
the flow at the Grand Anicut
it is evidently desirable that
there should be a greater margin
above F. I. than is the case
at present; a third way in
which more waterway could be
obtained would be by lowering
the crest wall and using shutters
to retain water, at the level of
the present crest, with however
more reliable alternatives;
it will be better to adopt
one of these unless shutters
should be found to be much
less expensive with equivalent
results.

F.I. 1858 - 63.10
Soffit of arches
Route Branch. 63.50
Roadway (present) 65.50
Top of parapet. 68.43

14^{thly} that in carrying on the ordinary
river Conservancy operations
in the Delta, the normal widths
of waterway of the several
parts of the many rivers by
which flood waters are
carried to the sea must be
based upon the quantities
now ascertained as needing
disposal. A table of normal
widths at each mile for
each river should be compiled
as soon as the best distribu-
tion of the maximum flood
discharge has been arrived at.
15^{thly} that a minimum width between
the flood banks of each river
will also have to be fixed,
and the present flood banks
must be reticled where found
to be too close together.

19. There are some matters noticed
in the concluding remarks of
Major Montgomery's Report,
which

which require brief notice here, though they are for the most part connected rather with the general efficiency of the Delta irrigation than with the question of the regulation of the flow at the Grand Anicut.

- (1) Construction of reservoirs to extend the duration of moderate freshes.

The subject has engaged attention during many years and but for the inability of the P.W. Department to find officers for this special duty, the question whether at all or at any reasonable cost, a material proportion of the discharge of the Cauvery and its tributaries when in excess of the current demand for irrigation can be impounded

would have been settled long ago. It is thought that the feasibility of forming a reservoir on the Showani, referred to in para 70 of the Report has not by any means been as yet established but further investigation should be made as soon as may be practicable.

- (2) Changes in the river bed's Report para 77.

Much importance need not attach to the local deposit of sand above the upper anicut. Major Montgomerie thinks that it forms a bank from which 2 or 3 feet of sand are poured into the open head of the Cauvery, but really the presence of the sand above the anicut, which is practically

a fixed deposit, indicates that it is not from this source that the sand which enters the Cauvery is derived. As the freshes in the Agunda Cauvery rise, and fall more or less sand is under transport, and the sand deposited on the Cauvery Dam varies according to the depth of water thereon, there being little when the water is deep, and the velocity considerable, and much when the circumstances are reversed. That this is the case Major Montgomery has himself shown. That the Upper Anicut has diminished the quantity of sand which formerly passed into the Coleroon at that point is certain, but the state of the beds of the Coleroon & Cauvery 4 miles below that Anicut indicates that in some 45 years no material change has taken place; and since the water

14. 51
distribution in the Delta has been facilitated by the construction of regulators at the heads of the principal branches of the Cauvery and Vennar, no inconvenience from sand in the lower parts of the rivers has been brought to notice. So long as these heads were unregulated, the water supply to the rivers having a smaller fall than their peers was necessarily very indifferent, and the regulators have remedied this; while much sand, which would have otherwise remained in the rivers having a comparative small fall, has been passed on to the sea.

Chepauk
8th April 1881

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3
3
Signed / John Mullins, Col. R.E.
Chief Engineer for Irrigation

P.N. 3416

Nov 8 June

Encls. 2

Statement showing the estimates for the head sluices for the Quarry and the Vernau rivers and the lock and basin at head separately.

