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CONNECTED WITH THE

CAUVERY RESERVOIR PROJECT

VOLUME V

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CAUVERY RESERVOIR PROJECT

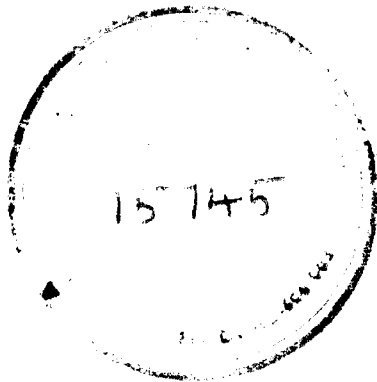
VOLUME V

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REPORT ON THE SECOND REVISION OF THE UNSANCTIONED
ESTIMATE FOR THE CAUVERY (METUR) RESERVOIR
PROJECT.

Extension of ayacut proposed in first revised estimate.—The first revision of the estimate, carried out in the year 1916, was necessitated by the reduction that would be caused in the river supplies on those originally anticipated owing to the construction in Mysore State of a reservoir on the Cauvery. The question of the construction of this reservoir formed the subject of an arbitration in the year 1913-14 and, when the Government of India confirmed the award in the year 1916, the working of the proposed Metur Reservoir was examined with reference to the probable supplies that might be expected under the operation of the award. As a result it was decided to retain the originally proposed capacity of the reservoir and to reduce the area to be irrigated by 32,396 acres of first or single crop and 70,000 acres of second crop. This reduced the extension of irrigation to 65,000 acres of second crop in the existing delta area and to 217,000 acres in the new area of which 10,000 acres would be double cropped. It was also proposed to supplement the supply to 80,000 acres irrigated under tanks in the new area.

2. *Previous working tables of the Metur Reservoir.*—The working tables of the proposed Metur Reservoir, which accompanied the original estimate, covered the twenty years ending 1910. Those accompanying the first revision of the estimate, prepared in 1916, were for thirteen years ending 1908, these being the only ones for which the discharges at Kannambadi, the site of the Mysore Reservoir, were available.

3. *Discharge of Cauvery above the Mysore Reservoir.*—The discharges at Kannambadi for the years 1896 to 1908 were not on a very sound basis, and are not available for the years 1909—1915, but since 1916 gauges on the three rivers above the reservoir have been calibrated by joint gaugings made by Mysore and Madras and the discharges deduced therefrom are accepted by both parties for the regulation of the Mysore Reservoir.

4. *Discharge of Cauvery at the Cauvery Dam, Upper Anicut.*—Joint gaugings have been made of the Cauvery at the Cauvery Dam (Upper Anicut) every year since 1916, and it will be seen from paragraphs 1 to 4 of Appendix I to this report that the discharges based on the gaugings of 1909, the basis of previous working tables, were considerably under-estimated. A comparison of the revised discharges at the Upper Anicut and those at the Bhavani Bridge is made in paragraphs 5 to 11 of Appendix I and it points to the latter being under-estimated. These were taken as the impounding basis for the previous working tables of the Metur Reservoir.

5. *Losses in transmission.*—The subject of transmission losses has been examined closely since the last working tables were prepared when a considerable length of the river above Hogenkal has not been explored, and it has become evident that the provision made for loss between the Mysore Reservoir and that proposed at Metur was largely in excess of that likely to occur. Further examination of the possible losses between Metur and the Upper Anicut also indicates that these have been greatly over-estimated. The question of losses in transmission is dealt with in paragraphs 12 to 19 of Appendix I to this report.

6. *Probable reduction of effective capacity of Metur Reservoir due to silting.*—In Part VII of Volume III of the printed papers connected with the Metur Project, the question of how the gross and effective capacity of the reservoir would be

affected by silt has been discussed and the conclusion arrived at was that the effective capacity would not be materially affected for fifty years or reduced by 12½ per cent before a 100 years. The proportion that the annual flow of the Cauvery at Kannambadi bears to that at Bhavani Bridge varies, but averages to about 50 per cent and assuming that the percentage of silt carried by the rivers contributing the other 50 per cent is the same, it may be reasonably presumed that the Mysore Reservoir will intercept half the silt or sand that would have been deposited in the Metur Reservoir and that the capacity of the reservoir will not be reduced to less than 80,000 mills. cubic feet under 100 years. It is proposed to retain the construction sluices as irrigation sluices and to increase the original effective capacity to 90,000 mills. cubic feet and, for the purpose of preparing working tables, an effective capacity of 82,000 mills. cubic feet has been taken instead of 80,000, the figure adopted in previous tables.

7. *Revised working tables of the Mysore Reservoir.*—The working tables of the Krishnarajasagara (Mysore Reservoir) for the years 1896-97 to 1908 have been revised and additional tables for the four years 1916-17 to 1919-20 prepared. These tables and the rules for their compilation will be found in Appendix II. The differences in the rules for the original and revised working tables are given below:—

	Original tables.	Revised tables.
Rules of regulation of Mysore Reservoir.	Award of 1914. (Vide Appendix B, Volume IV, Cauvery Reservoir Project Report.)	Mysore-Madras compromise.
Bhavani Bridge discharges.	1909 curve. (Vide table on page 23, Volume III, Cauvery Reservoir Project Report.)	1909 curve increased by amounts varying from 20 per cent to nil (Vide table in Rule 5 in Appendix II to this report.)
Loss in transmission, on impounded quantities, between Kannambadi and Metur.	13 per cent in south-west monsoon. 11 per cent in north-east monsoon.	Nil. (Vide Appendix I.)

NOTE.—Cauvery Reservoir Project report refers to volumes entitled "Papers regarding the Cauvery Reservoir project."

8 *Effect of revision of working tables of the Mysore Reservoir on river supplies at Bhavani Bridge.*—The resulting annual (1st June to 31st January) discharges, given by the two sets of working tables, at Bhavani Bridge are compared in the table below:—

Irrigation season (1st June to 31st January).	Resulting discharge, Bhavani Bridge mills. cubic feet.		Percentage increase of column 3 on column 2.	Remarks.
	Original.	Revised.		
(1)	(2)	(3)	(4)	(5)
1896-97	507,668	511,941	0.8	
1897-98	498,090	506,198	1.6	
1898-99	300,340	334,939	11.5	
1899-1900	154,755	172,421	11.4	Bad year.
1900-01	477,232	484,151	1.4	
1901-02	282,013	294,058	4.3	
1902-03	267,204	271,161	1.5	
1903-04	475,112	489,004	2.9	
1904-05	310,165	333,777	7.6	Bad year.
1905-06	174,237	205,989	18.2	Bad year.
1906-07	273,493	284,157	3.9	
1907-08	349,129	362,419	3.8	
1908-09	217,162	220,668	1.6	Bad year.

Material increase in the inflow into the Metur Reservoir is shown in the years 1899-1900, 1904-05 and 1905-06, three of the four years of poor supply.

9. *Effect of revision of working tables of the Mysore Reservoir on river supplies at the Upper Anicut.*—The resulting annual discharges at the Upper Anicut (1st June to 31st January) given by the two sets of working tables are compared in the table below:—

Comparative statement of resulting discharges of the Aghanda Cauvery at the Upper Anicut from the original and revised working tables for the years 1896 to 1909.

Irrigation season (1st June to 31st January).	Resulting discharge, Upper Anicut, in mills. cubic feet.		Percentage increase of column 3 on column 2.	Remarks.
	Original (column 5 of Mysore-Cauvery Reservoir working tables printed in Volume IV, Cauvery Reservoir Project).	Revised (column 16 of the revised Mysore-Cauvery Reservoir working tables).		
(1)	(2)	(3)	(4)	(5)
1896-97	640,827	719,086	16.9	
1897-98	584,888	692,516	18.4	
1898-99	408,780	544,933	33.3	
1899-1900	182,483	262,176	43.6	Bad year.
1900-01	603,319	685,010	13.7	
1901-02	398,722	510,786	28.1	
1902-03	369,608	466,859	26.3	
1903-04	658,179	781,839	19.4	
1904-05	306,144	390,533	27.6	Bad year.
1905-06	209,213	292,681	39.9	Bad year.
1906-07	330,840	412,012	24.5	
1907-08	402,329	492,944	22.5	
1908-09	271,629	336,822	22.6	Bad year.

In the years of poor supply there were prolonged periods during which the river did not reach a gauge of 5.5 feet at the Cauvery Dam and the big increases in discharge are partly due to the use of the 1917-1919 discharging curve, which gives discharges from 40 to 80 per cent in excess of those from the 1909 curve for gauges of 5.5 feet and below. The applicability of the 1917-1919 discharge curve to past years' gauge readings has been discussed in paragraphs 1 to 4 of Appendix I and in the bad years it seems safe to count on the percentage increases shown, in column 4 of the table above, less at most 10 per cent. The decreased demand on the reservoir due to this increase in supply from the catchment below it, which is indicated in every year examined, and due to the decreased loss in transmission allowed on water issued from it, would justify a considerable increase in the area proposed to be irrigated, but for a doubt as to the sufficiency of the supplies provided for existing irrigation in the delta in the previous working tables.

10. *Normal supplies required for the ayacut.*—The original project, and the first revision of it, allowed for the maintenance of steady supplies to the delta and new area to be irrigated. The existing area in the delta never has had steady supplies and doubts have been raised as to whether flush irrigation will not be necessary for the old area and whether in that event more water would not be required than the project has provided for.

A doubt has also been raised as to whether the supplies provided for in June are sufficient to charge the sandy beds of the rivers in the delta and also supply the area of first crop it is proposed to irrigate. Both these questions can only be settled when the reservoir is in actual operation. It has therefore been decided to retain the same duties as those previously adopted, but to restrict the new area to be irrigated to that possible under the reduced length of main canal provided for in the first revised estimate and also to allow for a limited extension of second crop. These extensions are very much less than the increased supplies, shown in paragraph 9 above, would warrant, but if, when the reservoir is in operation, it is found that the supplies provided for old irrigation are sufficient, or not much underestimated, the canal in the new area can be extended so as to command the area it was originally contemplated could be irrigated.

11. *Proposed extension of ayacut.*—The statement below shows the areas to which it is now proposed to extend irrigation as compared with previous proposals :—

Location.	Original proposals. New Irrigation.		Revised proposals. New Irrigation.		Present proposals. New Irrigation.		Reduction under present proposals on original proposals.	
	Single or first crop.	Second crop.	Single or first crop.	Second crop.	Single or first crop.	Second crop.	Single or first crop.	Second crop.
Existing delta area	ACS. Nil.	ACS. 70,000	ACS. Nil.	ACS. 65,000	ACS. Nil.	ACS. 70,000	ACS. Nil.	ACS. Nil.
New area under Grand Ancient canal or Vadavar extension.	329,396	75,000	217,000 80,000	10,000	221,000 80,000	20,000	28,396	55,000
Total	329,396	145,000	297,000	75,000	301,000	90,000	28,396	55,000

12. *Revision of working tables of the Metur Reservoir.*—Working tables of the Metur Reservoir for the ayacut proposed in the previous paragraph have been prepared for the years 1896-97 to 1908 and 1916-17 to 1919-20, the years for which discharges at Kannambadi are available and for which the Krishnaraja Sagara tables have been prepared.

The tables and rules for their compilation will be found in Appendix III.

The differences between the rules for the first and second revisions of the tables are shown below :—

	First revision.	Second revision.
Cauvery discharge at Cauvery Dam.	1909 discharge curve ...	1917-1919 discharge curves (Mysore).
Loss in transmission on water issued from reservoir.	See Rule 1 (b), Part VI, page 43, Volume III, Cauvery Reservoir Project.	See paragraph 20 of Appendix I to this report.
Effective capacity of reservoir.	80,000 mills. cubic feet.	82,000 mills. cubic feet.
Ayacut	See table in previous paragraph.	

13. *Probable effect of Metur Reservoir on irrigation supplies in the years 1899-1900, 1904-1905, 1905-1906 and 1908-1909.*—In the reports accompanying the original and revised estimates a detailed examination of the supplies, that the tables showed would probably have been given, was made for the bad years 1899-1900, 1904-1905, 1905-1906 and 1908-1909. In the statement below the periods of short supply in these years, as demonstrated by the previous working tables and these now prepared, are compared. It will be seen that the present working tables show considerably better supplies in each of the four years.

Periods of short supply from working tables in Volume IV, Cauvery Reservoir Project and those in Appendix III.

Note—First (Table of 1916). Second (Tables in Appendix III).	1899-1900.		1904-1905.		1905-1906.		1908-1909.		1917-1918.	1918-1919.	
	First. Days.	Second. Days.	First. Days.	Second. Days.	First. Days.	Second. Days.	First. Days.	Second. Days.	Table in Appen- dix III. Days.	Tables in Appen- dix III. Days.	Per cent. Reduction.
Reservoir opens late for double crop.	..	..	..	..	18	..	..	..	..	..	..
Reservoir opens late for single crop.	..	..	..	..	7	..	..	..	..	..	..
Old area, 10 per cent reduction of supply.	76	48	43	10	76	12	26	..	48	31 30 37 15 16 30 37	10 per cent. do. do. do. do. do. do.
New area, 10 per cent reduction of supply.	23	48	43	10	15	12	26	..	41	..	..
New area, 40 per cent reduction of supply.	53	..	..	..	61	..	..	..	7	..	..
Reservoir fails on ..	5th Decem- ber	..	..	..	22nd Novem- ber.	..	..	..	..	..	..
Closing balance, mills. cubic feet.	-11,218	+50,166	+5,449	+45,632	-7,158	+68,634	+24,398	+52,678	+81,064	+35,468	..

14. *Probable effect of Metur Reservoir on irrigation supplies in the years 1917-18 and 1918-19.*—In the four years 1916-17 to 1919-20 two years of deficient river supply occurred, due to a partial failure of the south-west monsoon.

In 1917-18, the first of the two years, the river supply during the south-west monsoon was poor, especially in July and the first three weeks of August. The deficient supplies resulted in late transplantation of the single crop, but the total loss was not considerable, the actual remissions being Rs. 5,303. The table in paragraph 13 above and that on the next page show the defect on the supplies required, at normal duties, indicated by the working tables. The supply available, above that required by the normal duty in the second half of June, would have been utilized for filling tanks in the new area and have made up for some of the deficiency later. The short supply in the old area would have only retarded the progress of transplantation of the single crop to a certain extent and the yield over the whole ayacut would probably have been good.

