GOVERNMENT OF MADRAS

PUBLIC WORKS DEPARTMENT

(IRRIGATION)

PAPERS

CONNECTED WITH THE

AUVERY RESERVOIR PROJECT

VOL. III

Reprinted Edition

(Omitting Parts VI, VIII, IX (1) and IX (2) of the 1910 Edition.)

MADRAS

PRINTED BY THE SUPERINTENDENT, GOVERNMENT PRESS

1925

Government of Madras

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VOLUME III.

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PART I.

SOURCES OF RIVER SUPPLY TO THE IRRIGATED AREAS.

CAUVERY RESERVOIR PROJECT.

VOLUME III.

PART I.

SOURCES OF RIVER SUPPLY TO THE IRRIGATED AREAS.

1. *General sources of river supply.*—A reference to the index map will show that the area to be irrigated or rather to be protected by the Metur reservoir is supplied by water almost entirely from the Cauvery river at the Upper Anicut.

Between the Upper Anicut and the site of the reservoir at Metur the Cauvery receives supplies from several rivers of considerable size, the most notable being the Bhavani which joins the Cauvery at Bhavani village and the Amaravati which joins the Cauvery just below Karur.

At the Upper Anicut the Cauvery (known above this as the Agunda Cauvery) bifurcates.

The main river takes the left (northernmost) course and is called from this bifurcation "The Coleroon," while the smaller branch known as "The Cauvery" takes the more southerly course. The point of bifurcation is the nose of the island of Srirangam. This island is a long, narrow strip and forms for 20 miles the northern margin of the Cauvery river from the head (the Cauvery dam) to the Grand Anicut at the tail of the island. Across the river between the upper end of Srirangam island and the north side of the Coleroon a regulating weir capable of holding up water levels has been built. This work is known as the Upper Anicut.

2. *Description of the Upper Anicut.*—Up to recent years the Upper Anicut was a solid masonry anicut with piers carrying over it a masonry bridge and with a few low-level sluices. In 1900 to 1902 the work was remodelled, the solid crest was lowered 4 feet and the low-level sluices closed, and 6 feet high 40 feet long shutters capable of being raised clear of floods or lowered on to the crest at will, were fitted, giving means of very complete regulation of the river flow.

3. *Description of the Cauvery dam.*—Across the other branch of the river (the Cauvery) a dam, rather of the nature of a grade wall, has been built from the nose of Srirangam island to the south bank of the river. This wall is generally for the greater part of its length buried in sand.

It is known as "the Cauvery dam" and the water levels of the Cauvery at the Upper Anicut are usually referred to the reading of the gauge at the north end of the Cauvery dam.

The readings of the Cauvery dam north gauge are constantly referred to in the correspondence and reports for many years regarding the floods and irrigation supplies to the Cauvery delta, and the officers who were experienced with the delta works got to know by experience the effect, as flood, or supply, of the readings of this gauge.

In the correspondence regarding the adequacy of seasonal supplies which passed some years ago between Colonel Smart and Mr. Hughes and in the reports of Mr. Moss on his reservoir scheme it is the depth of water on this gauge that is the standard of supply and not any specific discharge in cusecs. For purposes of the present Cauvery project this has been abandoned and a specific system of duties has been the basis of the supplies computed.

For the purpose of comparison with the older system, however, a column is shown in the table (page 34) giving supplies in a typical season for the deltaic area and showing the depth on the Cauvery dam equivalent to the discharge allowed.

Those acquainted with the older system of gauging supply will recognise from this column the adequacy of the supplies proposed with reference to their knowledge of the capacities for irrigation of the delta with certain seasonal depths on this gauge.

4. *Customary water regulation at the Upper Anicut.*—The facilities for regulation given by the Upper Anicut enable the distribution of water between the branches of the river to be fully affected here.

By custom the distribution made is, that the Cauvery (south branch) which is the main irrigation river is given all the water the works under it can carry conveniently and any surplus is passed into the Coleroon which constitutes the main flood carrier. When the shutters of the Upper Anicut are all lifted clear the power of further regulation is gone and flood water passes over the Cauvery dam and the Upper Anicut in proportion to the respective discharging capacities of these works.

5. *Importance of discharge over the Cauvery dam.*—From this it will be seen that for irrigation supply purposes the discharge of Cauvery dam is all important.

For discharge of floods the discharge of the both the Upper Anicut and the Cauvery dam must be considered.

6. *The Grand Anicut.*—At the Grand Anicut 20 miles below the Cauvery dam is at the tail end of Srirangam island. Here the Cauvery bifurcates into the two main rivers supplying the Cauvery delta. The Vennar the Southern branch and the Cauvery the northern. Regulators with lift shutters worked from bridges above are built across the head of each river, and a regulating weir, somewhat similar to the Upper Anicut stretches, from the tail end of Srirangam island, to the left end of the Cauvery regulator and holds up the Cauvery water to the required level, and gives facilities for surplusing excess water from here to the Coleroon.

This regulating weir is known as the Grand Anicut.

7. *Offtake of the proposed Grand Anicut canal.*—The new canal is to offtake from the south (right) side of the Cauvery with a regulator at the head somewhat similar to the existing Vennar and Cauvery regulators and will form a third great irrigation offtake channel from the Grand Anicut.

8. *Flow of Agunda Cauvery at Upper Anicut—Measure of available supply.*—From the above it will be clear that the measure of the Cauvery water giving supply to the areas both of existing and proposed wet cultivation is the flow of the "Agunda" Cauvery at the Upper Anicut. Extra water is received in the Cauvery between the Upper and Grand Anicut from the Kodamurti, a stream draining a local catchment of 768 square miles. In considering supplies available the flow of this has not been considered.

9. *Flow of Cauvery at Bhavani Bridge—A measure of water available for impounding.*—While the flow of the Agunda Cauvery at the Upper Anicut is the measure of flow available for irrigation purposes in Tanjore delta, the measure of the flow of the Cauvery at the proposed reservoir site is required, to know how much of such flow it is possible to impound in the reservoir.

It is fortunate that we have for 29 years daily gauge readings of Cauvery at Bhavani bridge, 26 miles below the dam site at Metur.

Between the dam site and Bhavani bridge the drainage area of the river is small (only about 725 square miles). Thus the flow of Cauvery at Bhavani bridge is an accurate measure of the flow which it is possible to impound in a reservoir at Metur.

10. *Basis of working tables of the reservoir.*—It is on the flow daily of the Agunda Cauvery during the irrigation season June to January, as recorded by readings of the north gauge of the Cauvery dam, and on the daily flow throughout the year of the Cauvery at Bhavani bridge (as recorded by the readings of the gauge on the bridge) that the working tables for the Metur reservoir are based, and in the parts II and III following a description is given of the means taken to measure the flow represented by the daily gauge readings at the Cauvery dam (Upper Anicut) and at Bhavani bridge.

PART II.

GAUGING THE CAUVERY FLOW OVER THE CAUVERY DAM AND METHODS OF COMPUTING DISCHARGE OF THE AGUNDA CAUVERY AT THE UPPER ANICUT.

PART II.

DESCRIPTION OF GAUGING OPERATIONS AND METHOD OF COMPUTING DISCHARGES OF AGUNDA CAUVERY AT THE UPPER ANICUT WITH DISCHARGE TABLES.

11. *Discharge over the Upper Anicut into the Coleroon.*—The Cauvery at the Upper Anicut is a wide river flowing over a bed consisting of sand to a considerable depth.

The Upper Anicut giving flow into the Coleroon is divided into two branches (North and South Branch) by a small island.

The North branch consists of—

Ten spans of 40 feet with crest level 2 feet above that of the Cauvery dam. Shutters are 6 feet in height.

The South Branch consists of—

45 spans similar to the above.

Before remodelling in 1899 to 1902 the work was a solid anicut with crest at 4 feet above the present cill level (6 feet above crest of Cauvery dam).

The North branch was 10 spans of $34\frac{1}{2}$ feet.

The South branch 36 spans of $33\frac{1}{2}$ feet.

As already explained the discharge of the Upper Anicut is of the nature of flood discharge which passes the work only when the discharge over the Cauvery dam is so great that the irrigation rivers, Vennar and Cauvery cannot conveniently utilise the water.

12. *Discharges over the Upper Anicut before remodelling.*—The discharge of the Upper Anicut before remodelling, entered in the working tables, is based on a table of discharges worked out by Major Montgomerie, R.E., for his report of 1881 on the flood discharges of the Coleroon. The table is based on the ordinary formula for discharge of weirs and takes into consideration velocity of approach, the co-efficients used varying with the depth on the crest. Details of this can be ascertained by reference to the report referred to. The table is attached (page 17).

13. *Discharges of the Upper Anicut since remodelling—Methods of computing.*—The discharges of the remodelled anicut have been specially calculated for purposes of the working tables for this project on the following data:—

For spans in which shutters are lifted clear, as weirs, with velocity of approach.

For spans in which shutters are partly raised as sluices.