Description of Charges	Rate per	Quarry Head Sluice		Ternau Head Sluice		Lock & Basin		Total	Remarks						
		Quantity	Amount	Quantity	Amount	Quantity	Amount								
Brick in Chunam	0 2 6	C.ft.	29998	16716	8 6	23386	26583	4	6	12244 5	12694	6 9	61607 5	12264	11 9
Cut stone	1 0 0	do	26720	26720	4 0	27985	27985	10 0	0	3701 5	3701	0 0	6538 5	12386	8 0
Rough stone in Chunam	0 6 0	do	22045	8266	4 0	7394	6575	4 0	0	0	0	0	3711 9	4782	2 0
Rough stone pitched	3 8 0	C.yd	5892	17597	0 0	4632	16212	0 0	0	366	1281	0 0	10000	35000	0 0
Plastering	2 8 0	Square	490	1256	0 0	385	962	8 0	0	175	437	8 0	1050	2625	0 0
Excavation & filling	0 3 0	C.yd	22096	6628	0 0	22890	4288	2 0	0	6486	1216	2 0	51452	9647	4 0
Making road	0 2 0	do	7895	986	4 0	4524	340	15 0	0	1308 5	1635	13 4	28509 5	3563	10 4
Graveling	1 0 0	do	289	289	0 0	289	289	0 0	0	581 5	581	0 2	1097 5	1097	0 2
Shaling	2 4 0	Square	4972	1176	4 0	5700	8255	0 0	0	1328	2985	0 0	10075 5	29869	4 0
Iron girders	0 2 3	do	46902	9409	3 11	52522	7392	15 8	0	160 7	623	8 0	19482 5	16802	3 7
Teakwood shutters	4 0 0	C.ft	1785	7140	0 0	1402 5	5610	0 0	0	0	0	0	3348 5	13393	8 0
Derrick with pinch stays	7 50 0	each	0 0	0	0 0	0	0	0 0	0	0	0	0	1	750	0 0
Pair of lock gates 1 1/2 high	15 0 0	pair	0 0	0	0 0	0	0	0 0	0	0	0	0	1	1575	0 0
do 16 1/2	150 0 0	do	0 0	0	0 0	0	0	0 0	0	0	0	0	1	1500	0 0
Teak wood posts and rails	1 8 0	C.ft	109	238	8 0	159	288	8 0	0	0	0	0	318	477	0 0
Embankments to protect work while under execution	0 0 0	do	0 0	0	0 0	0	0	0 0	0	0	0	0	0	4300	0 0
Surpluses and Contingencies	0 0 0	do	0 0	0	0 0	0	0	0 0	0	0	0	0	0	23256	2 2
			159000	0 0		125890		31200	0 0					319090	0 0

Cauvery Delta System

Classified Abstract of the Estimates for constructing works for the regulation of the Cauvery and its branches in the Tanjore District.

Subheads	Names of Works	Amount of individual estimate	Total of each Subhead	Total	Remarks
1	2	3	4	5	6
	(1) <u>Head Works.</u>				
G. Works	Grand ancient alterations	50,600			
	Dam at Vennair head—do	11,060	61,660		
H. Buildings	Executive Engineer's Bungalow	4,360			
	Office and Godown—				
	Superintendent's quarters—	3,150	7,490	69,150	
	(2) <u>Main Canals & Branches</u>				
	<u>Cauvery</u>				
D. Regulators	Head sluice—	1,59,000			
	Screw gearing—	6,720	1,65,720		
L. Navigation works	Lock and basin—	3,200			
	Lock shed and store—	770	3,1970		
H. Buildings	Shutter shed—R. B.—	1,610			
	— Do — L. B. —	1,780	3,390	20,100	
	<u>Vennair New Head</u>				
B. Land	Compensation for land—	29,100	29,100		
D. Regulators	Head sluice—	1,28,890			
	Screw gearing—	5,280	1,34,170		
H. Other Cross drainage works	Under Tunnel R. B.—	11,020			
	Tunnel 2' span L. B.—	1230	12,250		
H. Buildings	Shutter shed, L. B.—	980			
	— Do — R. B. —	1,780	2,760		
L. Earthwork	Excavation—	51,090			
	Revetment R. B.—	17,800	68,890	24,170	
	Total (2) Main Canals and Branches —			4,48,250	