1918-19.—The failure of the south-west monsoon in the year 1918-19 was the most serious one on record in the catchment of the Cauvery. The first fresh of any magnitude came in the second half of August too late to be fully utilized as the single crop seedlings had been lost over a considerable area. The north-east monsoon supplies were below normal and received late. The remissions of revenue were Rs. 3,55,525, the biggest since the year 1899-1900 when they amounted to Rs. 6,27,295. In the working tables for this year the rules for reduction on normal supplies, applied to the tables of previous years, were followed to the end of August. With an effective storage of only 21,860 millions cubic feet at the beginning of September and a falling river the supplies would have to be still further reduced in actual operation unless a risk of failure of the reservoir were taken. Failure of the reservoir in September would mean total loss of single crop in the new area. The normal supplies to the old area were therefore reduced by 25 per cent and those to the new area by 50 per cent. At the beginning of October the effective storage indicated is 8,708 millions cubic feet and on this date additional supplies for 185,000 acres of second crop are required. The first freshes due to the north-east monsoon might be received as early as about the end of the first week in October or as late as the second week in November. If the north-east monsoon were as late as November and issues were made to the second crop and single crop at the reduced rate of 25 per cent and 50 per cent to the old and new areas, respectively, failure of the reservoir would probably occur in the second half of October resulting in the shutting-off of supply to the new area. In the working tables it has been assumed that supply to the extension of second crop of 90,000 acres would be deferred until the break of the north-east monsoon in the catchment, and a further reduction of supplies has been made amounting in all to 33½ per cent in the old area and 60 per cent in the new area. These reduced supplies would have been given until 7th November, after which date full supplies could have been maintained. The periods for which short supply would have been given are shown in the table in paragraph 13 above. The rainfall in the delta was good for the first week in November and second crop would probably have been raised on part of the 90,000 acres of land from which water would have been withheld until the second week of November and probably no actual loss of single crop would have occurred in the old area, though yield would have been seriously affected.

In the new area partial failure would have occurred in the area not irrigated from tanks and the yield generally would have been poor.

Statement showing supplies required at normal duties and those indicated by working tables for years 1917-18 and 1918-19.

	June.		July.		August.		September.		October.		November.		December.		January.	Total to end of single crop season.	Total for whole irrigation season.
	First half.	Second half.	First half.	Second half.	First half.	Second half.	First half.	Second half.	First half.	Second half.	First half.	Second half.	First half.	Second half.	First half.		
Quantities at normal duties	5,310	5,310	26,685	26,573	23,745	25,228	21,345	12,720	15,615	10,480	7,860	7,215	5,715	4,805	3,240	194,609	200,243
Old area	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
New area	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
1917-18.	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Old area	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
New area	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
1918-19.	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Old area	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
New area	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..

* No water given to extension of 70,000 acres of second crop.

† No water given for second crop (30,000 acres).

15. *Irrigation supplies in years 1909-10 to 1915-16.*—In the statement below, the total natural flow at the Upper Anicut, during the irrigation season, is given for the years 1896-97 to 1919-20, so that some idea can be gathered of the measure of success that may be expected, under the operation of the reservoir, for the years 1909-10 to 1915-16 for which working tables could not be prepared. The discharges for the years 1916-17 to 1919-20 have been corrected by adding the quantities actually impounded in the Mysore reservoir.

In the seven years the supplies were above normal in the south-west monsoon and satisfactory in the north-east monsoon except in the year 1911-12. In this year, though the flow in the river was exceptionally good until the end of August, that of September was 27,116 millions cubic feet below requirements; the north-east supplies from 1st October to the end of the single crop season (15th December) were, however, so well distributed that very little impounding would have been permissible in the Mysore reservoir and the total flow, though below the average, would have sufficed for normal irrigation supplies.

Total discharge at the Upper Anicut during the irrigation season (south-west monsoon 1st June to 30th September, north-east monsoon 1st October to 15th January).

From 1917-19 discharge curve.

Year.	South-west monsoon.	North-east monsoon.	Total.	Remarks.
1896-97 ..	M. C. FT. 646,867	M. C. FT. 152,212	M. C. FT. 799,079	
1897-98 ..	574,012	166,714	740,726	
1898-99 ..	281,609	296,206	577,815	
1899-00 ..	234,761	43,628	278,389	Almost complete failure of north-east.
1900-01 ..	644,132	92,714	736,846	Poor but timely north-east following prolonged good south-west.
1901-02 ..	354,050	212,730	566,780	
1902-03 ..	296,875	228,795	525,670	
1903-04 ..	444,056	380,215	824,271	
1.04-05 ..	372,923	42,047	415,570	South-west closed early. Almost complete failure of north-east.
1905-06 ..	234,012	83,233	317,245	Poor but timely north-east following moderate and late south-west.
1906-07 ..	267,236	152,596	419,832	
1907-08 ..	425,121	110,919	536,040	
1908-09 ..	314,030	76,110	390,140	North-east failure after beginning November.
1909-10 ..	506,244	156,876	663,120	
1910-11 ..	372,983	311,482	684,465	
1911-12 ..	408,927	84,925	493,852	Poor but timely north-east following an early south-west with a bad September.
1912-13 ..	415,263	225,058	640,321	
1913-14 ..	..	..	..	Not traceable.
1914-15 ..	359,715	133,488	493,203	
1915-16 ..	342,716	141,672	484,388	
1916-17 ..	364,116	199,899	564,015	
1917-18 ..	218,231	175,108	393,339	Poor south-west but good September and north-east.
1918-19 ..	115,404	103,225	218,629	Worst south-west on record, late north-east.
1919-20 ..	286,714	182,259	468,973	

16. *Years of reduction in normal irrigation supplies.*—In the 24 years in the table in the preceding paragraph the only years in which the working tables indicate that short supplies would have had to be given are 1899-00, 1904-05, 1905-06, 1917-18 and 1918-19 and in only one of these years, 1918-19, is the deficiency such as to cause failure and that would probably not have been serious except in the second crop area.

MATERIALS OF CONSTRUCTION AND DESIGN OF WORKS.

17. *Nature of masonry for dam; deviations from original proposals.*—The following modifications in the original proposals have been made in the present estimate:—

(1) 'Cyclopean' masonry with 25 per cent of 'plums' has been substituted for 'rubble' masonry.

(2) 'Crushed stone' has been substituted for 'natural sand' in the concrete required for the cyclopean masonry.

(3) 'Coursed' rubble has been substituted for 'random' rubble for the upstream facing of the dam.

(4) Special facing for the downstream face of the dam has been omitted.

18. *Relative speed of construction with 'cyclopean' and 'rubble' masonry.*—Colonel Ellis in the original project report proposed to construct the dam of small rubble in surki mortar. He however anticipated that it might be impossible to make satisfactory progress with this class of masonry owing to the difficulty in getting a sufficient number of masons, and therefore provided in the estimate for plant for making two-thirds of the mass of the dam of concrete, should this be found desirable. Mr. Keeling in his report, made after his inspection of works in progress in America, was strongly in favour of adopting 'cyclopean' masonry, i.e., large stones set in concrete, for the hearting of the dam. Mr. Keeling proposed a seven years' programme of construction instead of the 9 years' one of Colonel Ellis and recommended that, if his suggestion to construct the dam of cyclopean masonry throughout was not adopted, cyclopean masonry should be resorted to as soon as it became apparent that an average output of 1,240 tons of masonry per working day for seven years would not be forthcoming.

19. To obtain an average output of 1,240 tons Mr. Keeling estimated that a maximum output of 2,000 tons per diem would be required. This output is equivalent to 1,185 cubic yards and he reckoned that 18 cranes could deal with this quantity, it is not clear whether he counted on a 10 or 8 hour day, but with the present unrestful state of labour it is not advisable to reckon on a day of more than 8 hours. On this basis each crane has to deal with $8\frac{1}{4}$ cubic yards per hour and Mr. Keeling points out that the best month's outturn at the Olive Bridge dam, with 16 cranes, averaged 2,400 tons per day, this quantity at 7 tons per 100 cubic feet (the weight of masonry put into the Olive Bridge dam) and for an 8-hour day is equivalent to 10 cubic yards per crane hour. The Olive bridge dam was, however, constructed of 'cyclopean' and not of 'rubble' masonry and it will be seen from the data in the table below that the crane hour capacity for 'cyclopean' masonry is considerably bigger than for 'rubble' masonry:—

Comparison of rubble and cyclopean methods.

	New Croton.	Wachusett.	Roosevelt.	Olive bridge.	Medina.
Large stone per cent	50	54	39.6	} 25.3	10.0
Spalls per cent	26	17	10.4		
Mortar per cent	24	29	13.8		
Concrete per cent	..	..	36.2	74.7	90.0
Rate of construction in cubic yard per hour per derrick.	..	3.8 to 6.0	9.0 to 18.0	20 to 27	..
Average rate when conditions were favourable to progress.	About 5.0	Not over 5.6	About 16.6	21.0	27.2
Nature of masonry	Rubble.	Rubble.	Mixed rubble and cyclopean.	Cyclopean.	Cyclopean.

20. The above data are taken from "Construction of Masonry Dams" by C. W. Smith, pages 69 and 162. It will be seen that the rate for the Olive Bridge Dam is considerably in excess of that given by Mr. Keeling, for the best month's outturn, and it agrees with that for the period 21st July to 20th August 1909, given on page 144 of Smith's book, referred to above. Smith however states that higher rates of progress have been obtained since and that the progress already attained with "cyclopean" masonry has been four times as fast as with "rubble" masonry. The rate at the Olive Bridge Dam cannot, therefore, be taken as supporting the rate proposed for "rubble" masonry in the case of the Metur Dam. Judging from the results obtained at New Croton and Wachusett, and allowing for the different class of labour, the biggest outturn for "rubble" masonry, it seems reasonable to expect at Metur is 4 cubic yards per derrick hour. With this outturn 37 cranes, or tackle having an equivalent lifting and placing capacity, would be required, whereas the number that could be used without hampering progress is not much over 20. Assuming 25 cranes and an average outturn for the whole period of construction of two-thirds the maximum, the time required to construct the dam would be 9.7

or say 10 years. This is presuming that a sufficient number of masons can be obtained which is doubtful. Data for American dams show that, if the dam be constructed of "cyclopean" masonry, the time of construction can be reduced to one quarter that required for "rubble" masonry or 2.4, say 3 years.

21. In estimating the time of construction with "cyclopean" masonry it should be perfectly safe to assume a working capacity of 20 derricks, a maximum outturn of 10 cubic yards per hour per derrick and an average outturn of two-thirds the maximum. The time required on the above assumptions is 4.8 years of 280 eight-hour days. Allowing for difficulties that may retard work on Sections I and II of the dam, the time of construction may be taken as six years or that is three years less than the period of construction allowed for in the original project report and seven years less than with rubble masonry estimated on the same lifting and placing capacity, i.e., 20 derricks.

22. *"Cyclopean" masonry proposed.*—As the project would not be financially feasible with such a protracted programme, as would be necessitated by the use of "rubble" masonry, it is now proposed to construct the dam wholly of "cyclopean" masonry containing 25 per cent of "plums". It is proposed to make exhaustive experiments and tests to obtain the densest concrete possible, with the materials available, and judging from results obtained elsewhere there is no apparent reason why a scientifically proportioned concrete having a density of 90 per cent or over of the stone used should not be obtained. "Cyclopean" masonry, with 75 per cent of concrete, having a density of 90 per cent would weigh 152 lbs. per cubic foot against 140 lbs. per cubic foot in the case of "rubble" masonry and would contain about 60 per cent less cementing material, lime and surki. The weight of the concrete used in the Periyar dam which, as far as is known, is stressed to 8 tons per square foot, was 150 lbs. per cubic foot and its density was 83 per cent of the stone used. Crushing tests of concrete made from the materials that will be used in the Metur dam gave results which show that a stronger concrete than that put into the Periyar dam will be obtained.

23. *Previous objection to use of concrete.*—Sir John Benton has restricted the use of concrete to parts of the dam where the intensity of stress is less than 60 lbs. per square inch and as "cyclopean" masonry would contain 75 per cent of concrete, this restriction presumably also applies to it. Sir John Benton's remarks on the use of concrete will be found in paragraphs 9 and 45 of his note on the project, printed on page 3 *et seq.* of Volume IV of the papers connected with the Cauvery Reservoir (Metur) Project. None of the defects attributed to concrete have been realised in the Periyar dam, which was constructed of surki concrete and is stressed to more than double Sir John Benton's restrictive limit, and in view of the fact that the concrete it is now proposed to use will be denser, will have a smaller percentage of cementing material and will be stronger, there is no reason to anticipate that anything serious will develop from its use, especially as the material will be placed under more favourable conditions than was the case with the Periyar dam.

24. *Substitution of crushed stone for natural sand.*—Another alteration now proposed in the materials for construction of the dam is the substitution of crushed stone for natural sand. A sufficient quantity of sand of suitable quality and grade has not yet been proved. To form a safe estimate it has been assumed that the more expensive of the two materials, crushed stone will be used, but this will not be done if tests show that no material advantage is secured thereby.

25. *Facing of dam.*—The previous estimate provided for using random rubble masonry throughout the section of the dam, but Rs. 15 per square was allowed for cement pointing the upstream face and Rs. 10 for the downstream face. Mr. Keeling considered that, if "cyclopean" masonry were used, the class of facework should be somewhat higher than that contemplated with rubble masonry and estimated the increase in cost at Rs. 50 a square. If the faces of the dam are of uncoursed rubble or coursed rubble they will be the factors determining the speed of construction and considerably hamper progress.

26. *Downstream facing.*—As the only object served by rubble facing on the downstream side of the dam is that of effect, it is proposed to omit it and the present

estimate only provides for treating the face of the concrete to remove the unsightliness of the lines due to forms.

27. *Upstream facing.*—For the upstream face it is considered that cement plaster, applied with a cement gun, would render it perfectly watertight, but “coursed rubble” has been estimated for as the rate for this will cover the cost of any type of facing finally decided on.

28. *Design of dam.*—No modifications have been made in the design of the dam and the only alteration in the previous proposals is the retention of the construction sluices as irrigation sluices; the extra cost due to this alteration has been provided for in the estimate.