The formulæ used are as follows :—

Q = Discharge in cusecs.

h = Difference of water level above and below the anicut in feet or where the overfall is clear the difference between water level above the work and the weir cill (crest) level.

h_a = Head due to velocity of approach.

l = Length of weir over which water is free to flow in feet.

d = Depth in feet of tail water level over crest of weir.

c = Co-efficient 0·75.

c_1 = „ 0·577.

c_2 = „ which varies as follows with d.

d = 0 to 8	... ...	$c_2 = 0{\cdot}6$
d = 8 to 9	... ...	$c_2 = 0{\cdot}8$
d = over 9	... ...	$c_2 = 0{\cdot}87$

Formula—

Weir with clear overfall—

$$Q = 3{\cdot}1\, l\, [(h + h_a)^{\frac{3}{2}} - h_a^{\frac{3}{2}}]$$

For submerged weir—

$$Q = \tfrac{2}{3}\, c_1\, l\, \sqrt{2g}\, [(h + h_a)^{\frac{3}{2}} - h_a^{\frac{3}{2}}] + c_2\, l\, d\, \sqrt{2g\,(h + h_a)}.$$

For sluice discharge—

$$Q = C\, A\, \sqrt{2g\,(h + h_a)}.$$

When the velocity of approach for sluice discharge is so small that the difference between $\sqrt{h}$ and $\sqrt{h + h_a}$ does not exceed 5 per cent of the former h_a is neglected and treated as zero.

14. *Method of computing velocity of approach, Upper Anicut.*—The velocity of approach has been determined by trial computation as follows :—

The mean bed level and width of section approach is determined from surveys of the site.

This with the level of water recorded above the work gives the water area of the section of approach. The discharge neglecting h is computed —d.

From this V_{a1} the velocity of approach due to this discharge d. is found with the corresponding h_{a1}.

The discharge is computed with velocity of approach V_{a1}.

From the result a second velocity of approach V_{a2} is computed.

The process is repeated until the results of two successive computations of velocity of approach do not differ by more than a fixed percentage (taken as 5 per cent for these calculations)

The above method would be generally accurate were the mean level of the approach constant. In a river with a sandy or changeable bed as is the Cauvery at the Upper Anicut this is not so.

Generally at the end of the flow season the mean level of the bed across the anicut is up to crest level. This however is scoured out the first fresh to a lower level.

15. *Assumptions made for computing velocity of approach, Upper Anicut.*—The assumptions made for these calculations regarding the mean level of the bed of the section of approach are—

(*a*) That the normal mean bed level is 1 foot below the crest of the anicut. That the width of section of approach (taken from the chart of 1907-08 is : North branch 520 feet, South branch 2,160 feet.

(*b*) That the bed maintains the mean level so long as the velocity of approach is below 1.3 V_{o}.

(*c*) Where this velocity is exceeded, it is assumed that the bed level is scoured out, by successive half foot differences of mean bed level, to such a depth as to bring the velocity within limit 1.3 V_o. (V_o. is Kennedy's critical velocity of Punjab sand.) The computation fails where "h" is very small and thus the error in reading "h" probably very large.

In certain cases at the Upper Anicut this is clearly shown from the records.

With a considerable flood there is no appreciable afflux at the Upper Anicut and the whole discharge is due to velocity of approach.

This inaccuracy does not materially affect the Reservoir tables, as it is accuracy of moderate to small discharges which are important. High flood discharges of the Upper Anicut do not materially affect the results, checked as they are by the recorded discharges at Bhavani bridge.

16. *Description of gauging flow at the Cauvery dam.*—During the year 1909-10 (July to January) daily velocity observations and flow calculations were made of the discharges over the Cauvery dam and these discharges recorded with reference to gauge readings of the North gauge.

The observations were taken by surface floats and also by an electric current meter.

The line of section for the latter was about 200 feet below the Cauvery dam and the run for the floats another 200 feet below this.

The width of the Cauvery here is about 2,000 feet.

A wire overhead rope was stretched across the river above the lines of observation and meter observations were made and floats started from a boat moored to successive points along the wire rope.

The floats used were ordinary reputed quart bottles, weighted so as to float with only the neck protruding from the water.

A stiff paper flag about 6 inches square, with a steel hat pin run through the edge was stuck in the cork of each bottle to enable it to be clearly followed by observers from the bank, and timed across the lines of observation with stop watches.

The general arrangement for observation daily was briefly as below :—

A boat moored successively at marked stations along the wire overhead rope WW and keeping a true alignment along the section line MM (*vide* sketch plan).

A trained observer (II) with two stop watches stations himself at II while two other men are stationed at I and III, respectively.

A man in the boat after signalling (with a flag) the number of his station and getting an acknowledgment puts in a float.

Observer I gives a signal shout when the float crosses line I. Observer II starts both stop watches. He stops one watch when the float crosses line II.

Observer III shouts when the float crosses line III and No. II stops the second stop watch. He then records timings.

Three runs are made from each station. Meanwhile a skilled observer in the boat after taking the depth lowers his current meter to .6 of the depth below the surface and takes with this also three runs which he records the revolutions at once (with the depth) in the register.

The same operation is repeated at each station.

When the day is favourable (with little wind) he takes three or four surface velocities with the current meter as well as velocities at .6 of the depth. From these observations the coefficient for reducing surface velocities to mean velocities were deduced and applied to the float observations to get discharges. Occasionally also with a view of checking the meter rating surface velocities with the meter were taken on the actual runs of floats, runs being selected where the floats have run truest and steadiest.

It will be seen that by the above system of observing the floats and meter results constituted a constant check on each other.

The resulting discharge computations are recorded in the curve and diagram in the pocket of this volume which shows the actual daily results computed by meter and by floats.

17. *Cauvery dam—Coefficient for reducing surface to mean velocities.*—When the river was in a state of good flow the coefficient for reducing surface to mean velocity deduced from a large series of observations was 0.83 and for these stages this has been used (viz., normal and high stages).

For the later observations an unexpected variation in this was observed and special care was taken to check this. The coefficient for observation with a gauge reading below 4.5 (low stage) was found to be .87. It has only been after careful scrutiny of the daily meter observations for mean and surface velocities and comparison with float results that this has been accepted. In December and January the observations for this coefficient were taken daily.

18. *Daily work sheets for computing discharge.*—For purposes of illustration two sheets are attached showing one day's working out of float and of current meter discharges of the Cauvery dam.

19. *Period of continuance of flow observations.*—Owing to the gross neglect of duty and unreliability of the Upper Subordinate originally posted to the duty only a few isolated (and unreliable) discharges for the month of June are available and these have been discarded. From July to December, however, uninterrupted observations are on record.

Daily Discharge Report.

Computed from current meter observations, No. 69 M., dated 13th October 1909.

Station number.	Distance from initial point of C.S.	Sounding at this distance.	Means of adjacent soundings.	Distance between soundings.	Area of compartment.	Depth at which current meter ran in feet.	Surface number of revolutions per second.	Surface velocity in feet per second.	Number of revolutions per second at ·6 of full depth.	Mean velocity of station in feet per second.	Mean velocity of compartment in feet per second.	Discharge = area of compartment × velocity.	Proportion between mean and surface velocity.	Remarks.
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)
..	0	..	..	..	..	..	..	..	..	..	..	..	..	
..	18	Water edge.		..	..	..	..	..	..	..	..	..	..	
1	39	11·50	5·75	21·00	121	6·90	2·45	4·17	1·89	3·20	2·13	257	0·77	Coleroon shutters.
2	126	8·80	10·15	87·00	883	5·28	2·21	3·78	1·91	3·28	3·24	2,861	0·86	North branch clear.
3	226	7·80	8·30	100·00	830	4·68	2·09	3·58	1·79	3·03	3·15	2,615	0·85	South branch clear.
4	362	6·60	7·20	136·00	979	3·96	..	..	2·07	3·55	3·29	3,221		
5	458	5·00	5·80	96·00	557	3 00	..	..	2·11	3·62	3·59	2,000	2·48	Propeller No. 1 used.
6	600	4·50	4·75	142·00	675	2.70	..	..	2·10	3·60	3·61	2,437	= ·83	
7	800	3·00	3·75	200·00	750	1·80	..	..	1·95	3·35	3·48	2,610	3	
8	1,000	2·00	2·50	200 00	500	1·20	..	..	134	2·30	2·82	1,410		
9	1,200	1·80	1·90	200·00	380	1·08	..	..	95	1·63	1·96	745		
10	1,300	4·50	3·15	100·00	315	2·70	..	..	172	2·90	2·26	712		
11	1,400	3·00	3·75	100·00	375	1·80	..	..	151	2·57	2·73	1,024		
12	1,600	2·00	2·50	200·00	500	1·20	..	..	117	2·02	2·30	1,150		
13	1,800	1·00	1·50	200·00	300 } 450	0·06	..	..	100	1·72	1·87	748		
14	1,900	1·00	1·00	100·00	100	..	..	..	..	..	..	..		
15	1,960	Water edge.	·50	60·00	30	..	..	..	..	..	1·15	35		
											Total, cusecs ..	21,825		

No. 69 M.

CAUVERY RESERVOIR PROJECT

CURRENT METER OBSERVATIONS OF THE CAUVERY RIVER

AT

Upper Anicut.

Name of observer—P. Muthuswami Aiyar.

Name of checker—N. Venkatarama Aiyar.

Name of computer—P. Muthuswami Aiyar.

Dated—13th October 1909.

Direction of wind——→

Gauge reading—

At start—6·7′. R.L. 242·94 }
At finish—6·7. R.L. 242·94 } Mean 6·7. R.L. 242·94.

Time—

At start—6-30 A.M.