Sub heads	Names of works.	Amount of individual estimates	Total of each subhead	Total	Remarks
1	2	3	4	5	6
	(3) <u>Distributaries</u>				
	<u>Tennaur new head</u>				
	<u>Pillay Norkal</u>				
C. Works	Head sluice	2450			
	Sluice	410	2860	2860	
	Total for Works			520260	
	Establishment at 25 per cent			130065	
	Tools and Plant at about 5 per cent			26175	
	Total Direct charges			676500	
	<u>Indirect charges.</u>				
	Capitalized abatement of land revenue			36375	An approximation arrived at by dividing the amount for compensation for land by 20 to find the annual Revenue lost & then capitalizing it (25 times the Revenue)
	Leave & pension allowances			27639	25 per cent on the amount for salaries which is 85 per cent on the establishment charges
	Loss by exchange				
	Interest during construction			60352	Assuming that the works will be completed in 5 years the probable outlay being taken as 120260 for the 1st year and 100000 for each of the subsequent years.
	Total Indirect charges			124366	
	Total Direct & Indirect charges			800866	

120,260 would be spent in 1st year
 & 2 lacs a year subsequently. All
 could be done in 5 years.

1071

Pk. 3416/87

Note by Colonel John Mullins R.E.
Chief Engineer for Irrigation No 71-2
dated 8th April 1887.

No 71-2.

Note by the Acting Chief Engineer for Irrigation

The above Note was written by
Colonel Mullins, and left in the
office with instructions that
when the estimates were received
from the Government of India
the alterations he proposed
should be made before submitting
the papers.

2. The estimates have been received
and it will take some little time
to make the necessary drawings
and recast the estimates, but it
appears

appears that by a reduction in the masonry and more extended use of concrete than provided for in the original plans, the amount of the estimates will be very slightly altered.

3. As the designs, which are now to be very slightly altered, have been before the Government of India since 1870, it seems desirable, to save delay, to submit the papers at once for consideration of the Government of India leaving the revised estimates to be forwarded when completed.

Cotacampus.

11th May 1881.

3rd Inst.

Lt. Colonel. R.E.

Ag. Chief Engineer for Suez.

To

The Ag. Joint Secretary to Govt

P.W.D. Suez Canal

P.W.C. N. 3417

No 363 J

PUBLIC WORKS DEPARTMENT.

PROCEEDINGS OF THE MADRAS GOVERNMENT.

UNDER date the 9th June 1881

Read the following:—

*with the
4/6 208/107 4/2/2*
Report by Major. Montgomerie } (H.E. no — of 16th July. 81.
J. R.R.

Note by Col. Mullins R.E. } (H.E. no 72. of 8th April 1881

Note by the ap. chief of } (H.E. no 72. of 11th May 1881.
Engineer for Irrigation

Res. 8 June.

Ordered that the foregoing papers be submitted to the Govt of India with reference to letter from the off^r Deputy Secretary to the Government of India no 81. J. dated 7th March 1881.
2. The plans & estimates which require revision will follow as soon as

4 5/6/81
25/ 35/6 - 12 3/4 10/0

as possible, it being
understood that the
revised estimate will
not differ materially,
as regards the amount
required for works,
from the abstract
estimate now forwarded.

For
No. 364 J. dated 28/5/81 June 1881
Forwarded.

Lt Col. M.
Adj. Gen. to the
Mys. B. Co.

C. E. for J.

Despatch
No. 363-4, has this
day, been despatched,
to the Govt. of India
and the Chief Secy,
please send the usual
number of spare copies.

27/6

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Enclosures to G. O. N^o 363-4 & 9th
June 1887 forwarded by the ~~United States~~
~~Commissioner~~ ~~Commissioner~~
on the 25th June

1. Report on the River Coleroon and the
Regulation of Canvey floods by Major
S. Montgomery, R.E.
2. Appendices to the above.
3. N^o 1. Portfolio
Maps & Sections.
4. N^o 2. Portfolio.
Water Diagrams
5. File of papers connected with the Water
Regulation of the Canvey Settles.

Please perhaps
with original
for
22/6

28-5-20 ✓
21-2-28 III

247
GOVT. OF 1881
PUBLIC WORKS.

Dated

From

To

For

6. 7 June 1881, No. 363
364

No. 1/2/2

on Investigations

where regarding the
connected to the

on Investigations

2/2/