29. *Canal system, materials of construction.*—The original and first revised estimates provided for plastering all works with cement. Surki plaster has now been substituted for cement plaster, as the advantage to be gained by using the latter is not commensurate with the big difference in cost. No other alterations have been made in the materials of construction originally proposed.

30. *Canal system, design of works.*—No modifications have been made in the design of any of the works in the canal system.

REVISION OF RATES.

31. *Revision of rates for head works in first revised estimate.*—In the first revised estimate the rates for works were not advanced because Mr. Keeling in his report, made after visiting England and America in 1911, estimated that he could work to the original rates and effect a saving of over Rs. 8 lakhs. This amount and that obtained by increasing the provision for “Unforeseen” from 1/10 to 1/8 was considered to be sufficient to cover any advances in rates likely to take place.

32. The rates arrived at by Mr. Keeling, printed on pages 30 to 32 of Part II, Vol. 1 of his report on his enquiries in connexion with the project, have been revised taking into account the increases in the local rates since 1912.

The revised rates are compared below with those of Mr. Keeling and of the original estimate :—

Material.	Original estimate.	Mr. Keeling's rate.	Second revised estimate.	Percentage increase of rate in second revised estimate.		Remarks.
				On rate in original estimate.	On Mr. Keeling's rate.	
	RS. A. P.	RS. A. P.	RS. A. P.			
Lime 100 c.ft.	19 10 0	16 8 0	23 10 0	36	61	
Surki	13 8 0	14 0 0	20 14 0	27	49	
Stone	4 8 0	2 8 0	6 0 0	33	140	* Was not proposed to be used.
Concrete	24 4 0	19 4 0	† 29 0 0	20	51	† Crushed stone mortar.
Cyclopean masonry c.ft. ..	* 21 0 0	17 4 0	† 26 0 0	24	51	‡ Not proposed to be used; sand mortar.
Random rubble	24 4 0	19 4 0	† 30 0 0	24	56	

The percentage increases in the rates for concrete and cyclopean masonry would be greater still if the same percentage of lime and surki had been allowed as in the original estimate. It is proposed to reduce the amount of cementing material by more than one half by carefully grading the aggregate and sand (crushed stone).

33. The rates for works involving the use of cement have been revised taking the cost of cement at Rs. 100 a ton.

34. It has not been found necessary to increase the rates for ordinary earthwork or for excavation in hard rock, as the former is in excess of the current rate and the excess on the latter will probably be covered by a certain percentage of usable stone for which a credit will be given.

35. The rates for excavation in soft rock and for benching and preparing founds in rock have been advanced 32 per cent. The rates provided for labour are as given below :—

	RS.	A.	P.	
Drill men (quarry)	2	0	0	per diem.
Assistant drill men	1	0	0	„
Special smiths	2	8	0	„
Stonecutters	2	0	0	„
Masons	1	8	0	„
Bricklayers	1	8	0	„
Coolies, man	0	10	0	„
Coolies, woman or boy	0	6	0	„

36. *Revision of rates, canal system, main canal and branches, materials and earthwork.*—The revised rates adopted for materials and earthwork are compared with those provided in the original and first revised estimates in the table below :—

Main Canal and Branches.

Material or work.	Original estimate rates.	First revised estimate rates.	Second revised estimate rates.	Percentage increase of 2nd on 1st revised estimate.
(1)	(2)	(3)	(4)	(5)
<i>Materials.</i>				
	RS. A. P.	RS. A. P.	RS. A. P.	
Table moulded bricks per 1,000 ..	10 0 0	12 0 0	14 6 5	20
Platform	8 0 0	8 0 0	8 14 3	11
Native	5 8 0	5 8 0	8 4 0	50
Brick jelly	8 8 0	8 8 0	9 9 0	12½
Lime (slaked and delivered at site per 100 c.ft.)	20 0 0	24 0 0	29 12 0	24
Sand	1 0 0	1 0 0	1 2 0	12
<i>Earthwork - 1,000 c.ft.</i>				
Loam, alluvial or black soil ..	3 12 0	4 0 0	4 6 5	10
Hard clay with gravel	5 0 0	5 6 0	5 14 7	10*
Extra for lead or lift (for each ten yards extra lead or one yard extra lift)	0 4 6	0 5 0	0 5 0	Nil.

The percentage increases shown in column 5 of the table are those by which the local rates have advanced since 1916. Current rates have been adopted for steelwork and Rs. 100 a ton for cement.

37. *Main Canal and Branches, rates for works.*—The increased cost of materials and labour has necessitated the advancing of the 1916 rates, for the most important items of work, by over 20 per cent. The revised rates for the main items are compared in the table below with those previously provided :—

Main Canal and Branches.

Work.	Original estimate rate.	First revised estimate rate, 1916.	Second revised estimate rate, 1921.	Percentage increase of 2nd on 1st revised estimate.
	RS. A. P.	RS. A. P.	RS. A. P.	
Concrete surki mortar	19 0 0	21 8 0	26 0 0	21
Do. ordinary mortar	17 0 0	19 8 0	23 8 6	20½
Table moulded brick surki mortar ..	23 8 0	28 0 0	34 8 0	23
Do. ordinary mortar	22 8 0	27 0 0	33 4 0	23
Platform moulded brick surki mortar ..	21 0 0	23 8 0	28 12 0	22½
Do. ordinary mortar	20 0 0	22 8 0	27 8 0	22

38. *Distributaries, rates for works.*—The revised rates for the chief works in the distributaries are compared with those previously adopted in the table below :—

Nature of work.	Original estimate rates.			First revised estimate rates.			Second revised estimate rates.			Percentage increase of 2nd over 1st revised estimate rates.
	RS.	A.	P.	RS.	A.	P.	RS.	A.	P.	
Concrete brick jelly and surki mortar	21	0	0	23	8	0	28	4	0	20
Brickworks, platform moulded bricks in surki mortar	23	0	0	25	8	0	29	13	0	17
Brickworks, platform moulded bricks in ordinary mortar	21	8	0	24	0	0	28	0	0	17
Brick on end packed dry	13	8	0	15	0	0	20	4	0	35
Brick jelly backing	10	8	0	11	12	0	13	4	0	24
Concrete blocks in surki	22	0	0	24	8	0	38	9	0	17

As in the case of the rates for the main canal and branches, the percentage advances are those by which the local rates have actually advanced since 1916.

SPECIAL TOOLS AND PLANT.

39. *Special Tools and Plant, Head works.*—

Original estimate of 1910, Rs. 20.60 lakhs.

Revised estimate of 1916, Rs. 29.02 lakhs.

The revised estimate provided Rs. 18,000 for core drills, that were not provided for in the original estimate, and for a 40 per cent advance in prices. This 40 per cent was to cover the advance in prices that had taken place, since Mr. Keeling reported in 1912 on the plant required for the project, and also a further advance that was likely to take place due to the war. All the plant will be either of British or American manufacture. The cost of plant manufactured in Great Britain has advanced by 250 to 300 per cent since the year 1912. Judging from the quotations received in 1920 for excavating machinery, the advance in prices in America was then about 160 per cent on pre-war prices. American prices have since been rising and allowing a further increase of 40 per cent and for the adverse rate of exchange, the increase on pre-war prices will be taken at 233½ per cent. As far as can be seen at present, the amount of plant that it will be necessary to obtain from America will not exceed about one-sixth of the total quantity required. It is impossible to forecast what prices will be about two years hence, but in view of the fall in the price of steel, which has recently taken place (25th February 1921), it would seem to be safe to estimate on the basis of an advance of prices of 250 per cent on those obtaining in the year 1912. Another doubtful factor, affecting the provision for special tools and plant, is the rate of exchange and, in view of the recent fluctuations in the exchange value of the rupee, it does not appear justifiable to reckon on a better rate than Rs. 15 to the pound.

An increase of 150 per cent on the provision for special tools and plant made in the first revised estimate of 1916 is equivalent to an advance of 250 per cent on the 1910 provision and the first revised estimate of Rs. 29.02 lakhs has accordingly been increased to Rs. 72.55 lakhs.

40. *Special tools and plant—Canal system.*—The amount provided in the first revised estimate was Rs. 7.35 lakhs. This has been increased by 150 per cent, as in the case of the head works, to Rs. 18.38 lakhs.

41. *Special tools and plant, whole project.*—The amounts provided for special tools and plant in the original and revised estimates are compared below :—

	Original estimate.	First revised estimate, 1916.	Second revised estimate, 1921.	Excess of second over first revised estimate.
	LAKHS.	LAKHS.	LAKHS.	LAKHS.
Head works	20.60	29.02	72.55	43.53
Canal system	1.00	7.35	18.38	11.03
Total	21.60	36.37	90.93	54.56

* Additional plant provided for.

On the total sum provided, every penny difference from the 1s. 4d. rate of exchange of the rupee will make a difference of Rs. 5.68 lakhs. A variation of 10 per cent from the estimated increase in prices of 250 per cent is equivalent to an amount of Rs. 2.6 lakhs.

42. No additional crushing plant has been provided for on account of the substitution of crushed stone for sand, as the Rs. 2 lakhs (now Rs. 7 lakhs), allowed by Mr. Keeling for floating plant (page 33 of Volume I, Part II of his report), not required if sand is not used, will cover the extra crushing plant required.

REVISION OF ESTIMATES BY SUB-HEADS.

43. *Head works.*—The provisions by sub-heads for head works made in the first and second revised estimates are compared in the statement below, the amounts of the estimates do not include any provision for unforeseen, which has been provided for at 12½ per cent on all items except A. Preliminary expenses.

Sub-heads.	Names of works.	First revised estimate, 1916.		Second revised estimate, 1921.		Excess of second revised over first revised estimate.
		Amount of estimate for individual works.	Total of sub-heads.	Amount of estimate for individual works.	Total of sub-heads.	
(1)	(2)	(3)	(4)	(5)	(6)	(7)
	I. WORKS.	RS.	RS.	RS.	RS.	RS.
	(i) HEAD WORKS.					
	1. Main dam including waterspread.					
A. Preliminary expenses.	Preliminary expenses	1,50,000	1,50,000	2,50,000	2,50,000	1,00,000
B. Land	Compensation for waterspread ..	13,86,500	13,86,500	20,31,200	20,31,200	6,44,700
C. Works	Main dam	1,24,51,000	..	1,46,21,000	..	..
	Bridge across Cauvery below dam site	50,000	..	1,20,000	..	..
	Borings in foundation of dam and grouting	50,000	..	1,00,000	..	..
	Tests of and experiments on materials and methods of construction	..	..	50,000	..	..
K. Buildings.	Sluice shutters and gear including curtains and cranes ..	5,54,100	1,31,05,100	15,00,000	1,63,21,000	32,65,900
O. Miscellaneous.	Workshops, storehouses, quarters, etc.	5,74,400	5,74,400	9,48,200	9,48,200	3,73,800
P. Maintenance.	Communications, sanitation, water-supply, etc.	5,15,000	5,15,000	11,53,000	11,53,000	6,38,000
	Maintenance during construction	1,50,000	1,50,000	1,92,000	1,92,000	42,000
	Total main dam including waterspread	..	1,58,81,000	..	2,09,65,400	50,84,400
	2. Main surplus sluices.					
C. Works	Main surplus sluice	3,58,300	..	4,95,400	..	1,37,100
	Shutters including gear and steel work	4,44,600	8,02,900	8,89,200	13,84,600	4,44,600
	Total (i), Head works	..	1,66,83,900	..	2,23,50,000	56,66,100

44. *Head works, A. Preliminary expenses.*—The provision in the original and first revised estimates of Rs. 1.5 lakhs has been increased by Rs. 1 lakh. The increased provision is mainly to cover relevelling the waterspread and demarcating sections, so that silting of the reservoir can be checked as opportunity occurs, investigating a hydro-electric power scheme from Hogenkal Falls to serve the project in lieu of a central power station and for making sand and fuel surveys.

45. *Head works, B. Land.*—The original estimate of Rs. 5½ lakhs for the cost of acquisition of land for the reservoir was increased to Rs. 13.865 lakhs in the first revised estimate, for the reasons given in paragraph 66 of the report printed on page 67 of Part III of Volume IV of the papers connected with the Cauvery Reservoir (Metur) Project. The Inspector-General for Irrigation (the late Sir Michael Nethersole) called for further explanation as to how so large an area as 6 square miles was omitted in the first estimate and of the increase in value of land since 1910. The

Inspector-General for Irrigation (Sir Thomas Ward) was furnished in June 1917 with a note by the Secretary to Government, Revenue Department, giving the explanations called for. As subsequently the Special Revenue Officer, who prepared the original estimate for the cost of acquisition of land, doubted the accuracy of the revised acreage in Kauveripuram, Bhavani taluk, it was decided to recheck the area to be acquired for the reservoir both in Coimbatore and Salem districts. The Collectors of Coimbatore and Salem districts were accordingly supplied in November 1917 with village maps, whereon the waterspread of the reservoir, land required for sites for dam, surplus escape, camping grounds, quarries for stone and lime, etc., had been marked in the office of the Chief Engineer for Irrigation. The previous estimates did not contain any provision for acquiring land for camping grounds and quarries.

46. Statements giving revised extents to be acquired and values were finally submitted and accepted in the year 1919, and a revised return M has been prepared and attached to the revised classified abstracts of estimates. The extents to be acquired, provided for in the original and revised estimates, are shown below by districts:—

	Original estimate.	First revised estimate, 1916.	Second revised estimate, 1921.
Salem	ACS. 7,764.94	ACS. * 7,764.94	ACS. † 7,408.73
Coimbatore	5,654.75	† 9,973.00	‡ 12,122.00
Total	13,420.69	17,737.94	19,530.73

* Area was not checked in 1916.

† Area checked in 1916.

‡ Area checked in 1917-19 and that required for camping grounds and quarries added.

§ Area rechecked in 1917-19 and that required for camping grounds and quarries added.