At finish—12 noon.

P. MUTHUSWAMI AIYAR,
Surveyor.

ALLEN CAMPBELL,
Executive Engineer, Upper Section, Cauvery Project.

Daily Discharge Report.

Computed from float observations, No. 73 F., dated 13th October 1909.

Station number.	Distance from initial line of C. S. on right bank.	Soundings at C.S. I.	Soundings at C.S. II.	Soundings at C.S. III.	Mean depth.	Means of adjacent soundings.	Distance between soundings.	Area of compartment.	Time in seconds for float to pass C.S. I and C.S. III.	Surface velocity = distance/time.	Mean velocity = ·88 of surface velocity.	Mean velocity for each compartment.	Discharge = area of compartment × velocity.	Remarks.
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)
0	18	Water edge.		..	..	..	..	..	..	..	..	..	..	
1	39	12·0	12·0	15·0	13·0	6·5	21	137	46	4·3	3·8	2·5	343	Coleroon shutters clear.
2	126	8·8	10·0	11·5	10·1	11·6	87	1,009	47	4·3	3·7	3·8	3,834	
3	226	7·2	6·4	7·0	6·9	8·5	100	850	51	3·9	3·5	3·6	3,060	
4	362	6·3	5·5	7·0	6·3	6·6	136	898	49	4·1	3·6	3·5	3,143	
5	458	5·2	5·3	5·6	5·4	5·8	96	557	52	3·8	3·4	3·5	1,950	
6	600	5·2	4·2	3·8	4·4	4·9	142	696	49	4·1	3·6	3·5	2,436	
7	800	3·6	2·8	2·9	3·1	3·8	200	760	60	3·3	2·9	3·3	2,508	
8	1,000	3·0	2·4	2·5	2·6	2·8	200	560	78	2·6	2·3	2·6	1,456	
9	1,200	3·2	2·2	5·0	3·5	3·1	200	620	76	2·6	2·3	2·3	1,426	
10	1,300	4·5	5·2	4·5	4·7	4·1	100	410	60	3·3	2·9	2·6	1,066	
11	1,400	3·2	2·7	3·0	3·0	3·8	100	380	66	3·0	2·7	2·8	1,064	
12	1,600	2·4	1·2	1·7	1·8	2·4	200	480	81	2·5	2·2	2·5	1,200	
13	1,800	1·0	0·6	0·6	0·7	1·2	200	240	133	1·5	1·3	1·8	432	
14	1,900	1·6	1·4	1·4	1·5	1·1	100	110	111	1·8	1·6	1·5	160	
15	1,950	Water edge.		..	..	·8	50	40	..	..	..	1·1	44	
											Total discharge, cusecs	..	24,127	

Explanatory note.—Column 12 subsequently recomputed with coefficient 0·83.

Float observations.

Station.	Distance from initial point of C.S. on right bank.	Time in $\frac{1}{5}$ second occupied to pass C.S. I and C.S. II.	Time in $\frac{1}{5}$ second occupied to pass C.S. I and C.S. III.	
..	18	Water edge.		
1	39	126 114 112	248 232 231	232
2	126	118 125 123	224 234 234	234
3	226	134 125 123 135	260 245 237 253	257
4	3d2	116 130 132	226 244 248	246
5	458	141 168 138	263 246 260	262
6	600	119 136 119	246 266 243	245
7	800	152 140 143	304 304 300	302
8	1,000	193 193 192	394 389 390	389
9	1,200	216 224 205	412 382 375	378
10	1,300	162 167 160	302 300 307	301
11	1,400	164 161 163	328 324 327	328
12	1,600	208 210 204	404 409 489	406
13	1,800	268 270 262	663 667 662	664
14	1,900	272 244 268	558 475 553	555
15	1,950	Water edge.		

No. 73 F.

CAUVERY RESERVOIR PROJECT.

FLOAT OBSERVATIONS ON THE CAUVERY RIVER

AT

Upper Anicut.

Name of observer—N. Venkatarama Aiyar.

Name of checker—P. Muthuswami Aiyar.

Name of computer—N. Venkatarama Aiyar.

Date—13th October 1909.

Length of runs—200 feet.

Direction of wind——/——>

Gauge reading—

At start—6·7
At finish—6·7 } Mean 6·7.—

Time—

At start—6-30 A.M.

At finish—12 noon.

P. MUTHUSWAMI AIYAR,
Officer in charge of Gauging Party, Upper Anicut

ALLEN CAMPBELL,
Executive Engineer, Upper Section, Cauvery Project

20. *Abnormal regulation at Upper Anicut in* 1909.—It is somewhat unfortunate that in this year the system of regulation of the Upper Anicut shutters should have perforce during the months of September and October been abnormal.

This was due to the breaching of the Grand Anicut in August and the consequent necessity to restrict the quantity of water passed down the Cauvery to what was actually required for irrigation. It is usual to pass down the Cauvery all water in the Upper River till the gauge on the Cauvery dam rises to 7 feet and from then, but not till then, so far as practicable to prevent a further rise by passing water into the Coleroon over the Upper Anicut.

It is quite abnormal to be passing large quantities of water over the Upper Anicut with gauge readings under 6½ feet, as was the case in this year from the end of August to the middle of October.

To what extent this may affect our results is not known, but it is believed that the difference in discharges due to the same gauge reading will not be very great whether the Coleroon Anicut is open or closed. The unfortunate abnormality is however here noted.

21. *Cauvery dam—Seasonal variations of flow for the same gauge reading.*—The daily discharges calculated from observations both with surface floats and with current meters when plotted in a diagram showed a marked seasonal variation.

This was not unexpected. It had long been known that during prolonged freshes the sand shoals lying over the crest of the Cauvery dam were much reduced in volume and the waterway for the same gauge reading thus increased.

Major Montgomery made allowance and as the curve shows excessive allowance for this in his curve of 1881. The results of discharges actually gauged and plotted in different colours however show the variation. For normal stages (gauge readings 4.5 to 6.7) it will be noted there are variations on either side the average or normal discharge curve of over 10 per cent—(vide Discharge Diagram in pocket of this volume).

For instance, referring to the diagram, it will be noticed that—

(1) the July readings (blue) are below the normal curve,

(2) after the prolonged flood of preceding dates the discharge of 4th to 14th August (black) are all above the normal curve,

(3) again after the high stages preceding 15th August to 18th September (red) the discharges are above the normal curve,

(4) from 4th October to 10th November (blue) the discharges succeed a low stage period and are below normal curve.

Examining the dates and registers of flow it is found that the excesses over normal all occur after a period of prolonged fresh while deficient discharge is recorded after a period of prolonged "low stage". It is clear from the observations that some notice of such variations of flow must be taken in converting gauge readings into "flow in cusecs" if any approach to accuracy is to be attained.

From a study of the way the river discharges varied for the same gauge readings during observation of 1909 the rules which follow were drawn up for converting "gauge readings" into "flow" past the Cauvery dam.

The rules are admittedly purely arbitrary. Actual comparison of the results obtained by applying the rules to the gauge readings of 1909, with the actual results of daily discharge observations produced the following totals:—

	From discharge observations.	Discharges by gauge readings and rules.
	M.C.FT.	M.C.FT.
July	67.64	69.74
August	61.70	59.67
September	35.33	33.10
October	45.25	45.75
Total ...	209.92	208.26

The flow of the river over the Cauvery dam has been computed from this gauge readings (north gauge Cauvery dam) for the working tables by applying the rules to the recorded gauge readings for the 20 years period which the tables cover.

22. *Rules for computing discharge of Cauvery dam from readings of north gauge with the aid of the table (or curve) "Normal" discharge—*

Rule I.—For gauge readings, 6.7 and upwards being "high stages" take the discharges from table (or curve) of "normal" discharges.

(*a*) In cases of continuous "high stage" of 20 days or over a discharge of 10 per cent over "normal" to be recorded from 20th day.

(*b*) In the case of a sudden "high stage" occurring after a prolonged period (10 days or more) of "low stage" (4.5 or below) deductions to be made from "normal discharges" as under :—

Deduct 1 per cent of discharge for each day less than 10 from the date of the gauge reading exceeding 4.5 to date of the discharge being computed.

When the river has not been in a "low stage" for as long as 10 consecutive days no deduction for sudden flood will be made.

Example.—Between 16th October and 20th October 1904 gauge reading rose from 4.5 to 6.9 and from 6th to 16th October all gauge readings were below 4.5.

Thus the discharge for 20th October would be computed.

	M.C.FT.
6.9 normal discharge	2,225
Deduct 6 × 22	132
... Discharge, 20th October ...	2,093
For the same gauge reading the discharge for 21st October would be.	2,115

Rule II.—For "normal stages" (gauge readings 4.5 and upwards and below 6.7).

(*a*) The discharges generally to be taken from the table or curve of "normal discharge".

(*b*) When the period of "normal stage" succeeds a period of "prolonged high stage" (10 or more successive days in that stage) then 10 per cent is to be added to the normal discharge for the first fifteen days of the "normal stage".

(*c*) When the period of "normal stage" succeeds a period of "prolonged low stage" then 10 per cent is to be deducted from normal discharges for the first fifteen days in that stage.

Rule III.—For "low stages" (viz., gauge readings below 4.5) discharges to be taken from the "normal discharge" table or curve.