47. *Salem district, extent to be acquired.*—The reason for the decrease in the extent to be acquired in Salem district, though it includes that required for camping grounds, etc., has been the subject of investigation. The only villages in which acquisition is necessary for camping grounds and quarries are those of Koluayakanpatti, Malliakondan and Pallipatti, which did not appear in the previous returns. Reference to the second revision of return M and that printed on page 79, Part IV, Volume IV, of the Cauvery Project, papers will show that the following considerable variations occur:—

Village.	Taluk.	First revised estimate.	Second revised estimate.	Difference Col. 3. Col. 2.
Pottaneri and Nallakavundanpat ..	Omair (formerly Salem).	ACS. 72.65	ACS. 1,027.20	ACS. + 954.55
Konur	Do.	443.01	337.87	— 105.14
Sholapadi	Do.	1,017.11	916.89	— 90.22
Do.	Dharmapuri	1,119.02	1,515.68	+ 396.66
Badraballi	Do.	1,904.65	924.87	— 979.78

Fieldwar statements of the areas to be acquired have been prepared, but, as those upon which the original return M was based cannot yet be traced, it is not possible to account with certainty for the differences. In the previous returns an area of 720 acres for the surplus escape has been entered without being allocated to any particular village or villages. This is now included in Pottaneri-Nallagoundampatti villages, within which it lies, and accounts for 720 acres of the 954 acres increase in these villages. The decreases in Konur and Sholapadi villages are believed to be due to relinquishment subsequent to the preparation of the original list. In Badrahalli, Dharmapuri taluk, there is a very large decrease in area. The original return was an extent of occupied land of 1,904.65 acres, whereas the revised return gives the total area that will be submerged as 1,329.31 acres of which 924.87 acres are occupied lands for which compensation will have to be paid. The Collector states that the revised figures are correct and that the original area, if it were correct as far as extent to be submerged is concerned, must include assessed and unassessed wastes for which no compensation would have to be paid.

The revision of return M for Salem district has resulted in a reduction of 564 acres, of occupied lands, in the waterspread area, and the addition of 208 acres for camping grounds and quarries.

48. *Coimbatore district—Extent to be acquired.*—The additional extent in the revised return for Coimbatore are for camping grounds and quarries.

49. *Estimated cost of acquisition of lands.*—The value of the lands to be acquired has been revised in accordance with prices prevailing in 1918 and the total estimated cost of acquisition is compared below with the previous estimates:—

	LAKHS.
Original estimate	RS. 5.5
First revised estimate	13.865
Second revised estimate	20.312

50. *C. Works—Head works, Main Dam.*—

	RS.
First revised estimate	1,24,51,000
Second revised estimate	1,46,21,000
Excess	21,70,000

Provision for closing the construction sluices has been omitted, as it is proposed to retain them as low-level irrigation sluices. The provision of Rs. 30,000 for 'turbine pipes in dam' has been increased to Rs. 70,000 and that for 'surplus during construction' has been increased from Rs. 1.4 lakhs to Rs. 1.8 lakhs. Mr. Keeling's recommendations of Rs. 1.8 lakhs for diversion works in river bed and Rs. 1 lakh for pumping have been increased to Rs. 2 lakhs and 1.25 lakhs respectively. The remainder of the difference is due to the change in material of which the dam is proposed to be constructed and to the increase in rates (vide paragraphs 17 to 35 above).

51. *Head works, Bridge across Cauvery.*—The estimate for the bridge has been revised providing for the enhanced rates and for a 17 feet roadway instead of 16 feet. The revised estimate amounts to Rs. 2,44,000 against Rs. 1.5 lakhs in the first revised estimate and the excess due to this item after deducting the saving due to omitting road over the dam is Rs. 70,000.

52. *Head works, Borings in foundations of dam and grouting.*—The provision in the first revised estimate of Rs. 50,000 has been increased to Rs. 1 lakh to provide for increase in cost of materials and of running drills.

53. *Tests and experiments on strength and proportions of materials.*—This is a new item for which Rs. 50,000 is provided. The tests are preliminary ones which will be put in hand immediately sanction is accorded to the project.

54. *Sluice shutters and gear including curtains and cranes.*—

	RS.
First revised estimate	5,54,100
Second revised estimate	15,00,000
Excess	9,45,900

Messrs. Ransomes and Rapier furnished in 1920 an approximate estimate of £100,000 for the sluice shutters, gear, etc., provided for in the first revised estimate and for six additional shutters and gear for the new low-level irrigation sluices. As the price of steel is going down in England, with a prospect of a considerable further fall in the next year, no provision has been made for freight on Messrs. Ransomes and Rapier's approximate estimate. Carriage to site and erection is provided for in separate estimates included under 'Main Dam'—C Works.

55. *Head works, K. Buildings.*—

	LAKHS.
First revised estimate	RS. 5.744
Second revised estimate	9.482
Excess	3.738

The buildings provided for are the same as detailed by Mr. Keeling on page 19 of his report, Part II, Volume I, with the addition of a rest-house. The rates have been increased to those that are now current, the square foot rate being Rs. 3-5-0 against Rs. 2-8-0 provided for by Mr. Keeling. Rupees 12,306 has been provided for the rest-house and maintenance increased from Rs. 1,000 to Rs. 1,500 a month for eight years.

						RS. IN LAKHS.
56. <i>Head works, O. Miscellaneous.</i> —						
First revised estimate	...	...	...	...	...	5.15
Second revised estimate	...	...	...	...	...	11.53
Excess						6.38

Mr. Keeling on page 33 of his report, Part II, Volume I, recommended that the provision originally made be increased to Rs. 8,02,500, but only Rs. 5.15 lakhs were provided in the revised estimate. The estimate for this item has now been revised on the basis of Mr. Keeling's recommendations and is compared with them below:—

Item.	Mr. Keeling's recommend- ation.	Second revised estimate.
	RS.	RS.
1. Laying light rail track ...	77,000	1,00,000
2. Laying, maintenance, renewal and extension ...	1,01,500	1,50,000
3. Maintenance of road from Erode to Metur, 34 miles at Rs. 500 per mile per year, for 12 years.	2,04,000	1,83,600 *
4. Putting in order, improving and bridging road from Erode to Metur, 9 miles at Rs. 1,500 a mile, 16 miles at Rs. 3,000 a mile and 9 miles at Rs. 7,500 a mile.	Nil.	1,29,000
5. Constructing 10 miles of road at head works at Rs. 5,000 a mile.	50,000	65,000 †
6. Maintenance of item 6 at Rs. 400 per mile for 12 years.	48,000	45,400 ‡
7. Sanitation for 12 years ...	1,22,000	1,25,000
8. Water-supply (share of, for domestic supply and maintenance).	2,00,000	3,55,000
	8,02,500	11,53,000

Item No. 4 is based on a recent inspection on the road.

* Rupees 600 a mile.

† Rupees 6,500 a mile.

‡ Rupees 500 a mile.

All maintenance and recurring charges are for a three years shorter period in the second revised estimate than that estimated for by Mr. Keeling, as the programme of construction will be shortened by three years.

57. *Head works, P. Maintenance.*—The provision for maintenance during construction in the first revised estimate was Rs. 1.5 lakhs against Mr. Keeling's recommendation of Rs. 24,000 annually for ten years. Rupees 24,000 per annum for eight years is now provided or Rs. 1,92,000 in all.

						RS. IN LAKHS.
58. <i>Main surplus sluices, C. Works.</i> —						
First revised estimate	...	...	...	...	...	3.583
Second revised estimate	...	...	...	...	...	4.954
Excess						1.371

Excess due to enhanced rates.

59. <i>Main surplus sluices, shutters, gear and steel work.</i> —						
First revised estimate	...	...	...	...	...	4.446
Second revised estimate	...	...	...	...	...	8.892
Excess						4.446

The provision for the shutters has not been advanced as much as that for those for the dam as they will be made locally if prices do not come down in England.

60. *Canal system.*—The percentage increases in the sub-heads of the estimates for "Main canal and branches" and "Distributaries" on the sums provided in the first revised estimate (excluding unforeseen) are shown below. After making the percentage increases, 20 per cent has been added for "Unforeseen" as in the case of the first revised estimate.

Sub-head.	Percentage increase on first revised estimate.	
	Main canal and branches.	Distributaries.
A. Preliminary expenses	Nil.	Nil.
B. Land	12½	12½ *
C. Works	...	11 *
D. Regulators	21	...
E. Falls and weirs	14	...
F. Cross drainage	18	...
G. Bridges	100	...
H. Escapes	17	...
K. Buildings	33½	...
L. Earthwork	10	10 *
M. Plantations	20	...
O. Miscellaneous	21	12½
P. Maintenance	20	20 *

* Plus provision for 4,000 acres extension under minor distributaries, Grand Anicut canal system.

61. *Canal system, B. Land.*—In the revised estimate of 1916 the estimate for land for the "Main canal and branches" was increased by 50 per cent, except for digging pits, the provision for which was kept unaltered. The provision for land for distributaries in the original estimate was retained unaltered. The provision for land in the first revised estimate, both for "Main canal and branches" and "Distributaries," has been increased by 12½ per cent to provide for a possible rise in value of land since 1916.

62. *Canal system, sub-heads C, D, E, F, G, H, K and O.*—Typical works have been estimated for using the enhanced rates referred to in paragraph 36 above, and the percentage increases shown in paragraph 60 above have been deduced from these estimates and applied to the sub-head concerned.

63. *Canal system, L. Earthwork.*—The provision under this head in this estimate and the previous ones is based on the current rate for manual labour and in excess of it. It is, however, proposed to excavate practically the whole of the main canal and some of the branches by means of drag line bucket excavators. The cost of the excavators is provided for under special tools and plant, and, though no reliable data are available, it is believed that the rate for earthwork will cover the running costs of the plant.

64. *Canal system, M. Plantations, P. Maintenance.*—No increase was made under these heads in the first revised estimate and 20 per cent has now been added to allow for the increase in cost of materials and labour.

65. *Canal system, extension of area to be irrigated.*—It is proposed to extend the area to be irrigated in the Grand Anicut canal system by 4,000 acres. This area has been distributed in the proportion of the revised to the original area as was done in the case of the first revised estimate when the ayacut was reduced in extent, page 70, Part III, Volume IV of papers connected with the Cauvery Reservoir (Metur) Project. The necessary additions due to this extension have been made to the estimates for the sub-heads concerned. The distribution of the revised ayacut under the Grand Anicut canal is shown below:—

	ACS.
Major distributaries	218,145
Minor "	27,295
Direct irrigation	12,469
	257,909

* In addition minor distributaries irrigating 100,827 acres will take off from major distributaries.

The statement printed on page 71 of Volume IV of the papers connected with the project has been revised and is given below :—

For revision of this statement, vide page 17 of Letter No. 95 I., dated 31st March 1924, in print.

Cost of Grand Anicut canal major and minor distributaries allocated by sub-heads in rupees including provision for unforeseen contingencies.

(Revision of statement, page 71, Volume IV.)

	Major distributaries 218,145 acres.		Minor distributaries 128,122 acres.		Total amount.	Add for increase in rates (12 per cent on masonry, etc., and 6½ per cent for earthwork).	Total (1916).	Add for increase in rates for 1920-21.	Total.	Add 20 per cent for unforeseen contingencies.	Grand total.
	Rate per acre.	Amount.	Rate per acre.	Amount.							
	RS.	RS.	RS.	RS.	RS.	RS.	RS.	PER CENT.	RS.	RS.	RS.
A. Preliminary expenses.	0.25	54,536	0.40	51,249	1,05,785	..	1,05,785	..	1,05,785	315	1,06,100
B. Land ..	3.05	6,55,342	2.44	3,12,618	9,77,960	..	9,77,960	12½	1,22,245	11,00,205	13,20,250
C. Works ..	2.42	5,27,911	2.82	3,61,304	8,89,215	1,06,706	9,95,921	11	1,09,550	11,05,471	13,26,570
L. Earthwork ..	2.53	5,51,907	1.52	1,94,745	7,46,652	48,532	7,95,184	10	79,520	8,74,704	10,49,650
O. Miscellaneous ..	0.04	8,723	0.06	7,687	16,410	..	16,410	12½	2,050	18,460	22,150
P. Maintenance ..	0.12	26,177	0.04	5,125	31,302	..	31,302	20	6,260	37,562	45,080
Total ..	8.41	18,34,596	7.28	9,32,728	27,67,324	1,55,238	29,22,562	..	3,12,625	32,42,187	38,69,800

PROGRAMME OF CONSTRUCTION.

66. *Revised programme of construction.*—The original programme of construction provided for the completion of the work at the end of the 13th year from the date of sanction. It was proposed to devote the first year to the preliminary operations detailed in paragraph 133, page 56, of Volume I of the papers connected with the Cauvery Reservoir Project, and the 2nd and 3rd years to the preparatory works referred to in paragraph 130. The period of actual construction was to occupy nine years, that is from the beginning of the 4th to the end of the 12th year, and the 13th year was allotted to finishing up. Sir John Benton urged that the rate of progress should be quickened up so as to reduce the programme by two years. This would not have been feasible if the dam had to be constructed of 'rubble' masonry but, if 'cyclopean' masonry is used instead, as proposed in paragraphs 17—23 above, the period of construction originally proposed can be reduced by three years. The programme as now proposed is compared below with the original one :—

	Originally proposed.	Now proposed.
YEARS.	YEARS.	YEARS.
Preliminary operations ..	1	1
Preparatory works ..	2	2
Construction ..	9	6
Finishing up ..	1	1
Total ..	13	10

Provided sufficient excavating machinery is indented for as soon as possible after sanction there should be no difficulty in speeding up the programme of construction for the canal system to conform with that now proposed for the dam.

ORGANIZATION FOR EXECUTION OF WORKS AND ESTABLISHMENT CHARGES.

67. *Head works.*—The shortening of the period of construction of the dam and the basing of the estimate of cost of establishment on the probable actuals, instead of on the old percentage basis, has necessitated a re-examination of the organization of works charges and the forming of a closer estimate of the establishment required. The charges and establishment proposed originally are detailed in Section XIII of Part I of Volume I of the papers connected with the project. Sir John Benton in paragraph 18 of his note on the project, printed on page 3 et seq. of Volume IV of the papers connected with the project, stated that he considered that the establishment proposed was excessive for the protracted programme originally

proposed, and that a Superintendent of Works for the head works was unnecessary, as the Engineer-in-Chief could be in direct charge of the head works. The Superintendent of Works has now been omitted, but it is considered that this will necessitate a more senior Personal Assistant to the Engineer-in-Chief than was originally provided for and an Executive Engineer is now proposed; it will probably be found that a junior Personal Assistant will also be required.

68. *Head works, organization of work charges.*—In the original report four charges were proposed, the Engineers in charge to work under the Superintendent of Works. It is now proposed to have six charges, the Engineers in charge working directly under the Engineer-in-Chief.

The charges now proposed are—

1. Construction.
2. Transport.
3. Materials.
4. Workshops and machinery.
5. Stores and tests.
6. Camps, buildings and sanitation.

69. *Construction Division.*—It was originally proposed that the Construction division should deal with manufacture and delivery. As now the average and maximum output will be 1,450 and about 2,200 tons per diem respectively, which is considerably greater than was originally proposed, and as the major portion of the labour will now be unskilled, instead of skilled, it is considered necessary to relieve the Construction division of manufacture and transport.

70. *Materials Division.*—It is proposed to transfer manufacture to the Materials division which will then deal with materials and manufacture.

71. *Transport Division.*—Transport is now proposed to be made a separate charge and a junior 'liason' engineer is provided for to work between the engineers in charge of Transport and Construction.

72. *Workshops and Stores Divisions.*—No alteration is proposed in the Workshops and Machinery and the Stores and Tests divisions, as far as the nature of the work with which they will deal is concerned.

73. *Camps and Sanitation.*—The camps, buildings and sanitation charge will be a small one in charge of an Assistant Executive Engineer on the junior scale.

74. *Head works—Establishment required.*—The establishment and period of employment proposed is shown in the statement below :—

Establishment—Head works.

Designation of officer.	Preliminary works.	Preparatory works.		Construction.						Finishing up.
	First year.	Second year.	Third year.	Fourth year.	Fifth year.	Sixth year.	Seventh year.	Eighth year.	Ninth year.	Tenth year.
Engineer-in-Chief	1	1	1	1	1	1	1	1	1	1
Personal Assistant	1	1	1	1	1	1	1	1	1	1
Assistant Engineer in charge of Drawing office.	1	1	1	1	1	1	1	1	1	1
Engineer in charge Construction ..	1	1	1	1	1	1	1	1	1	1
do. do. West ..	1	1	1	1	1	1	1	1	1	1
do. do. East ..	1	1	1	1	1	1	1	1	1	1
Engineer in charge Delivery (liaison officer between Transport and Construction).	1	1	1	1	1	1	1	1	1	1
Engineer in charge Transport	1	1	1	1	1	1	1	1	1	1
Motor Foreman	1	1	1	1	1	1	1	1	1	1
Engineer in charge Materials	1	1	1	1	1	1	1	1	1	1
do. Lime, Surki and Mixers.	1	1	1	1	1	1	1	1	1	1
do. Quarries and Breakers.	1	1	1	1	1	1	1	1	1	1
Quarry Manager	1	1	1	1	1	1	1	1	1	1
Engineer in charge Workshops and Machinery.	1	1	1	1	1	1	1	1	1	1
Electrical Engineer	1	1	1	1	1	1	1	1	1	1
Repair Shops Foreman	1	1	1	1	1	1	1	1	1	1
Engineer in charge, Stores and Tests ..	1	1	1	1	1	1	1	1	1	1
do. Camps and Buildings.	1	1	1	1	1	1	1	1	1	1
Upper subordinates	10	10	12	21	21	21	21	21	21	21

75. *Pay of establishment estimated for.*—The average pay estimated for is shown in the statement below :—

Establishment—Head works.

Designation of officer.	Average pay per mensem.	Period required for.
	RS.	YRS.
Engineer-in-Chief	2,750	7½
Personal Assistant	1,325	7½
Assistant Engineer, Drawing office	500	2
<i>Engineers-in-charge—</i>		
Construction	1,650	9½*
Do. West	900	7½
Do. East	1,225	6½*
Do. Delivery	900	5
Transport	1,025	6½
Materials	1,375	7
Lime, Surki and Mixers	900	7½
Quarries and Breakers	1,225	7*
Workshops and Machinery	1,485	7½*
Electrical Engineer	1,000	7*
Stores and Tests	1,225	2†
Camps and Buildings	600	7‡
	500	8
<i>Foremen—</i>		
Quarry (Manager)	800	7§
Repair shops	600	6
Motor	500	7
Upper subordinates	160	21 for six years. 12 for one year. 10 for two years. 6 for one year.

* Temporary Engineer.
† Executive Engineer.

‡ For first two years.
§ From England.

76. *Engineer-in-charge of Construction.*—The pay provided for is on the assumption that a specific officer is appointed. If he is not, the pay will cover that of a Senior Executive Engineer. It is proposed to employ the Engineer-in-charge of Construction from practically the start of the project and put him in charge of all "Preliminary Works", except tests, and the first year's "Preparatory works", as it is very desirable that this officer should be at the site of the dam while the exploratory borings and excavation for foundations of the dam are in progress and that he should be in charge of this work.

77. *Engineer-in-charge of Construction, "East".*—The pay for this officer is shown as greater than that for the officer in the "West" sub-charge, as it is recommended that, if possible, a young Engineer be procured from England or America with experience of the construction of dams with cyclopean masonry or concrete. He would be in charge of the river section of the dam.

78. *Engineer-in-charge of Workshops and Machinery.*—A suitable officer is available in the Public Works Department and the pay is fixed accordingly.

79. *Electrical Engineer.*—This engineer will probably have to be obtained from England. A capable man is required as he will be in charge of a 2,000 horse-power hydro-electric plant, 26 miles of transmission line and distribution at head works. He will also have to periodically inspect two portable power stations in the canal system if the excavators are run electrically.

80. *Engineer-in-charge, Stores and Tests.*—The work of this charge in the first two years will be practically confined to testing and experimenting with the materials for the construction of the dam. This work is of the greatest importance and requires to be under the direct supervision of a painstaking officer with a bent for such work. A suitable officer is available and the pay fixed is that which he would draw if appointed.

81. *Foremen.*—The average pay has been fixed on the assumption that all three men will have to be obtained from England, though it is possible that the Repair shops and Motor foremen may be available in India.

82. *General.*—The pay provided for the other engineers-in-charge assumes that they will be permanent officers of the Public Works Department drawing their ordinary pay and that they will be entitled to technical and overseas allowances, except in the case of the engineers-in-charge, "Stores and Tests" (last seven years) and "Camps and buildings." As a certain number of the officers will probably not be entitled to these allowances the estimate should be a safe one. Part of the pay of the Engineer-in-chief, his personal assistant, the Engineer-in-charge of Workshops and Machinery and the Electrical Engineer will be chargeable to the canal system, but in this estimate it is shown as being charged in full to headworks.

83. *Upper subordinates.*—It is understood that the revision of the scale of pay of the Upper Subordinates is under consideration and an average pay of Rs. 160 is provided, which will allow for a very considerable increase on the present scale.

84. *Local allowance.*—The site of the dam is in a long narrow valley flanked by ranges of high rocky hills and is stated to be very hot in the hot season, which is a long one in the locality. It is also 34 miles from Erode from which town practically all supplies will have to be obtained and, with the large population introduced by the work, the cost of living will be high. With the class of material of which it is proposed to construct the dam very close supervision over its manufacture and placing will be required, which will have to be given by the executive staff under very trying conditions in the best part of the working season of the year. Apart from this it is almost certain that extra shifts will have to be put on occasionally especially on the river section to keep up to programme; special engineer establishment cannot be employed for these periods, and this will put an additional strain on the executive staff. The work will not be popular with Europeans or Indians unless a compensatory allowance is granted.

It is therefore proposed that a local allowance be granted on the same scale as that granted for Mopad project. The scale proposed is given below :—

Executive and Assistant Engineers	Rs. 100 per mensem
Upper and Lower Subordinates, Clerks, Accountants, Sub-Assistant Surgeon.	At the rates admissible in the Periyar, Wynaad and Ganjam tracts—Appendix 19, Volume III of the Public Works Department Code.
Draughtsmen, typists and storekeepers	Thirty per cent on salaries varying from Rs. 30 and upwards subject to a maximum allowance of Rs. 40 and 50 per cent on salaries under Rs. 30 subject to a maximum allowance of Rs. 8.
Peons and menials	Rs. 2 per mensem.

The estimate of cost of establishment has provided for these allowances to all permanent and temporary establishment except Foremen and the Engineer-in-chief.

85. *Proposed concessions.*—The above allowances do not represent the same degree of compensation as they did when sanctioned for Mopad, owing to the general rise in cost of living, and bigger allowances would have been recommended but for the following further concessions being proposed :—

- House accommodation rent free.
- Free carriage of supplies and goods to and from Erode.
- Free current for electric light and fans.

The first proposal does not represent a considerable allowance as the buildings are only semi-permanent and therefore comparatively cheap. The second proposal is one that will cost very little, as lorries will be running practically daily to and from Erode for coal and material required for the work.

The third proposal will cost practically nothing, as the current will be generated hydro-electrically and there will always be a night load in connexion with the water-supply.

These proposed concessions are such as would be given by any private firm carrying out a similar work, because it would pay them to do so and it would

equally pay Government to make the work more attractive to its officers. Private firms moreover either give a bonus or extra pay for overtime, whereas Government do not.

86. *Drawing and Clerical establishment.*—The drawing and clerical establishment that will be eventually required cannot be accurately forecasted and has been estimated for on the basis of the usual establishment allowed for divisions and subdivisions, slightly reduced, and on a special scale for the Engineer-in-chief's office. It would be advisable to relieve executive officers of as much accounts and clerical work as possible and if the accounts are centralised in the Engineer-in-chief's office a saving in establishment would result, though a second Personal Assistant would be required. In any case the estimate is considered to be a liberal one.

87. *Head works, total estimate of cost of establishment, Public Works Department.*—The total estimate of establishment charges for the head works amounts to Rs. 30,48,000 which includes Rs. 1,00,000 for travelling allowances and passages to and from India for temporary employees obtained from abroad and 5 per cent for contingencies. The total represents 14.6 per cent on the total estimate for works, excluding preliminary expenses, land and cost of sluices, gates and gear (dam only) and is Rs. 14,45,000 less than would have been provided on the old 21½ per cent basis.

88. *Head works, establishment for sluice shutters.*—In the second revised estimate 10 per cent was allowed for establishment for sluice shutters in dam and surplus. In the present estimate Rs. 1¼ lakhs is allowed for sluices in dam only, which is at the rate of 7.4 per cent on the estimated cost of the shutters and gear, and is considered to be ample in view of the inflated cost of the sluice gates.

89. *Head works, establishment, other departments.*—In the original and first revised estimates the provision for establishment, other departments, amounted to Rs. 3,48,000 made up as follows:—

Medical	...	...	...	...	...	...	...	Rs.
Magistrate and Police	...	...	...	...	...	...	...	1,68,000
Forest	...	...	...	...	...	...	...	72,000
	...	...	...	...	...	...	...	1,08,000
Total	...	...	...	...	...	...	...	3,48,000

The whole of the estimated cost of revenue establishment for land acquisition was shown under "Canal system." The provisions have now been revised taking into account increase in pay and the shorter period for which the establishment will now be required and the cost of the revenue establishment has been distributed between "Headworks" and "Canal system".

The revised estimate amounts to Rs. 5 lakhs distributed as follows:—

Medical	...	...	...	...	...	...	...	Rs.
Magistrate and Police	...	...	...	...	...	...	...	1,90,000
Forest	...	...	...	...	...	...	...	90,000
Revenue	...	...	...	...	...	...	...	1,00,000
	...	...	...	...	...	...	...	1,20,000
Total	...	...	...	...	...	...	...	5,00,000

90. *Canal System, Organization for execution works.*—The charges and establishment originally proposed are dealt with in Section XIII of Part I of Volume I of the papers connected with the project. It was not proposed to post any establishment to the canal system during the first year after sanction to the project, but as the programme of construction has now to be quickened up, it is proposed to form a survey party immediately the project is sanctioned and about six months later to post the Superintendent of Works, as he will be required for the preparation of construction plans and to supervise the survey work. The survey party would in the second year be turned into the No. 1 division and continue to the end of construction, eventually becoming the permanent division. No. 2 division would be formed at the end of the first year from sanction and be engaged mainly on survey work for the first year and continue to about the end of the eighth year. No. 3

division would be employed about 18 months to two years after sanction to the project has been given and be retained to the end of the seventh year. This division corresponds to the Vadavar division, but will undertake more work than was originally proposed for it.

91. *Canal System, Establishment required.*—The establishment and period of employment proposed is shown in the statement below:—

Establishment, Canal System.

Designation of Officer.	Year dating from sanction to project									
	1	2	3	4	5	6	7	8	9	10
Superintendent of Works	1	1	1	1	1	1	1	1	1	1
Personal Assistant	1	1	1	1	1	1	1	1	1	1
<i>Engineers-in-charge.</i>										
No. 1 Division	1	1	1	1	1	1	1	1	1	1
No. 2 "	1	1	1	1	1	1	1	1	1	1
No. 3 "	1	1	1	1	1	1	1	1	1	1
<i>Engineers-in-sub-charge.</i>										
No. 1 Division	1	2	2	2	2	2	2	2	2	1
No. 2 "	1	2	2	2	2	2	2	2	2	1
No. 3 "	1	2	2	2	2	2	2	2	2	1
Upper subordinates	8	26	32	32	32	32	32	24	12	8

The number of Upper Subordinates provided for is probably more than will be required, but the present object is to frame a safe estimate and only such establishment as is necessary will be employed.

92. *Canal System, Estimate of cost of establishment.*—The average pay estimated for is—

Superintendent of Works (Executive Engineer) Rs. 1,750, Engineers-in-charge Rs. 1,100, Engineers-in-sub-charge Rs. 800 and Upper Subordinates Rs. 160 per mensem as in the case of the headworks. As probably 50 per cent of the Engineers will not be entitled to technical and overseas allowances the actual cost of the establishment may be considerably less than has been estimated for.

93. *Canal System, total estimated cost of establishment.*—The total estimate for establishment charges amounts to Rs. 20,19,000, which includes Rs. 1,20,000 for travelling allowances and 7½ per cent for contingencies. The latter provision is 2½ per cent in excess of the percentage allowed in the headworks estimate and is intended to cover a local allowance to the establishment of one of the divisions, which will have remote headquarters. No recommendation can be made until the headquarters are actually fixed.