Rule IV.—The continuance of a "stage period" is not to be considered as terminated by intervals of other "stages" of less than 5 continuous days.

Each such day if in the "normal" or "high" stages will be subject to the same percentage alteration as the items of the uninterrupted stage but will not be counted as a day in that stage.

Rule V.—Doubtful cases in which it appears desirable to treat as exceptions to be submitted for orders by the computer.

TABLE of "Normal discharges", Cauvery Dam, from readings, North Gauge (from curve of discharges based on gaugings of 1909).

Discharge in cusecs.	North gauge, Cauvery dam.	Discharge in millions cubic feet per 24 hours.	Discharge in cusecs.	North gauge, Cauvery dam.	Discharge in millions cubic feet per 24 hours.	Discharge in cusecs.	North gauge, Cauvery dam.	Discharge in millions. cubic feet per 24 hours.	Discharge in cusecs.	North gauge, Cauvery dam.	Discharge in millions cubic feet per 24 hours.
46	·1	4	4,478	3·1	386	19,604	6·1	1,690	45,054	9·1	3,884
93	·2	8	4,663	3·2	402	20,358	6·2	1,755	46,029	9·2	3,968
139	·3	12	4,849	3·3	418	21,112	6·3	1,820	47,003	9·3	4,052
186	·4	16	5,034	3·4	434	21,866	6·4	1,885	47,978	9·4	4,136
232	·5	20	5,220	3·5	460	22,620	6·5	1,950	48,952	9·5	4,220
302	·6	26	5,475	3·6	472	23,432	6·6	2,020	49,950	9·6	4,306
371	·7	32	5,730	3·7	494	24,244	6·7	2,090	50,947	9·7	4,392
441	·8	38	5,986	3·8	516	25,056	6·8	2,160	51,945	9 8	4,478
510	·9	44	6,241	3·9	538	25,868	6·9	2,230	52,942	9·9	4,564
580	1·0	50	6,496	4·0	560	26,680	7·0	2,300	53,940	10·0	4,650
766	1·1	66	6,890	4·1	594	27,492	7·1	2,370	55,054	10·1	4,746
951	1·2	82	7,285	4·2	628	28,304	7·2	2,440	56,167	10·2	4,842
1,137	1·3	98	7,679	4·3	662	29,116	7 3	2,510	57,281	10·3	4,938
1,322	1 4	114	8,074	4·4	696	29,928	7·4	2,580	58,394	10·4	5,034
1,508	1·5	130	8,468	4·5	730	30,740	7·5	2,650	59,508	10 5	5,130
1,670	1.6	144	9,094	4·6	784	31,598	7·6	2,724	60,633	10·6	5,227
1,833	1·7	158	9,727	4·7	838	32,457	7·7	2,798	61,758	10·7	5,324
1,995	1·8	172	10,347	4·8	892	33,315	7·8	2,872	62,884	10·8	5,421
2,158	1·9	186	10,974	4·9	946	34,174	7·9	2,946	64,009	10·9	5,518
2,320	2·0	200	11,600	5·0	1,000	35,032	8·0	3,020	65,146	11·0	5,616
2,529	2·1	218	12,296	5·1	1,060	35,937	8·1	3,098	66,271	11·1	5,713
2,738	2·2	236	12,992	5·2	1,120	36,842	8·2	3,176	67,396	11·2	5,810
2,946	2·3	254	13,688	5·3	1,180	37,746	8·3	3,254	68,521	11·3	5,907
3,155	2·4	272	14,384	5 4	1,240	38,651	8·4	3,332	69,646	11·4	6,004
3,364	2·5	290	15,080	5·5	1,300	39,556	8·5	3,410	70,760	11·5	6,100
3,550	2·6	306	15,834	5·6	1,365	40,461	8·6	3,488	71,897	11·6	6,198
3,735	2·7	322	16,538	5·7	1,430	41,366	8·7	3,566	73,034	11·7	6,296
3,921	2·8	338	17,342	5·8	1,495	42,270	8·8	3,644	74,170	11·8	6,394
4,106	2 9	354	18,096	5·9	1,560	43,175	8·9	3,722	75,307	11·9	6,492
4,292	3·0	370	18,850	6·0	1,625	44,080	9·0	3,800	76,444	12·0	6,590

TABLE of discharges of Old Upper Anicut into the Coleroon before remodelling from gauge readings, North Gauge, Cauvery Dam.

This table is based on the discharge curve of Major Montgomerie.

The discharge of the under sluices in the old dam are not taken into account.

Gauge reading.	Discharge in millions cubic feet per 24 hours	Gauge reading.	Discharge in millions cubic feet per 24 hours.	Gauge reading.	Discharge in millions cubic feet per 24 hours.	Gauge reading.	Discharge in millions cubic feet per 24 hours.	Gauge reading.	Discharge in millions cubic feet per 24 hours.
5·0	..	6·9	623	8·8	3,145	10·7	6,576	12·6	10,694
5·1	..	7·0	689	8·9	3,300	10·8	6,774	12 7	10,929
5·2	..	7·1	812	9·0	3,456	10·9	6,973	12·8	11,180
5·3	..	7·2	933	9·1	3,629	11·0	7,166	12·9	11,422
5·4	..	7·3	1,054	9·2	3.802	11·1	7,370	13·0	11,664
5·5	...	7·4	1,175	9·3	3,975	11·2	7,578	13·1	11,894
5·6	..	7·5	1,296	9·4	4,147	11·3	7,789	13·2	12,124
5·7	14	7·6	1,419	9·5	4,320	11·4	7,999	13·3	12,356
5·8	62	7·7	1,542	9·6	4,493	11·5	8,208	13 4	12,598
5·9	79	7·8	1,659	9·7	4,666	11·6	8,433	13·5	12,839
6·0	86	7·9	1,780	9 8	4,838	11·7	8,657	13·6	13,077
6·1	138	8·0	1,901	9·9	5,011	11·8	8,884	13·7	13,325
6·2	189	8·1	2,056	10·0	5,184	11·9	9,100	13·8	13,582
6·3	239	8·2	2,212	10·1	5,383	12·0	9,332	13·9	13,830
6·4	294	8·3	2,357	10·2	5,581	12·1	9,556	14·0	14,712
6·5	345	8·4	2,523	10·3	5 608	12·2	9,782		
6·6	415	8·5	2,681	10 4	5,989	12 3	10,005		
6·7	483	8·6	2,833	10·5	6,187	12·4	10,229		
6·8	553	8·7	2,990	10 6	6,377	12·5	10,453		

NOTE.—The discharges of the Old Upper Anicut are compared with those of the Cauvery Dam, small for all gauge readings under 7 feet. At 8 feet, it is less than ½ the discharge on the Cauvery Dam. Discharges are equal at gauge reading 9·6.

PART III.

GAUGING THE CAUVERY AT BHAVANI BRIDGE AND DISCHARGE TABLE, BHAVANI BRIDGE.

PART III.

Gauging Discharges of Cauvery at Bhavani Bridge and Discharge Table.

23. *Discharges of Cauvery at Bhavani Bridge.*—There are available for 28 years gauge readings taken daily of the gauge fixed on the Right Pier downstream end of the road bridge across the Cauvery at Bhavani village. The bridge is about a furlong above the point of junction of the Bhavani river with the Cauvery. Between Bhavani bridge and the Metur Reservoir, site 26 miles above it, no stream of any importance feeds the Cauvery and the total drainage area between the two sides is only about 725 square miles. The flow at Bhavani bridge is taken for purposes of working tables as the flow which will pass through the reservoir.

The Cauvery at Bhavani bridge is perennial, but when the flow is that of the normal dry season (February to May), it is less than 1,000 cusecs and is below the zero of the gauge; there is no measure of the ordinary dry season flow for these past years, but there is record of the occasional freshes in these years as readings are taken whenever a rise in the river above the zero of the gauge takes place.

As regards the minimum dry season flow this was gauged for this year (April 1910) at its lowest at Metur, as 372 cusecs, the latter part of 1909 and early part of 1910 having had rainfall below average. The minimum flow gauged at Sivasamudram 90 miles above Metur where the Mysore Government Electric Power Scheme is in operation is recorded as 94 cusecs.

It is considered a reasonable assumption that the minimum mean monthly flow is not below 150 cusecs at Metur. Credit is taken for this as set off against evaporation and percolation in of the reservoir, when it falls to a level, below which the impounded water is not fully effective (below + 700).

This is explained in detail in the notes on the evaporation table paragraph 46.

24. *Bridge across the Cauvery at Bhavani.*—The bridge at Bhavani across the Cauvery is a masonry brick arched bridge 26 spans of 46 feet. The floors of the events are uneven and at varying levels ranging from R.L. 518 to 523. The zero of the gauge is 519.19.

The following levels on the bridge are noted :—

The zero of the gauge	+ 519.19
Spring of arches	+ 535.68
Under side arches	+ 543.68
Top of cornice cutwaters	+ 532.2
Top main cornice on face wall	+ 547.68
Roadway (about)	+ 547.78
Maximum recorded flood (1902)	+ 535.75

25. *Nature of Cauvery bed at Bhavani bridge.*—The river bed above and below the work is rock with occasional beds of sand and the variations of mean bed level with different conditions of flow must be small.

Thus the accurate graduation of the gauge Bhavani bridge with the gauged flow of the past year (1909), may be confidently applied to the gauge readings of previous years as an accurate record of the flow in those years.