The total amount of the estimate for establishment is 18.15 per cent of the total cost of 'Works', after deducting preliminary expenses and estimated cost of land, and Rs. 3.73 lakhs less than the provision that would have had to be made under the old 21½ per cent rule.

94. *Canal System, estimated cost of revenue establishment.*—Out of the Rs. 3 lakhs provided for revenue establishment for the acquisition of land Rs. 1.8 lakhs has been included in the canal system estimate.

TOOLS AND PLANT ORDINARY, SUSPENSE AND RECEIPTS ON CAPITAL ACCOUNT.

95. *Tools and plant ordinary, whole project.*—The provision under this head is at the usual rate of 1½ per cent on the estimate for 'Works' less that for 'Land'.

96. *Suspense, whole project.*—The provision of Rs. 50,000 and Rs. 30,000 for 'Headworks' and 'Canal system', respectively, have been increased to Rs. 75,000 and 37,000 on account of increase in cost of materials.

97. *Receipts on Capital Account.*—The estimated credit under this head is to cover sale and rent of buildings and sale of tools and plant when no longer

required. It has been proposed in paragraph 85 above that no charge be made for the occupation of buildings and no provision is made for this. The sale of buildings at the 'Headworks' will realize very little and therefore the bulk of the credit will be from the sale of tools and plant. Though the cost of plant will be much greater than was previously estimated, it is possible that it will realize very little more than was originally anticipated, if there is a big fall in prices while the work is in progress. If, however, the power for the work is obtained hydro-electrically as is now proposed from Hogenkal Falls, a considerable credit will be obtained from the sale of the plant and more still if it is taken over as part of a bigger installation for which water will then be available. The provision under 'Headworks' has therefore been increased from Rs. 3,52,368 to Rs. 6,50,000. Under canal system Rs. 49,692 was provided in the original estimate and this sum was retained in the first revision of the estimate though nearly Rs. 6 lakhs was provided for additional Special Tools and Plant not contemplated in the first estimate. The sale of buildings in Tanjore district and the rent from the permanent quarters to be built will realize a considerable amount and therefore the provision for the 'Canal System' has been increased to Rs. 1 lakh.

INDIRECT CHARGES.

98. *Abatement of land revenue.*—The sums in the estimate under this head represent the estimated annual loss of land revenue capitalized at 25 years purchase.

99. *Leave and pension allowances.*—The provision for these is at the rate of 14 per cent on the revised establishment charges less provision for travelling allowances.

100. *Total of revised estimate.*—The revised estimates for the 'Headworks', 'Canal System' and whole project are compared with the previous ones below:—

	Original estimate (1910).	First revised estimate (1916).	Second revised estimate (1921).	Percentage increase of second on first revised estimate.
	RS.	RS.	RS.	
Headworks	2,39,15,000	2,59,31,640	3,66,02,000	41.5
Canal system	1,46,85,000	1,50,13,960	1,88,18,000	25.3
Total	3,85,00,000	4,09,45,600	5,55,00,000	35.5

101. *Probable expenditure by years.*—A statement showing the probable expenditure year by year for the ten years construction programme is attached to the classified abstracts of estimates which accompany this note.

GENERAL REMARKS.

102. Sir John Benton in paragraph 24 of his Note on the original estimate for the project, printed on page 9 of Volume IV of the Cauvery Reservoir Project papers, recommended certain procedure to ensure that the project estimate is adhered to. Mr. Keeling, in paragraph XX of Volume I, Part II of his report on the inquiries he made in 1911, put forward the lines on which he proposed to proceed. Mr. Keeling's proposals guard against unwarrantable departures from the sanctioned estimate and will entail very little work in the Chief Engineer for Irrigation's office. No provision has therefore been made for charging a share of the Chief Engineer for Irrigation's establishment to the project under establishment charges, Public Works Department.

103. *Superintendence of improvements in Cauvery delta.*—Mr. V. T. Srinivasa Ayyangar, the present Executive Engineer in charge of Vennar division, has suggested that the Engineer-in-Chief of the project should take over the superintendence of the irrigation work of the Tanjore and Vennar divisions from the Superintending Engineer, VII Circle, as soon as the project is started, so that he could study the peculiar conditions of the delta irrigation and initiate and carry out improvements in the delta having in view the economising of water under the altered conditions of supply that will obtain when the reservoir is in operation. This is certainly desirable, but the Engineer-in-Chief could not undertake this work without

detriment to his project work in the first two or three years after sanction to the project and thereafter only if a Superintendent of Works is put in direct charge of the construction of the dam.

104. *New Circle for irrigation dependent on the reservoir.*—A second suggestion is that as soon as the reservoir comes into operation, which will be about seven years after the project is put in hand, a new circle be formed to take over all the irrigation dependent on the reservoir. This would include the old irrigation in Coimbatore, Salem and Trichinopoly districts, the existing Tanjore irrigation, the new area and the Lower Anicut system, an area of nearly 1½ million acres in all. To this could be added the Vellar irrigation, as works for the common benefit of the Lower Anicut system and that of Shatiatope on the Vellar have been carried out and will be in the future.

In view of the conflicting interests of the river channel irrigation above the delta, the old delta area, new irrigation and the Lower Anicut system and of the very altered conditions with a reservoir, which will give a continuous instead of a fluctuating supply and deprive the Lower Coleroon system of most of its flood water, the proposal seems a sound one. If a new circle is decided on, it should be formed three or four years before the reservoir comes into operation so that preparation may be made for the altered conditions of supply; if this is not done, there will be every chance of the working of the reservoir causing dissatisfaction, and if it occurs in a bad year, prejudicing extension under it.

F. E. MORGAN—18-3-21.

For revision of this statement, vide page 13 of Letter No. 95 I., dated 31st March 1924, in print.

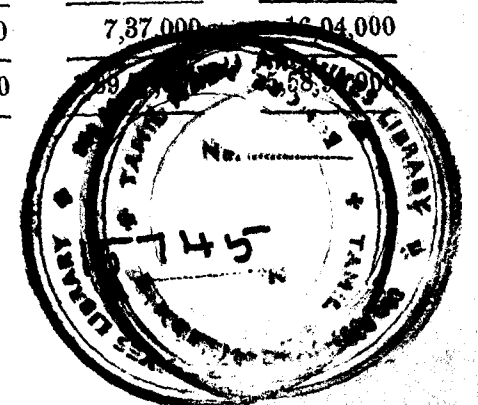
CONDENSED ABSTRACT OF COST.

(Revision of Statement, Volume IV, page 75, C.R.P.)

Serial number.	Departmental head.	Head works.	Canal system.	Total.
		RS.	RS.	RS.
A. Direct charges.				
1. Works		2,51,20,000	1,39,08,000	3,90,28,000
2. (a) Establishment, Public Works Department.		30,48,000	20,19,000	58,72,000
(b) Establishment on sluice shutters ..		1,25,000	...	
(c) Establishment, other departments ..		5,00,000	1,80,000	
3. Tools and plant, ordinary		3,42,000	1,69,000	5,11,000
Tools and plant, special		72,55,000	18,38,000	90,93,000
4. Suspense		75,000	67,000	1,42,000
5. Receipts on capital accounts		— 6,50,000	— 1,00,000	— 7,50,000
6. Audit and accounts 1 per cent on I works.		2,51,000	1,39,000	3,90,000
A. Total, Direct charges ...		3,60,66,000	1,82,20,000	5,42,86,000
B. Indirect charges.				
Abatement of Land Revenue		3,67,000	4,46,000	8,13,000
Leave and Pension allowances 14 per cent on establishment less travelling allowances ..		5,00,000	2,91,000	7,91,000
B. Total, Indirect charges ...		8,67,000	7,37,000	16,04,000
Grand Total ...		3,69,33,000		

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For revision of this statement, vide pages 13 and 14 of Letter No. 95 I,
dated 31st March 1924, in print.

Statement of cost of Cauvery Reservoir Project under Departmental head "Works".

Head Works.

Sub-heads.	Main dam.	Main surplus sluices.	Total.
	RS.	RS.	RS.
1. Head Works.			
A. Preliminary expenses	2,50,000	...	...
B. Land	22,85,100	...	...
C. Works	1,84,47,375	15,57,675	2,00,05,050
K. Buildings	10,66,725	...	...
O. Miscellaneous	12,97,125	...	...
P. Maintenance	2,16,000	...	...
Total	2,35,62,325	15,57,675	2,51,20,000

Canal System.

Sub-heads.	Grand ancient canal system.	Vadavar system.	Total.
	RS.	RS.	RS.
2. Main Canal and Branches.			
A. Preliminary expenses	96,800	20,500	1,17,300
B. Land	8,60,100	1,24,700	9,84,800
D. Regulators	4,23,200	27,900	4,51,100
E. Falls and weirs	1,34,000	35,400	1,69,400
F. Cross drainage works	24,31,000	62,700	24,93,700
G. Bridges	17,32,100	1,38,300	18,70,400
H. Escapes	43,100	22,500	65,600
K. Buildings	2,95,900	28,200	3,24,100
L. Earthwork	23,79,400	1,74,700	25,54,100
M. Plantations	50,000	12,900	62,900
O. Miscellaneous	1,46,700	9,400	1,56,100
P. Maintenance	72,000	11,500	83,500
Total, Main Canal and Branches	86,64,300	6,68,700	93,33,000

3. Distributaries.

A. Preliminary expenses	1,06,100	19,300	1,25,400
B. Land	13,20,250	2,36,500	15,56,750
C. Works	13,26,570	2,44,200	15,70,770
L. Earthwork	10,49,650	1,92,300	12,41,950
O. Miscellaneous	22,150	3,900	26,050
P. Maintenance	45,080	9,000	54,080
Total, Distributaries	38,69,800	7,05,200	45,75,000
Total, Canal System	1,25,34,100	13,73,900	1,39,08,000
Total, Works	...	...	3,90,28,000

For revision of this statement, vide page 14 of Letter No. 95 I,
dated 31st March 1924, in print.

CLASSIFIED ABSTRACTS OF ESTIMATES.

HEAD WORKS.

ABSTRACT COST BY SUB-HEADS.

(Revision of Statement, Volume IV, page 76, C.R.P.)

Name of work.	A. Preliminary expenses.	B. Land.	C. Works.	K. Buildings.	O. Miscellaneous.	P. Maintenance.	Total.
	RS.	RS.	RS.	RS.	RS.	RS.	RS.
Main dam	2,50,000	20,31,200	1,63,91,000	9,48,200	11,53,000	1,92,000	2,09,65,400
Main surplus sluices.	..	..	13,84,600	..	..	..	13,84,600
Total	2,50,000	20,31,200	1,77,75,600	9,48,200	11,53,000	1,92,000	2,23,50,000
Add unforeseen 12½ per cent on works.	..	2,53,900	22,29,450	1,18,525	1,44,125	24,000	27,70,000
Grand Total	2,50,000	22,85,100	2,00,05,050	10,66,725	12,97,125	2,16,000	2,51,20,000

Classified Abstracts of Head Works.

Sub-head.	Names of works.	Amount of estimate for individual works.	Total of sub-heads.	Total for each canal or distributary.	Total of each main head.	Remarks. In this column the numerators represent estimate number and the denominators plan number.
I. WORKS.						
(1) HEAD WORKS.						
1. Main dam including waterspread.						
A. Preliminary Expenses.	Preliminary expenses	2,50,000	2,50,000	..	..	..
B. Land	Compensation for water spread area, camping grounds, etc., from Revenue Officer's report (as now revised).	20,31,200	20,31,200	..	..	..
C. Works	Main dam	1,46,21,000	..	..	..	..
	Bridge across Cauvery below dam site.	1,20,000	..	..	..	..
	For borings in foundations of dam and grouting.	1,00,000	..	..	..	..
	For testing experimenting on strength and proportioning of materials and on methods of construction.	50,000	..	..	..	..
K. Buildings.	Sluice shutters and gear including curtains and cranes.	15,00,000	1,63,91,000	..	..	..
	Workshops, store-sheds, quarters, etc.	9,48,200	9,48,200	..	..	..
	Communications, roads, etc.	11,53,000	11,53,000	..	..	..
O. Miscellaneous.	Maintenance during construction.	1,92,000	1,92,000	..	..	..
P. Maintenance	Total main dam including waterspread.	..	2,09,65,400	..	..	..
2. Main surplus sluices.						
C. Works	Main surplus sluices	4,95,400	..	..	..	..
	Shutters including gear steel-work of road way.	8,89,200	13,84,600	..	..	..
	Total (I), Head Works	..	2,23,50,000	..	..	..

For revision of this statement, vide page 15 of Letter No. 95 I., dated 31st March 1924, in print.

CLASSIFIED ABSTRACTS OF ESTIMATES.

GRAND ANICUT CANAL SYSTEM.

MAIN CANALS AND BRANCHES.

Abstract of Cost by sub-heads.

(Revision of Statement, Volume IV, page 77, C.R.P.)

Particulars.	A Preliminary expenses.	B Land.	D Regulators.	E Falls and weirs.	F Cross drainage works.	G Bridges.	H Escapes.	K Buildings.	L Earthwork.	M Plantations.	O Miscellaneous.	P Maintenance.	Total
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)
	Rs.	Rs.	Rs.	Rs.	Rs.	Rs.	Rs.	Rs.	Rs.	Rs.	Rs.	Rs.	Rs.
Grand anicut canal ..	78,800	5,09,937 58,564 10,357	2,25,852	..	17,10,033	6,28,690	24,475	1,11,020	15,92,149	23,541	91,465	40,000	50,53,792
Kalianodai branch canal ..	8,500	68,871 34,582 1,644	30,206	57,244	..	55,945	..	22,880	1,28,412	5,410	5,104	5,000	8,57,563
Vadakadu branch canal ..	5,300	36,226 17,030 2,947	13,024	14,355	..	24,860	3,069	8,140	41,334	3,200	2,420	2,750	1,54,708
Rajamadam ..	3,400	19,977 1,860 229	14,222	16,181	6,760	14,234	3,190	33,858	33,631	2,100	1,430	1,750	1,50,833
Pudupatnam ..	1,000	2,089 5,86,563 50,537	8,052	10,164	..	..	..	9,020	6,998	450	627	500	38,900
Total ..	96,800	6,37,100	2,91,456	97,944	17,16,793	7,21,730	30,734	1,84,948	18,02,554	34,691	1,01,545	50,000	57,65,796
Add for increase in rates ..	..	79,638	61,208	13,712	3,09,023	7,21,730	5,225	61,849	1,80,255	6,888	21,220	10,000	11,70,598
Total ..	96,800	7,16,738	3,52,664	1,11,656	20,25,816	14,43,460	35,959	2,46,597	19,82,809	41,579	1,22,766	60,000	72,36,394
Add 20 per cent for unforeseen contingencies.	..	1,43,562	70,536	22,344	4,06,184	2,88,640	7,141	49,303	3,96,591	8,371	24,484	12,000	11,27,906
Grand total ..	96,800	8,60,100	4,23,200	1,34,000	24,31,000	17,32,100	43,100	2,95,900	23,79,400	50,000	1,46,700	72,000	86,64,300

For revision of this statement, vide page 16 of Letter No. 95 I., dated 31st March 1924, in print.