26. *Sites of gauging operations near Bhavani.*—On originally starting gauging in June 1909 the gauging station was just below Bhavani bridge, surface floats (bottles with flags) were employed being let go from the bridge at suitable intervals. Owing to the rocky and uneven character of the river-bed the float runs were unsatisfactory, especially on a low river, and this site was abandoned as a gauging station in favour of one at Urachi, three miles above the bridge.

Between these sites no appreciable drainage comes into the river, and here a good straight reach with a steadily flowing stream is found.

All the later gaugings were taken at this site with surface floats.

27. *Method of gauging velocities near Bhavani.*—The method of operation is generally similar to that described for the Cauvery dam gaugings, except that the floats, instead of being released from a boat, were dropped at the required intervals from a telegraph wire stretched across the river above the float runs, by means of an ingenious arrangement introduced by Mr. Allen Campbell (Executive Engineer) and which he has called "The Compbell Float Train". (This is fully described in Chief Engineer's Memorandum, Dis. No. 456, dated 11th April 1910.)

It was intended at this station to use an electric current meter similar to that used at the Cauvery Dam (Upper Anicut) as a check on float results. The meter however was defective from the start, and never worked efficiently for any continuous period. It was useful for some time in November, for getting the co-efficient to be applied to the surface velocities for conversion to mean velocities, and this was the only useful work got from it at this station.

28. *Bhavani observations—Co-efficient for converting surface to mean velocities.*—As a result of the above observations 0.83 was the co-efficient selected. This agrees with that at the Cauvery Dam and is considered safe. Owing to the small number of observations and the low stage of flow in which these were taken, the co-efficient is not nearly so well established as that for the Cauvery Dam observations.

Reference to "River Discharges" by Hoyt and Grover (First Edition, 1907) page 50 shows that the mean relation between the surface and mean velocity from 34 observing stations and 476 vertical velocity curves made since 1905 in America give a mean value of .87, the highest being .98 and the lowest .79.

One station only gives .79 and the next lowest is .82 and having this in view it is considered that .83 is a safe co-efficient for purposes of irrigation supply although the accuracy is admitted not to be fully established.

29. *Limits within which curve of discharges, Bhavani bridge, is reliable.*—The observations of 1909 on the Cauvery above the confluence with the Bhavani river do not (as is also the case at the Cauvery Dam) give any record of high floods. The highest gauge readings recorded during the year is 13 feet one day, and 12.7 feet one day, and 12 feet one day. The velocity observation for these days were all taken from Bhavani bridge owing to the breaking of the telegraph wire across the river at Urachi, and are not considered reliable. The curve of discharge is only considered reliable up to a gauge reading of 11 feet. The curve from 11 feet upwards has been produced by the method of Mr. J. C. Stephens, described on the diagram, and also page 91 of Hoyt and Grover's Book above referred to.

The produced curve there is reason to believe gives discharges rather below the actuals, and is therefore safe for purposes of impounding supply, but not safe for dealing with maximum flood discharge. This is considered in the part of the report on the reservoir dealing with surplus works, and need be no further referred to. The table following gives the discharges of the Cauvery in mill. c. ft. per 24 hours taken from the curve of discharges and this table is that used for compiling the reservoir working tables. (The curve will be found in the pocket of this volume.)

30. *Discharge below zero of gauge, Bhavani bridge.*—It will be noticed that with water at the zero of the gauge there is still a discharge over the lower parts of the bridge floor of about 1,000 cusecs.

TABLE of discharges of Cauvery River through Bhaváni Bridge in terms of readings of the gauge on the right pier of the bridge (Down stream end) zero of gauge + 519·19 M.S.L.

Discharge in cusecs.	Gauge reading.	Discharge in mill. cubic feet in 24 hours.	Discharge in cusecs.	Gauge reading.	Discharge in mill. cubic feet in 24 hours.	Discharge in cusecs.	Gauge reading.	Discharge in mill. cubic feet in 24 hours.	Discharge in cusecs.	Gauge reading.	Discharge in mill. cubic feet in 24 hours.
1,125	1	97	14,488	4·2	1,249	48,279	8·3	4,162	103,774	12·4	8,946
1,241	·2	107	15,045	4·3	1,297	49,578	8·4	4,274	105,374	12·5	9,084
1,357	·3	117	15,590	4·4	1,344	50,866	8·5	4,385	106,987	12·6	9,223
1,473	·4	127	16,135	4·5	1,391	52,107	8·6	4,492	108,588	12·7	9,361
1,601	·5	138	16,739	4·6	1,443	53,360	8·7	4,600	110,200	12·8	9,500
1,717	·6	148	17,342	4·7	1,495	54,601	8·8	4,707	111,801	12·9	9,638
1,833	·7	158	17,915	4·8	1,547	55,854	8·9	4,815	113,413	13·0	9,777
1,949	·8	168	18,537	4·9	1,598	57,095	9·0	4,922	115,118	13·1	9,924
2,065	·9	178	19,140	5·0	1,650	58,418	9·1	5,036	116,812	13·2	10,070
2,192	1·0	189	19,743	5·1	1,702	59,728	9·2	5,149	118,517	13·3	10,217
2,448	1·1	211	20,346	5·2	1,754	61,039	9·3	5,262	120,222	13·4	10,364
2,714	1·2	234	20,950	5·3	1,806	62,350	9·4	5,375	121,928	13·5	10,511
2,981	1·3	257	21,553	5·4	1,858	63,661	9·5	5,488	123,611	13·6	10,657
3,236	1·4	279	22,156	5·5	1,910	64,972	9·6	5,601	125,326	13·7	10,804
3,503	1·5	302	22,864	5·6	1,971	66,294	9·7	5,715	127,020	13·8	10,950
3,782	1·6	326	23,572	5·7	2,032	67,605	9·8	5,828	128,725	13·9	11,097
4,072	1·7	351	24,280	5·8	2,093	68,916	9·9	5,941	130,419	14·0	11,243
4,350	1·8	375	24,999	5·9	2,155	70,226	10·0	6,054	132,124	14·1	11,390
4,640	1·9	400	25,707	6·0	2,216	71,537	10·1	6,167	133,829	14·2	11,537
4,918	2·0	424	26,518	6·1	2,286	72,848	10·2	6,280	135,534	14·3	11,684
5,278	2·1	455	27,330	6·2	2,356	74,170	10·3	6,394	137,228	14·4	11,830
5,626	2·2	485	28,154	6·3	2,425	75,481	10·4	6,507	138,933	14·5	11,977
5,974	2·3	515	28,936	6·4	2,495	76,792	10·5	6,620	140,627	14·6	12,123
6,322	2·4	545	29,778	6·5	2,565	78,149	10·6	6,737	142,332	14·7	12,270
6,670	2·5	575	30,624	6·6	2,640	79,506	10·7	6,854	144,026	14·8	12,416
7,088	2·6	611	31,505	6·7	2,716	80,864	10·8	6,971	145,742	14·9	12,564
7,505	2·7	647	32,376	6·8	2,791	82,221	10·9	7,088	147,436	15·0	12,710
7,923	2·8	688	33,257	6·9	2,867	83,578	11·0	7,205	149,327	15·1	12,873
8,340	2·9	719	34,127	7·0	2,942	84,947	11·1	7,323	151,218	15·2	13,036
8,746	3·0	754	35,090	7·1	3,025	86,327	11·2	7,442	153,097	15·3	13,198
9,187	3·1	792	36,053	7·2	3,108	87,708	11·3	7,561	155,988	15·4	13,361
9,628	3·2	830	37,016	7·3	3,191	89,088	11·4	7,680	156,890	15·5	13,525
10,069	3·3	868	37,978	7·4	3,274	90,468	11·5	7,799	158,781	15·6	13,688
10,498	3·4	905	38,941	7·5	3,357	91,837	11·6	7,917	160,672	15·7	13,851
10,939	3·5	948	40,032	7·6	3,451	93,218	11·7	8,036	162,551	15·8	14,013
11,426	3·6	985	41,134	7·7	3,546	94,598	11·8	8,155	164,442	15·9	14,176
11,925	3·7	1,028	42,224	7·8	3,640	95,978	11·9	8,274	166,332	16·0	14,339
12,412	3·8	1,070	43,314	7·9	3,734	97,347	12·0	8,392	168,699	16·1	14,543
12,911	3·9	1,113	44,405	8·0	3,828	98,948	12·1	8,530	171,065	16·2	14,747
13,398	4·0	1,155	45,704	8·1	3,940	100,560	12·2	8,669			
13,943	4·1	1,202	46,992	8·2	4,051	102,173	12·3	8,808			

REMARKS.—The gauge was graduated by surface float observations made in year 1909 (*vide* diagram in pocket). A co-efficient 0·83 was employed to reduce surface velocities to mean velocities.

PART IV.

DUTY OF WATER AND DUTY TABLES, CAUVERY PROJECT.

PART IV.

Duty of water and Duty Tables.

31. *Duties and duty tables.*—In considering the duties to be allowed in the working tables Cauvery Project, the conditions of the double and single cropped areas will be taken separately.

32. *Duties for double cropped lands.*—For the double crop it is very desirable to make as early a start at cultivation as possible. A careful study of the working tables has shown that in a normal year it is safe to open the reservoir and issue supplies for *double crop ploughing and transplantation* on 1st June.

Under the "Rules for working the reservoir" on which the tables have been drawn up, the date of opening for double crop area for 17 years out of the 20 years for which the tables are drawn is 1st June which is therefore considered the normal date of commencing double crop. The water to double crop lands is allowed for 7½ months from the date of first issue there being a cessation of supply for one month in the period to allow of harvesting the first crop. In actual working under abnormal conditions the issues would be varied to suit the special conditions of rain distribution and flow of tributary rivers but the tables are drawn up on hard and fast rules, which have not been varied to suit the conditions of such season. The duty figures allowed for the double cropped area are the same for the old and new areas except in the second month when the new areas are given a smaller supply than the existing deltaic area. This difference is made because at this time the canals feeding the new area will be running at full capacity. The allowance for the first month is very liberal and is made so because at this time the whole country is dry with sub-soil water at its lowest and losses by percolation at a maximum.

The irrigation is scattered and the canals carrying water are of large capacity in comparison to the amount of water to be passed for the double crop and thus lower duty is realised than when the supply passed is combined with that required for the large single crop area.

For the large single crop area as will be seen considerably higher duty figures have been taken for the new area than for the existing area, but with the limited areas of double crop involved it has been considered prudent to allow low duties for the double crop area on the new tract as well as for the existing deltaic area—*vide* double crop duty table, page 32.

33. *Single crop duties for existing irrigated area.*—Different duties have been fixed for the existing deltaic area and the new area to be brought under wet cultivation.

In the existing area the main feeders are natural rivers with wide sandy beds capable of carrying over double the amount of water required for a maximum supply for the irrigated area. The system is a very old one and the system of channels distributing water is not of such a nature as to conduce to great economy in distribution.

One of the great objects of the reservoir is to safeguard existing irrigation by substituting for the fluctuating supply now given by "direct flow" a steady supply which can be depended on issued in quantities which the average of a series of years shows to be very ample for the maximum flow seasons (July to September) while they are materially in excess of the direct flow which can now be counted on in the later months (October to December).

Thus the duties for the existing area are fixed with a view to give not only a steady and assured supply, but as regards quantity an increased supply to existing lands.

In view of the intention to charge to existing delta lands increased assessment in consideration of the great additional security and improved and steady supply given under the Cauvery Reservoir it has been considered advisable to make very liberal allowances for the existing area in the duty tables, and this course has been adopted—*vide* single crop duty table, page 33.

34. *Single crop duties—New area.*—In considering the duties for the single crop for the new area, the problem is a different one. There is no reason why in this area the duty of water should be abnormally low, as the canals and distributaries will be designed to carry economically the supply water required and wastage will be much reduced.

The area to be irrigated is of a similar nature as regards soil-rainfall and general conditions as the existing irrigated area under the Vennar, the southern of the two great irrigating rivers into which the Cauvery divides at the Grand Anicut. It has been recognised for many years that the conditions of soil, sub-soil and irrigation generally under the Vennar are much more favourable to a high duty than under the Cauvery and the existing rules for distributing flow between them have laid down that Cauvery duty is lower than that of Vennar in the proportion 2 to 3.

The maximum steady duty contemplated for the transplantation season has been 44 acres per cusec for Cauvery (3 cubic yards per acre per hour) and 66 acres per cusec for Vennar (2 cubic yards per acre per hour).

The river flow being very fluctuating the rules provide for carrying water in excess of these duties in both rivers when available up to a fixed level in each river. Over and above this level water is not carried unless specially asked for or required for purpose of surplusing off the superabundant flood waters of the main river (*vide* "Rules for Regulation of water at the Grand Anicut, page 35").

The depth of flow fixed by these rules are—

—	Gauge reading in rear head regulator.	Corresponding flow cusecs.	Duty acres per cusec.
Cauvery, 486,000 acres	4·5	13,000	37
Vennár, 406,000 acres	7·0	7,850	52

The attached table (page 36) gives the actual mean monthly discharges of Cauvery and Vennar extracted from the triennial reports of Madras Irrigation for the two periods ending 1904-05 and 1907-08 for the months of July, August, September, the period of maximum flow in the Cauvery river.

It will be seen that the flow through the Head Regulators Cauvery and Vennar for the 6-year period works out to a mean duty—

		Acres per cusec.
Cauvery Regulator	... ...	47.2
Vennar ,,	... ...	70.9

Where the mean monthly flow has exceeded the flow due to maximum supply level, the latter has been substituted in the table for the former which has been written in brackets underneath.

If the duty of Vennar Regulator is 70.9 with such a distribution system as it has for the period of maximum demand, it is considered quite safe to fix the maximum carrying capacity of the new Grand Anicut and of the remodelled Vadavar systems at 70 acres per cusec, and it is this figure which has been fixed as the lowest single crop duty figure.

35. In fixing this as the maximum capacity duty for the new canals and the lowest single crop duty for the new area in the reservoir working tables the following further points have been considered.

The duty of 70 has been shown to be a suitable head duty for a well designed system from the record of quantities of water supplied in the Kistna and Godavari deltas. In these deltas the soil is of a heavy nature, and when wet is impervious to percolation, but when dry it opens out in huge cracks, and the quantity of water required to wet the soil and close the cracks at the beginning of a season is very great.

In the Vennar deltaic tract, as also in the new area the soil is a yellow clayey loam with free admixture of sand.

It does not crack and is very retentive of water a few feet below the surface where clay has not been washed out of the soil. The water required to prepare this land for transplantation at the commencement of the irrigation season will be materially less than in the Kistna. On the other hand the average rainfall in Kistna is heavier than in the Cauvery at this season of the year as below:—

	Rainfall in inches. Kistna.	Cauvery.
Second half of July	2.88	0.9
First ,, August	3.34	1.7
Second ,, ,, ...	3.35	2.2
First ,, September	3.06	2.5
Second ,, ,, ...	3.07	2.5

36. The lowest single crop duty for the new area has thus been fixed at 70 and the table (page 33) attached gives details of the successive half monthly duties fixed for the remainder of the irrigation season.

37. *Period of supply for the single cropped area.*—The duty and working tables provide an allowance of water for the single crop for five months from 16th July to 15th December.

When the supply of water for this crop cannot be passed from the reservoir by 16th July which occurs once in 20 years in the working tables (in 1906), the date of discontinuing supply is correspondingly later.

The 15th August is the best date for transplantation to suit seasonal rainfall (*vide* Revenue Officer's Report, Vol. I) and as transplantation of the single crop will take two months water for this is allowed from 16th July to 15th September.

In addition to the above provision is made to pass water to the single crop from the reservoir normally from 1st July, and under the "rules for working the reservoir" on the first date in July on which it is safe to do this.

This period being rather early for transplantation of the *normal single crop*, this early supply is not counted as part of the five months during which supplies should be maintained, and paddy transplanted in the early part of July should be from seed which will not mature till January as it is undesirable to harvest crops in December owing to seasonal rainfall.

The water issued before 15th July will help to expedite and encourage early transplantation, fill tanks, soften the fields for ploughing, and generally give facilities for avoidance of any delay in general transplantation being vigorously carried out from 16th July. In one year in 20 (1905), only does this early issue of water have the effect of diminishing subsequent supplies and in that year some extra deficiency in supply in September results. On the whole, however, the arrangement will tend greatly to benefit and assist rapid and punctual transplantation.

38. *Normal dates of supply.*—In the normal year, which the working tables show may be taken as five years in six, issues from the reservoir for double crop will be maintained from the 1st of June and for single crop from 1st July.

For such a normal year the table (page 34) shows the flow required at the Cauvery dam and it is interesting to compare the equivalent gauge readings with the gauge readings proposed to be maintained in Mr. Moss's Project (*vide* appendix G.O. No. 971 I. of 2nd September 1904, page 8).

39. *Losses of water in transmission from the reservoir to the canal head.*—The losses between the reservoir and the Grand Anicut are allowed as a percentage (shown in column 11 of the duty tables) on the issue required from the reservoir daily to make up the flow at the Cauvery dam to that required for the day. The losses vary from 50 per cent in the first month to 20 per cent in the full flow season.

40. *Area of irrigation for which working tables provide.*—The areas for which water at the duties laid down in the duty table is provided for in these tables are as follows :—

In the existing deltaic area—

	ACS.
Single-cropped land	840,000
Double „ „	165,000
Total ...	1,005,000

In new area—

	ACS.
Single-cropped land	255,000
Double „ „	75,000
Total ...	330,000
Grand Total ...	1,335,000

41. *Details of single and double crops in existing irrigated area.*—In existing irrigated area the returns show a tendency towards increase of the area of single-cropped land while diminishing the area under double crop.

The areas under the Cauvery Delta system and Coleroon Lower Anicut systems from the triennial report, Madras Irrigation Branch, for the triennium ending 1907-1908 give the following :—

Single-cropped area—

	ACS.
Lower anicut	104,168
Cauvery delta	805,037
Total ...	909,205

Double-cropped area—

	ACS.
Lower anicut	4,144
Cauvery delta	92,607
Total ...	96,751

For the working tables having in view the above, the following areas were provided for in the existing irrigated area :—

	ACS.
Single crop	910,000
Double crop	95,000

On this area it is proposed to irrigate an additional 70,000 acres with double crop.