CLASSIFIED ABSTRACT OF ESTIMATES.

VADAVAR SYSTEM.

MAIN CANALS AND BRANCHES.

Abstract of cost by sub-heads.

(Revision of Statement, Volume IV, page 78, C.R.P.)

Canals.	A. Preliminary expenses.	B. Land.	D. Regulators.	E. Falls and Weirs.	F. Cross drainages.	G. Bridges.	H. Escapes.	K. Buildings.	L. Earthwork.	M. Plantations.	O. Miscellaneous.	P. Maintenance.	Total.
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)
	Rs.	Rs.	Rs.	Rs.	Rs.	Rs.	Rs.	Rs.	Rs.	Rs.	Rs.	Rs.	Rs.
The Vadavar and Vadavar extension canal.	20,500	81,950 10,467	19,200	25,650	44,300	57,600	16,020	17,580	1,39,300	8,900	6,440	8,000	4,49,107
Add increase in rates ..	..	11,552	4,032	3,619	7,974	57,600	2,723	5,860	13,230	1,780	1,852	1,800	1,11,322
Total ..	20,500	1,03,969	23,232	29,269	52,274	1,15,200	18,743	23,440	1,45,530	10,680	7,792	9,800	5,60,429
Add 20 per cent for unforeseen.	..	20,731	4,668	6,931	10,426	23,100	3,757	4,760	29,170	2,220	1,608	1,900	1,08,271
Grand total ..	20,500	1,24,700	27,900	35,400	62,700	1,38,300	22,500	28,200	1,74,700	12,900	9,400	11,500	6,68,700

For revision of this statement, vide page 17 of Letter No. 95 I., dated 31st March 1924, in print.

CLASSIFIED ABSTRACT OF ESTIMATES.

VADAVAR SYSTEM.

DISTRIBUTARIES.

Abstract of cost by sub-heads.

(Revision of statement, Volume IV, page 78, C.R.P.)

Particulars.	A. Preliminary expenses.	B. Land.	C. Works.	L. Earth-work.	O. Miscellaneous.	P. Maintenance.	Total.
Vadavar extension channel with all its offtakes.	Rs. 19,240	Rs. 1,75,150	Rs. 1,83,338	Rs. 1,45,690	Rs. 2,875	Rs. 6,225	Rs. 5,32,518
Add for increase in rates	..	21,894	20,162	14,570	360	1,245	58,231
Total ..	19,240	1,97,044	2,03,500	1,60,260	3,235	7,470	5,90,749
Add 20 per cent for unforeseen contingencies.	60	39,456	40,700	32,040	665	1,530	1,14,451
Grand total ..	19,300	2,36,500	2,44,200	1,92,300	3,900	9,000	7,05,200

For revision of this statement, vide page 18 of Letter No. 95 I., dated 31st March 1924, in print.

Statement showing expenditure to conform with Programme of Works.

Cauvery (Metur) Reservoir Project.

(Revision of Table A on page 43 on Volume IV, C.R.P.)

Main heads.	Year of construction and expenditure in each year in rupees.										Total rupees.
	Preliminary works. (1)	Preparatory. (2)	Works. (3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	
Works—											
Head works	2,40,000	11,35,000	15,50,000	25,00,000	32,33,000	38,50,000	33,33,000	24,00,000	15,07,000	3,39,050	2,01,47,050
Sluice gates and gear	..	..	..	1,50,000	50,000	11,60,000	12,00,000	1,87,850	..	..	26,87,850
Distribution system	1,04,000	3,65,000	12,50,000	20,42,800	20,95,000	21,13,000	17,82,550	9,12,150	5,83,000	1,18,950	1,13,66,450
Land—											
Head works	1,20,000	3,00,000	10,00,000	2,07,200	6,21,700	10,36,200	..	..	..	..	22,85,100
Distribution system	1,56,000	2,00,000	10,00,000	9,00,000	1,00,300	1,00,800	..	..	..	..	25,41,550
1. Total, Works ..	6,20,000	20,00,000	38,00,000	58,00,000	61,00,000	82,00,000	64,00,000	35,00,000	21,50,000	4,58,000	3,50,28,000
Establishment—											
Public Works	2,37,475	4,18,555	6,05,715	6,93,155	6,88,804	7,07,819	7,39,532	5,42,935	3,59,915	1,56,965	51,92,000
Special	13,625	62,445	1,02,285	1,06,815	1,07,096	1,07,181	60,468	52,065	52,085	16,036	6,80,000
2. Total, Establishment ..	2,51,000	5,11,000	7,08,000	8,00,000	7,95,900	8,15,000	8,00,000	5,95,000	4,22,000	1,73,000	58,72,000
Tools and plant—											
Ordinary	5,000	22,500	42,000	70,400	80,700	1,05,900	94,800	52,500	32,200	5,000	5,11,000
Special	1,00,000	4,77,500	30,00,000	50,00,600	3,00,800	1,14,500	1,00,000	..	..	..	90,93,000
3. Total, Tools and plant ..	1,05,000	5,00,000	30,42,000	50,71,000	3,81,000	2,20,500	1,94,800	52,500	32,200	5,000	96,04,000
4. Suspense	20,000	55,000	2,00,000	1,80,000	—28,000	—75,000	—75,000	—60,000	—40,000	—35,000	1,42,000
5. Receipts on capital account	—500	—10,000	—10,000	—10,000	—12,000	—12,500	—30,800	—1,18,500	—2,35,200	—3,10,000	—7,50,000
6. Audit and accounts 1 o/o on I works ..	6,000	20,000	38,000	58,000	61,000	82,000	64,000	25,000	21,500	4,500	3,90,000
A. Total, Direct charges ..	10,01,500	30,76,000	77,79,000	1,18,99,000	72,98,000	92,30,000	73,53,000	40,04,000	23,50,500	2,95,000	5,42,86,000
Capitalised abatement of Land Revenue ..	43,000	84,000	1,70,000	1,88,000	1,22,000	1,92,000	14,000	..	..	..	8,13,000
Leave and Pension allowances	26,000	80,000	98,000	1,07,000	1,05,000	1,08,000	1,07,000	81,000	66,000	22,000	7,91,000
B. Total, Indirect charges ..	69,000	1,64,000	2,68,000	2,95,000	2,28,000	3,00,000	1,21,000	81,000	56,000	22,000	16,04,000
Grand total ..	10,70,500	32,40,000	80,47,000	1,21,94,000	75,26,000	95,30,000	74,74,000	40,85,000	24,04,500	3,17,000	5,68,90,000

Taluk.	Village.	Extent of occupied land (patta to be taken up).	Assessment on it.	Average value per acre.	Total value at proximate.	Value of houses, garden, sheds, temple and churches.	Value of wells.	Value of trees.	Total 6-9 columns.
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Omalur ..	Salem district.								
	Pottaneri Nallagoundampatti	1,027 20	1,308 11	25 to 75	45,359 12	8,940 0	8,550 0	5,200 0	63,401 12
	Kovur	337 87	382 8	10 to 100	20,550 4	5,567 0	1,655 0	977 4	28,749 8
	Sholappadi	916 89	812 9	20 to 300	86,200 0	2,500 0	1,400 0	857 0	90,457 9
	Kolanayakampatti	186 41	253 4	20 to 100	13,825 8	630 0	2,800 0	70 0	17,325 8
	Pallipatti	19 77	19 10	20 to 50	418 11	..	..	..	418 11
	Malliyakundam	2 50	2 13	20	50 0	..	..	..	50 0
	Sholepadi	1,515 68	1,057 1	60 to 300	1,04,300 0	36,104 0	9,830 0	1,605 0	1,51,839 0
	Badrabelli	924 87	823 3	60 to 100	53,314 0	7,977 8	4,385 0	384 0	72,060 8
	Manjarahalli	213 12	218 6	50 to 100	13,747 0	8,630 0	5,960 0	1,596 8	29,933 8
Dharmapuri ..	Gendanshalh	111 97	100 0	50	6,598 8	250 0	200 6	260 0	6,808 8
	Naganarai	1,617 20	1,167 7	10 to 120	71,781 0	11,313 0	11,530 0	551 0	95,175 0
	Jarimankurichi	538 25	..	70 to 100	38,738 0	1,800 0	2,620 0	1,200 0	44,358 0
	Total	7,408 73	6,145 8	..	4,58,982 11	83,671 8	49,430 0	8,692 12	6,00,076 15
	North Salem Forest reserve.	..	..	..	..	..	..	..	20,000 0
Bhavani ..	Total for Salem								
	..								
	..								
	..								
	..								
Kollegal forests ..	Coimbatore district.								
	Kaveripuram	4,925 13	3,427 2	49 to 200	2,48,405 0	72,044 0	68,259 0	7,441 0	3,98,149 0
	Sampalli ..	3,402 79	2,583 0	25 to 100	2,15,367 0	33,165 0	44,996 0	10,254 0	3,03,782 0
	Mulekkadu	1,698 40	1,140 0	Do.	94,366 0	10,335 0	32,663 0	6,230 0	1,42,994 0
	Kolethur	697 99	815 13	80 to 500	2,05,899 0	3,720 0	3,350 0	19,185 0	2,32,154 0
	Navappatti	527 89	180 6	100 to 150	34,317 8	450 0	475 0	2,000 0	37,242 8
	Madewaramalai	450 0	..	..	..	..	..	2,025 0	2,025 0
	North Bargar	210 0	..	..	..	..	..	200 0	200 0
	Total for Coimbatore	12,122 32	8,536 0	..	8,28,114 8	1,20,134 0	1,49,743 0	47,355 0	11,44,727 0
	Total for Salem and Coimbatore	19,531 5	14,681 8	..	12,86,997 3	2,03,805 8	1,99,173 0	55,427 12	17,69,804 0
Add 15 per cent compulsory acquisition on all bot forests									2,61,395 0
Grand total									20,31,200 0

APPENDIX I.

REVISION OF DISCHARGES OF THE CAUVERY AT CAUVERY DAM AND BHAVANI BRIDGE AND OF LOSSES IN TRANSMISSION.

Discharge of the Cauvery at the Cauvery Dam.—The Cauvery at the Cauvery Dam was gauged in 1909 by the Cauvery Reservoir Project Party and the discharge curve obtained for the Cauvery Dam North Gauge was used in the preparation of the working tables which accompanied the original and revised estimates for the Mettur Reservoir Project. Daily current meter gaugings of the Cauvery at the Cauvery Dam have been made by a joint Mysore-Madras Party, for six months a year, from and including the year 1917. The results of the gaugings for the three years ending 1919 are compared with those of 1909 in the statement below:—

Comparative statement of discharges at the Cauvery Dam for readings on the Cauvery Dam North Gauge from the discharge curves obtained from joint Mysore-Madras gaugings and those of 1909.

Cauvery dam, gauge reading feet.	Discharge in cusecs.				Percentage differences from average of 1917 to 1919 gaugings				
	Joint gaugings.								
	Gaugings of 1909.	1917.	1918.	1919.	Average of three years 1917 to 1919.	Columns 2-2 5-2 × 100	Columns 2-6 5-6 × 100	Columns 3-6 6-6 × 100	Columns 4-6 6-6 × 100
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
3.0	..	4,200	..	5,650	7,050	6,350	+ 61.2	— 33.9	— 11.0
3.5	..	5,400	7,900	8,360	9,850	8,703	+ 61.2	— 38.0	— 3.9
4.0	..	6,600	10,850	11,350	12,675	11,635	+ 76.3	— 43.3	— 6.7
4.5	..	8,150	13,950	14,530	15,550	14,677	+ 80.1	— 44.5	— 5.0
5.0	..	11,200	17,180	17,750	18,550	17,860	+ 59.5	— 37.3	— 3.8
5.5	..	15,100	20,550	21,000	22,000	21,183	+ 40.3	— 28.7	— 3.0
6.0	..	18,750	24,350	24,880	25,800	25,027	+ 33.5	— 25.1	— 2.7
6.5	..	22,750	28,800	29,650	30,400	29,617	+ 30.2	— 23.2	— 2.8
7.0	..	26,500	33,700	35,600	36,360	34,883	+ 31.6	— 24.0	— 3.4
7.5	..	33,250	38,850	..	40,600	39,725	+ 19.5	— 16.3	— 2.2

2. It will be seen from the statement above that for stages of river connoted by gauge readings of 5.5 feet and above, there is good agreement between the three years' gaugings, the variation from the average discharge curve, 1917—19, from that for any single year being within 4 per cent. The average discharge curve for these gauges gives discharges from 20 to 40 per cent in excess of those obtained from the 1909 curve. Below a gauge of 5.5 feet, the excess shown by the average discharge curve is greater still, varying from 40 to 80 per cent, and the agreement with the individual curves from which it is obtained is also not so good as for higher gauges, the variation being as much as 13 per cent at a gauge of 3.5 feet.