The above figures then become—

	ACS.
Single crop (910,000 − 70,000)	840,000
Double crop	165,000
Total ...	1,005,000

42. *Details of single and double crops proposed in new area.*—This is sub-divided into new irrigated areas :—

	ACS.
Under Grand Anicut canal system	287,000
Under the Vadavar system	43,000
Total new area ...	330,000

Of this area it is proposed to raise double crop on 75,000 acres. Provision of water for the new area is thus made—

	ACS.
For single-cropped area	255,000
For double „ „	75,000
Total ...	330,000

43. *Omission of area in French territory.*—By an unfortunate oversight an area of existing wet cultivation of 27,000 acres was omitted from total existing irrigation. This is the area in French territory (Karikal) irrigated under the Cauvery branch. The area is 2 per cent of the whole area proposed to be irrigated. The error will not, however, be so great as this as the low existing duty for the existing irrigation as computed omitted this area (Table page 36) and a still lower mean duty for the period of maximum supply has been provided for in the working tables. It is reasonable to conclude therefore that the omission of this area (which is not included in the returns of irrigated areas, Cauvery delta) will not in any material degree affect the accuracy of the working tables or the conclusions drawn from them.

CAUVERY RESERVOIR PROJECT.

Duty Table—" Double crop ".

Period. (1)		In existing area, 165,000 acres. Area in thousand acres. (2)	Duty acres per cusec. (3)	Approximate equivalent depth on area in inches. (4)	Discharge millions cubic feet in 24 hours. (5)	In new area, 75,000 acres. Area in thousand acres. (6)	Duty acres per cusec. (7)	Approximate equivalent depth on area in inches. (8)	Discharge millions cubic feet in 24 hours. (9)	Total discharge millions cubic feet in 24 hours (column 5 + 9). (10)	Centage loss in transmission on issue from Reservoir to Head Regulator. (11)	Rainfall average, Tanjore district. (12)	Dates corresponding in normal year. (13)
First month	1st half	165	40	9·0	356	75	40	9·0	162	518	50	0·75	June.
	2nd ,, ...	165	40	9 0	356	75	40	9·0	162	518	50	0·45	
Second month	1st half	165	40	9·0	356	75	70	5·1	93	449	20	0·75	July.
	2nd ,, ...	165	60	6 0	238	75	70	5·1	93	331	20	0·9	
Third month	1st half	165	89	4·0	160	75	89	4·0	73	233	20	1·7	August.
	2nd ,, ...	165	89	4·0	160	75	89	4·0	73	233	20	2·2	
Fourth month	1st half	..	..	..	..	..	..	..	..	..	20	2·5	September.
	2nd ,, ...	..	..	..	..	..	..	..	..	..	..	2·5	
Fifth month	1st half	165	74	4·8	194	75	74	4·8	86	280	20	2·8	October.
	2nd ,, ...	165	112	3·2	127	75	112	3·2	58	185	20	5·4	
Sixth month	1st half	165	143	2·5	100	75	143	2·5	45	145	20	6·1	November.
	2nd ,, ...	165	143	2·5	100	75	143	2·5	45	145	30	5·2	
Seventh month	1st half	165	112	3·2	127	75	112	3·2	58	185	30	4·2	December.
	2nd ,, ...	165	95	3·75	150	75	95	3·75	68	218	40	3·4	
Eighth month—1st half ..	.. ..	165	66	5·4	216	75	66	5·4	98	314	40	0·9	January.

CAUVERY RESERVOIR PROJECT.

Duty Table—" Single crop."

Period. (1)		Existing irrigation, 840,000 acres. Area in thousand acres. (2)	Duty acres per cusec. (3)	Approximate equivalent depth in inches. (4)	Discharge required million cubic feet per 24 hours. (5)	New irrigation, 255,000 acres. Area in thousand acres. (6)	Duty acres per cusec. (7)	Equivalent depth in inches. (8)	Discharge required millions cubic feet per 24 hours. (9)	Total discharge, millions cubic feet, 24 hours, columns (5 + 9). (10)	Centage loss in transmission on issue from reservoir to head regulator. (11)	Average rainfall over irrigated area in normal, Tanjore district. (12)	Dates corresponding in normal year. (13)
Extra early issue	.. ..	840	53	6 75	1,371	255	70	5·1	315	1,686	20	0·75	July.
First month	1st half	840	53	6·75	1,371	255	70	5·1	315	1,686	20	0·9	
	2nd ,, ...	840	53	6 75	1,371	255	70	5·1	315	1,686	20	1·7	August.
Second month	1st half	840	53	6·75	1,371	255	70	5·1	315	1,686	20	2·2	
	2nd ,, ...	840	53	6·75	1,371	255	70	5·1	315	1,686	20	2·5	September.
Third month	1st half	840	89	4·0	815	255	89	4 0	248	1,063	20	2 5	
	2nd ,, ...	840	89	4·0	815	255	89	4 0	248	1,063	20	2·8	October.
Fourth month	1st half	840	143	2·5	508	255	143	2·5	154	662	20	5·4	
	2nd ,, ...	840	178	2·0	408	255	178	2·0	124	532	20	6·1	November.
Fifth month	1st half	840	178	2·0	408	255	178	2·0	124	352	30	5·2	
	2nd ,, ...	840	297	1·2	244	255	297	1·2	74	318	30	4·2	December.

Cauvery Reservoir Project.

Duty table shewing water allowances on a normal year.

Period. (1)		Existing wet deltaic, existing cultivation area. Average rainfall, inches. (2)	Area in thousand acres. (3)	Duties in acres per cusec. (4)	Equivalent inches. (5)	Equivalent discharge, millions cubic feet. (6)	Equivalent depth, Cauvery dam. (7)	Newly irrigated area. Area in thousand acres. (8)	Duties, acres per cusec. (9)	Equivalent depth in inches. (10)	Equivalent discharge, millions cubic feet. (11)	Total discharge, millions cubic feet in 24 hours. (12)	Equivalent depth of water on Cauvery dam. (13)
June ..	1st half.	0·75	165	40	9·0	356	2·9	75	40	9·0	162	518	3·8
	2nd ,,	0·45	165	40	9·0	356	2·9	75	40	9·0	162	518	3·8
July ..	1st ,,	0·75	165	40	9·0	356	6·1	75	70	5·1	93	2,135	6·7
			840	53	6·75	1,371		255	70	5·1	315		
	2nd ,,	0·9	165	60	6·0	238	6·1	75	70	5·1	93	2,017	6·6
			840	53	6·75	1,371		255	70	5·1	315		
August ..	1st ,,	1·7	165	89	4·0	160	5·9	75	89	4·0	73	1,919	6·5
			840	53	6·75	1,371		255	70	5·1	315		
	2nd ,,	2·2	165	89	4·0	160	5·9	75	89	4·0	73	1,919	6·5
			840	53	6·75	1,371		255	70	5·1	315		
September ..	1st ,,	2·5	840	53	6·75	1,371	5·7	255	70	5·1	315	1,686	6·1
	2nd ,,	2·5	840	89	4·0	815	4·7	255	89	4·0	248	1,063	5·1
October ..	1st ,,	2·8	840	89	4·0	815	5·6	255	89	4·0	248	1,343	5·5
			165	74	4·8	194		75	74	4·8	86		
	2nd ,,	5·4	840	143	2·5	508	4·2	255	143	2·5	154	847	4·7
			165	112	3·2	127		75	112	3·2	58		
November ..	1st ,,	6·1	840	178	2·0	408	3·8	255	178	2·0	124	677	4·3
			165	143	2·5	100		75	143	2·5	45		
	2nd ,,	5·2	840	178	2·0	408	3·8	255	178	2·0	124	677	4·3
			165	143	2·5	100		75	143	2·5	45		
December ..	1st ,,	4·2	840	297	1·2	244	3·0	255	297	1·2	74	503	3·8
			165	112	3·2	127		75	112	3·2	58		
	2nd ,,	3·4	165	95	3·75	150	1·7	75	95	3·75	68	218	2·1
January ..	1st ,,	0·9	165	66	5·4	216	2·1	75	66	5·4	98	314	2·6

The figures in thick type refer to double crop in columns 3 to 6 and 8 to 11.
The roman figures refer to single ,, ,,
On a normal year water will be passed down for double crop in 1st June.
,, ,, for single crop in 1st July.
The water for double crop is to provide for the seed-beds for the single crop area and a very low duty figure fixed for the first one and a half months.

Rules for the regulation of water at Grand Anicut—1907.

Regulation during floods.

1. The Anicut Superintendent will in the absence of any requisitions from the Executive Engineers, Cauvery and Vennâr, regulate the water so as to maintain 7 feet on the rear gauge of the Vennár and 4.5 feet on the rear gauge of the Cauvery.

2. Should the Anicut Superintendent notice heavy rain to the south-east in the basin of the Vennár, he will at once lower the rear gauge of the Vennár to 6 feet without waiting for orders.

3. Should he receive requisition from the Executive Engineers, Cauvery or Vennár, to alter the deapth of water on the rear gauges of the Cauvery or Vennár, he will promptly carry out these requisitions *as long as the front gauge of the Lower Anicut is below* 13 *feet*. After receiving intimation that the front gauge of Lower Anicut reads 13 feet, he will cease to comply with such requisitions and maintain 7 feet on the rear gauge of the Vennár and 4.5 feet or more on the rear gauge of the Cauvery.