3. The question of the stability of the river bed at the Cauvery Dam was gone into during the Mysore-Madras Arbitration and it was accepted, on the evidence of annual levels taken since 1885, that there had been no material alteration in the average bed level and that it agreed closely with that of the year 1867. Since the Arbitration in 1914 no change has taken place. Two reasons have been advanced for the variation in the discharge-gauge relation below a gauge of about 5.5 feet. The first is that a sand shoal divides the river into two channels at the Cauvery dam for gauges up to about 5 feet and the second that a scour sets up round the north gauge when the Upper Anicut regulator has been closed for a considerable period. As the shoal is constantly shifting and altering in width the discharge, gauge for gauge, when the river flows over the dam in two channels, may vary very appreciably, and in the same season; it is however not practicable to gauge the river where it is divided into two parts. With regard to the second reason, the set of the river round the nose of the island, when the regulator is closed, has been observed to cause a local reduction on the ruling level of the river in the immediate neighbourhood of the gauge. When the regulator is opened, the set disappears and there is then no reason to believe that the gauge reading does not accurately represent the level of the channel of the river on the north side. If the scour seriously affects the accuracy of the discharge curve, then for years of poor supply when the regulator is kept closed for abnormally long periods, the discharge, gauge for gauge, should be higher than in a normal year. This is not, however, borne out by the gaugings of 1917—19 as in the years 1917 and 1918 the regulator was kept

closed for abnormally long periods whereas the year 1919 was practically a normal one. Reference to the table in paragraph 1 above will show that the discharges given by the curve of 1919 are larger than those from the curves of 1917 and 1918, whereas they should be smaller if the gaugings were seriously affected by the gauge giving low readings when the regulator was closed. It looks therefore as if the probable chief cause of the differences in the discharge curves of 1917, 1918, 1919 at low gauges is due to the sand shoal.

4. The gaugings of 1909 were conducted in a year when the regulator was kept open for abnormally long periods, this would not however affect the gauge discharge relation for gauges of 5.5 feet and above and for these gauges the 1917—19 discharge curve must be accepted in preference to that of 1909, as the former is based on far more accurate gaugings conducted at 9 more suitable sites; there is also no apparent reason why the 1917—19 curve should not apply to the recorded gauge readings of 5.5 feet and above of all past years. Whether the 1917—19 curve is applicable to the low readings of 1909 or not is of no importance as the supplies in that year were good. The 1917—19 curve must also be taken as being more applicable to readings below 5.5 feet on the Cauvery Dam north gauge of past years than that of 1909, especially in years of poor supply, as the 1917—19 curve embraces two such years; it is, however, realized that by so doing, errors of considerable magnitude may occur, but an error of as much as 10 per cent on the whole year's flow in a bad year is not probable. The discharges at the Upper Anicut entered in the working table previously prepared have accordingly been revised, using the 1917—19 discharge curve.

5. *Discharge of the Cauvery at Bhavani Bridge.*—The discharges at Bhavani bridge, which are those which form the impounding basis for Metur Reservoir, were in previous working tables taken from a discharge curve, for the rear gauge at the bridge, obtained from gaugings made in 1909. As the gaugings of 1909 at the Upper Anicut have been shown by recent gaugings to have given results on the low side, the discharges at Bhavani bridge from the 1909 curve have been compared with those at the Upper Anicut based on the 1917—19 curve during periods when there was either no rainfall in the intermediate catchment or insufficient to produce any appreciable run-off.

6. The only rivers joining the Cauvery below Bhavani bridge, which have a portion of their catchments in the hills, are the Bhavani, the Amaravati and the Noyel. The latter river contributes nothing in a poor south-west monsoon and what little water is left over from its irrigation requirements in a normal monsoon is diverted into the Pogalur channel. Across the Bhavani there is an anicut at Kodiveri, 114 miles above the Upper Anicut, which intercepts the whole of the flow from the catchment in the hills. Twenty-four miles below this anicut is another one across the Bhavani, just above its junction with the Cauvery, this however, is useless as a measuring anicut. The tail anicut of the Amaravati is at Pallapolliyam 21 miles from its junction with the Cauvery and 51 miles above the Upper Anicut.

7. The catchment areas above the various measuring points are—	SQ. MILES.
Cauvery above Upper Anicut	26,172
Do. above Bhavani bridge... ..	16,612
Between Bhavani bridge and Upper Anicut	9,560
Bhavani above Kodiveri anicut	1,900
Amaravati above Pallapolliyam anicut	2,380
Noyel above Pogalur channel	1,304
	<u>* 5,584</u>

The unmeasured catchment between Bhavani bridge and the Upper Anicut is 3,976 square miles. This is all in the plains, and a number of rain gauges are located in the area. The area irrigated from the Cauvery below Bhavani bridge and above the Upper Anicut and from the anicut across the Bhavani just above its junction with the Cauvery is 120,000 acres, of which 70,000 drain above the Upper Anicut and 50,000 drain below. The requirements of this irrigation in July, August and September are—

$$\frac{70,000}{60} + \frac{50,000}{30} = 2,834 \text{ cusecs.}$$

or, say, 7,600 million cubic feet in July and August and 7,350 million cubic feet in September. The quantity of water that would be taken in June, if available, depends on whether the 'korambus' are in existence or not and it will be taken as 1,500 million cubic feet.

* Of the area, 640 square miles of the Bhavani catchment and 480 square miles of the Amaravati catchment are in the hills.

8. In Table A, appended to this note, the measured contributions of the Bhavani and Amaravati, less irrigation requirements,* have been compared with the differences of the discharges at Bhavani bridge and the Upper Anicut for months in which rainfall data show that the run-off from the unmeasured catchment was nil or practically so. The quantities unaccounted for are compared with the estimated discharge at Bhavani bridge in Table B at the end of this note.

9. It is possible that the quantity of water actually utilized in the channels draining back into the river above the Upper Anicut has been over-estimated, but even if the figures in column 7 of Table A have been very much over-estimated, still it is evident that if the discharges at the Upper Anicut are correct, then the Bhavani bridge ones are considerably under-estimated.

10. If allowance were made for loss in transmission between Bhavani bridge and the Upper Anicut on the scale adopted in previous working tables of the Metur reservoir, the quantities unaccounted for would be increased still more and these tables, though prepared with a different object, support the proposal made later for very considerably reducing the provision for losses in transmission on water issued from the reservoir.

11. This examination was made too late in the season to conduct useful gaugings at Bhavani bridge as the river had fallen to a low stage. Two sets of current meter gaugings were, however, made between 17th and 20th of November 1920 at gauges of 1.80 and 1.91. The discharges obtained were 26 and 24 per cent respectively in excess of those given in the table of 1909, printed on page 23 of Volume III of the Cauvery Reservoir (Metur) Project papers. These gaugings were made under considerable difficulties, and much reliance cannot be placed on them. The Cauvery Gauging division will, however, systematically, gauge the Cauvery above Bhavani bridge throughout the coming irrigation season.

12. The table of discharges printed on page 23 of Volume III of the Metur Project papers has been revised, the low discharges being increased by 20 per cent, decreased to nil at a gauge of 6.6. This table of discharges has been used in all the revised working tables.

13. *Loss in transmission between the Mysore reservoir and Metur.*—In the working tables of the Metur reservoir, which accompanied the first revised estimate, the amount available for impounding was taken as the discharge at Bhavani bridge less the amount impounded at Kannambadi two days previously, reduced by allowing a transmission loss on the amount impounded of 13 per cent in the south-west monsoon and 11 per cent in the north-east monsoon.

14. The distance between the Mysore reservoir, and the Hogenkal Falls, up to which water will be ponded by the Metur dam, is 105 miles and for 45 miles of this length the river runs through a rocky bed where it is ponded by a succession of barriers forming deep pools. The loss in this length, due either to evaporation or absorption, is for all practical purposes a constant for all stages of river above the minimum flow which has to be maintained for power at Sivasamudram. Between Sivasamudram and Kannambadi a distance of 60 miles, the water in the river is ponded at several anicuts and though, owing to this cause, the absolute loss due to a small flow may be high, it is very little more if any greater, due to a very considerable flow. Further when impounding takes place in the Krishnaraja Sagara there will always be a considerable flow below the junction of the Kabbani with the Cauvery, that is for 29 miles of the length above Sivasamudram.

15. The extra loss that would have occurred, if a quantity impounded had been left in the river, on most occasions would be nil, or practically so, and therefore to be on the safe side no loss in transmission has been allowed, in the present working tables, in arriving at the resulting flow at Bhavani bridge after impounding.

16. *Loss in transmission between Metur reservoir and the Upper Anicut.*—The provision made for loss in transmission on water issued from the reservoir in previous working tables has been as follows:—

	PER CENT.
For first month after opening	50
From second month first half to sixth month first half inclusive	20
From sixth month second half to seventh month first half inclusive.	30
From seventh month second half to eighth month first half inclusive.	40

17. The distance between the proposed dam at Metur and the Upper Anicut is 102 miles. The width of the Cauvery between Metur and Bhavani, a distance of 26 miles, is under 2,000 feet on the average and that of the remaining 76 miles is less than 3,500 feet but will be taken at that figure. The waterspread, with the river

running full, is therefore about $102 \times 5,280 \times 3,500 = 1,884$ m. sq. ft. and this waterspread does not vary much for stages of river down to about 5 feet on the Cauvery dam north gauge. Taking the loss due to evaporation on the whole waterspread at one-sixth of an inch per diem, which is the maximum that is likely to occur during the irrigation season, the total loss per diem due to this cause would be 26.2 m. c.ft.

18. The deep bed of the river is rocky throughout and from Bhavani to the Upper Anicut there is irrigation on the right side of the river for the whole length, and on the left side for about half the length, throughout the whole year, which must cause the ground water surface to slope towards the river. Whatever loss in transmission there may be due to absorption will be confined to the water absorbed by the sand in the river bed at the beginning of the irrigation season or after periods of low water. Between Metur and Bhavani, rock outcrops in the river bed for quite 15 per cent of the waterspread and the beds of sand are very shallow for the greater part of the remaining area. There is a larger percentage of sandy bed below Bhavani and the thickness is greater, but the whole of the sand cannot drain in the dry weather owing to the perennial flow and the high subsoil water level on both banks of the river. It can be safely assumed that, only 2 to $2\frac{1}{2}$ ft. reckoned on the whole waterspread of 1,884 m. sq. ft. requires recharging to replace the loss due to evaporation and that due to drainage into the deep channel of the river in which the flow is perennial.

Taking the higher figure of $2\frac{1}{2}$ ft., the amount required to recharge the sand would be—

$$1,884 \times 10^6 \times 2.5 \times \frac{40}{100} = 1,884 \text{ m. c.ft.}$$

19. As the reservoir only supplements the supply in the river below Bhavani, 26 miles down river, it does not have to make good the whole of the losses in transmission estimated above

20. The rules for estimating the loss on transmission in the working tables are given below and these are considered to be on the safe side:—

(i) For first month of opening 50 per cent.

(ii) For second month of opening to seventh month first half inclusive for *evaporation*—

$$\frac{D}{I} \times 26$$

where D=Deficiency in irrigation requirements to be made good in m. c.ft. ;

I—Irrigation requirements in m. c. ft.

(iii) In addition on the first four days of the second month of opening a provision for loss by *absorption* of

$$\frac{D}{I} \times \frac{2200 - M}{4}$$

Where M = Maximum flow at the Upper Anicut in m. c.ft per diem during the previous fortnight ;

D and I have the same significance as in the evaporation formula. Only positive quantities to be taken into account

(iv). From the seventh month second half to eighth month first half inclusive for *evaporation*—

$$\frac{D}{I} \times 20$$

TABLE A.

Comparison between the difference of the discharges of the Cauvery at the Upper Anicut and Bhavani bridge and the probable inflow between these two points.

All discharges are in million cubic feet.

Year.	Month.	Godavari anicut.		Pallapalayam anicut surplus.	Total of columns (3), (4) and (5).	Used for irrigation.	Excess of quantity in column (6) over that in col. (7).	Discharge at Upper Anicut less that at Bhavani bridge.	Unaccounted for (column 9—8).
		Surplus.	Half channel supply.						
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
1899	..	June ..	6,995	883	..	7,878	1,500	6,378	15,074
1904	..	Do. ..	19,951	556	1,567	22,474	1,500	20,974	12,295
1905	..	Do. ..	8,398	774	418	9,590	1,500	8,090	— 604
1917	..	Do. ..	3,950	810	21	4,781	1,500	3,281	6,385
1918	..	Do. ..	3,350	850	112	4,312	1,500	2,812	6,374
1899	..	July ..	6,503	995	421	7,919	7,600	319	27,683
1905	..	Do. ..	17,323	1,114	637	19,074	7,600	11,474	27,763
1914	..	Do. ..	21,061	1,399	1,483	23,943	7,600	16,343	39,071
1917	..	Do. ..	4,770	875	58	5,703	7,600	— 1,897	11,864
1918	..	Do. ..	2,050	755	..	2,805	7,600	— 4,795	3,021
1904	..	August.	9,215	975	634	10,844	7,600	3,244	15,817
1905	..	Do. ..	4,266	888	..	5,154	7,600	— 2,446	12,929
1918	..	Do. ..	4,530	909	18	5,457	7,600	— 2,143	8,665
1906	..	Sep. ..	6,234	884	89	7,207	7,350	— 143	12,327
1918	..	Do. ..	900	521	..	1,421	7,350	— 5,929	— 2,409

TABLE B.

Quantities unaccounted for in Table A, compared with discharge at Bhavani bridge deduced from curve of discharge of 1909.

Year.	Month.	Discharge at Bhavani bridge m. c.ft.	Unaccounted for from column (10) in Table A m. c.ft.	Quantity unaccounted for as a percentage of Bhavani bridge discharge Col. (4) Col. (3) × 100.
(1)	(2)	(3)	(4)	(5)
1899	June ..	30,844	15,074	48.8
	July ..	60,020	27,364	45.6
	Average for June and July ..	..	..	47.2
1904	June ..	61,146	12,295	20.1
	August ..	67,838	12,573	18.5
	Average for June and August ..	..	..	19.3
1905	June ..	10,433	— 604	— 5.8
	July ..	85,827	16,289	19.0
	August ..	42,453	15,375	36.2
	September ..	34,794	12,470	35.8
	Average for four months ..	..	..	21.3
1917	June ..	16,004	6,385	39.9
	July ..	28,636	13,761	48.1
	Average for June and July ..	..	..	44.0
1918	June ..	40,574	6,374	31.0
	July ..	23,051	7,816	33.9
	August ..	35,051	10,808	30.8
	September ..	20,919	3,520	16.8
	Average for four months ..	..	..	28.1

Appendix II—Revision of the Krishna Raja Sagara (Kannambadi Reservoir) working tables—Not Printed.

Appendix III—Second Revision of the Madras Cauvery (Metur) Reservoir working tables—Not printed.

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