4. Should water rise in front of the regulators he will regulate the shutters so as to maintain 7 feet in the Vennár and 4.5 feet in the Cauvery or whatever the Executive Engineers, Cauvery and Vennár, may have asked for, and open first the undersluices and then the Grand Anicut shutters so as to reduce the height of water in front of the regulators to give the necessary head to maintain the above depths in the Cauvery and Vennár.

5. Should water go on rising he will go on lifting the Grand Anicut shutters until there is 4 feet on the crest of the Grand Anicut when he will lift the shutters clear and keep them clear as long as water rises. Should water fall below 4 feet on crest he will again lower the shutters and regulate the water as laid down in rule 4 and if necessary again close the undersluice shutters.

6. If the water instead of falling as indicated in rule 5 still continue to rise, he will leave the Grand Anicut and undersluice shutters fully open and gradually open the Cauvery shutters so as to keep the depth of water in rear of the Cauvery Regulators just 6 feet below the depth in front.

N.B.—The maximum or rear gauge of the Cauvery is not to exceed 7.5 feet.

7. When the Superintendent receives intimation from the Lower Anicut that water has risen to 13 feet on front gauge, he will raise water in the Cauvery to 6 feet.

8. If further intimation is received that water has risen to 14 feet, he will raise water in the Cauvery to 7.5 feet.

9. If further intimation is received that the water has risen to 15 feet, he will open the Vennár Regulator and raise water to 9 feet on the Vennár rear gauge.

10. He must maintain this condition of things until he hears that water has fallen to below 15 feet on front gauge of the Lower Anicut when he will reduce Vennár to 7 feet. On hearing that water has fallen below 14 feet at Lower Anicut, he will reduce the Cauvery to 7 feet and when the water at the Lower Anicut has fallen to 13 feet, he will regulate the Cauvery so as to keep it 6 feet below the water in front.

11. When the water has fallen to below 13 feet at Lower Anicut, he will regulate again as laid down in rules 1, 2, 3, 4 and 5.

Regulation during low supply.

The present "morai" will be adhered to until further orders, *viz.*, full supply to the Cauvery for two days (Monday and Tuesday) and full supply to the Vennár for two days (Wednesday and Thursday) and a proportionate supply to the Cauvery and Vennár for the remaining three days of the week, the proportion being 3 to the Cauvery and 2 to the Vennár.

A. H. Morin,
Executive Engineer,
Cauvery Division.

June 1907.

Table showing actual mean monthly discharges in cusecs and equivalent mean monthly duties in acres per cusec for the Cauvery and Vennar Head Regulators from 1902 to 1907 for the months of July to September.

Area irrigated.		Years.	Cauvery.						Vennar.						Remarks.
			July.		August.		September.		July.		August.		September.		
			Discharge, cusecs.	Duty, acres.	Discharge, cusecs.	Duty, acres.	Dis-charge, cusecs.	Duty, acres.	Dis-charge, cusecs.	Duty, acres.	Dis-charge, cusecs.	Duty, acres.	Dis-charge, cusecs.	Duty, acres.	
Cauvery	ACS. 484,137	1902–1903	10,365	46·7	7,204	67·2	11,290	42·9	7,078	57·2	4,861	83·4	6,340	63·9	The maximum "average monthly flow" has been taken as 13,000 cusecs for the Cauvery and 7,850 cusecs for the Vennar. Where the actual flow exceeded this, it is entered below this figure in brackets (*vide* paragraph 34).
		1903–1904	12,287	39·4	13,000 (14,441)	37·2	8,223	58·9	6,425	63·1	7,135	56·8	3,290	123·2	
Vennar	405,300	1904-1905	13,000 (14,692)	37·2	9,938	48·7	5,913	81·9	6,623	61·2	6,338	63·9	4,102	98·8	
Cauvery	488,410	1905–1906	12,481	39·1	9,747	50·1	10,092	48·4	6,035	67·8	4,732	86·5	5,174	79·1	
		1906–1907	7,574	64·5	12,692	38·5	16,774	45·3	4,024	101·8	7,699	53·2	5,037	81·2	
Vennar	409,234	1907-1908	8,079	60·4	13,000 (18,566)	37·6	9,648	50·6	4,958	82·5	7,850 (10,752)	52·1	5,705	71·7	
Cauvery Vennar	486,273 407,367	Mean of six years.	10,631	45·7	10,929	44·5	9,323	52·2	5,857	69·5	6,436	63·3	4,941	82·4	
		Mean discharge and duty for three months.	10,294	47·2	..	..	..	..	5,745	70·9	..	..	..	..	

Mean duty for the combined area, viz., "the Cauvery delta system" for the three months = 55·77.

PART V.

ALLOWANCES FOR EVAPORATION AND PERCOLATION CAUVERY RESERVOIR AT METUR.

CAUVERY RESERVOIR PROJECT.

Table of daily evaporation in millions cubic feet to one place of decimal.

Effective impounded water in reservoir in millions cubic feet.	June.	July.	August.	September.	October.	November.	December.	January.	February.	March.	April.	May.
"Any thing over" 0	8·3	6·2	6·6	6·9	5·7	4·7	4 6	4·6	5·1	6·9	10·6	11 5
2,000	9·2	6·9	7·4	7·6	6·4	5·3	5·1	5·1	5·6	7·6	11·8	12·7
4,000	10·1	7·5	8·1	8·4	7·0	5 8	5·6	5·6	6·2	8·4	13·0	14·0
6,000	10·9	8·2	8·8	9·1	7·6	6·3	6·1	6·1	6·7	9·1	14·1	15·1
8,000	11·7	8·7	9·4	9·7	8·1	6·7	6·5	6·5	7·2	9·7	15·0	16 2
10,000	12·5	9·3	10·0	10·3	8·6	7·1	6·9	6·9	7·6	10·3	16·0	17·2
12,000	13·2	9·8	10·6	10·9	9·1	7·5	7·3	7·3	8·1	10·9	16·9	18 2
14,000	13·9	10·4	11·1	11·5	9·6	7·9	7·7	7·7	8·5	11·5	17·8	19·2
16,000	14·5	10·9	11·7	12·1	10·1	8·3	8·0	8·0	8·9	12·1	18·7	20·1
18,000	15·1	11·3	12·1	12·5	10·5	8·6	8·4	8·4	9·3	12·5	19·4	20·9
20,000	15·7	11·7	12·6	13·0	10·8	8·9	8·7	8·7	9·6	13·0	20·1	21·6
24,000	16·7	12·5	13·4	13·9	11·6	9·6	9·2	9·2	10·2	13·9	21·5	23·1
28,000	17·6	13·1	14·1	14·6	12·2	10·1	9·7	9·7	10·8	14·6	22·6	24·3
32,000	18·5	13·8	14·8	15·3	12·8	10·6	10·2	10 2	11·3	15·3	23 8	25·5
36,000	19·5	14·6	15·7	16·2	13·5	11·2	10·8	10·8	12·0	16·2	25 1	27·0
40,000	20·6	15·4	16·6	17·1	14·3	11·8	11·4	11·4	12·6	17·1	26·5	28·5
44,000	21·7	16·2	17·4	18·0	15·0	12·4	12·0	12·0	13·3	18 0	27·9	30·0
48,000	22·6	16·9	18·1	18 7	15·6	12·9	12·5	12·5	13·8	18·7	29·0	31·2
52,000	23·4	17·4	18·7	19·4	16·2	13·4	13·0	13·0	14·3	19·4	30·1	32·3
56,000	24·1	18·0	19·4	20·0	16·7	13·8	13·4	13·4	14·8	20·0	31·0	33·4
60,000	25·1	18·7	20·1	20·8	17·3	14·3	13·9	13·9	15·3	20·8	32 2	34·7
64,000	25·9	19·4	20·8	21·5	17·9	14·8	14·8	14·3	15·9	21·5	33·3	35·9
68,000	26·7	19·9	21·4	22·1	18·5	15·3	14·1	14·8	16·3	22·1	34·3	36·9
72,000	27·4	20·4	21·9	22 7	18·9	15·6	15·1	15·1	16·7	22·7	35·2	37.8
76,000	28·0	20·9	22·4	23·2	19·3	16·0	15·5	15·5	17·1	23·2	36·0	38·7
80,000	28·5	21·3	22·8	23·6	19·7	16·3	15 8	15·8	17·4	23·6	36·6	39·4

46. *Why no allowance for losses made below level of effective supply.*—It will be seen from the table that no allowance is made for loss by evaporation, etc., below the level of full effective supply. In the earlier stages of the life of the reservoir the non-effective capacity will and must be filled with water, as a condition prior to supply, and such water is subject to evaporation and percolation losses. The reason for this omission is that the dry weather flow of the Cauvery has not been allowed for in the tables, flow at Bhavani bridge not having been recorded for very low stages at the river (below 1,000 cusecs discharge).

It is known that the normal dry weather flow of the Cauvery is not less than an average 16 millions cubic feet (200 cusecs) per day. This is much more than evaporation would be over the non-effective area and is set-off against it.

PART VI. (Not printed.)
Working Tables—Cauvery Reservoir.

PART VII.

SILT OBSERVATIONS AND DEDUCTIONS.

PART VII.

Silt Observations and Deductions.

49. *Mr. Moss's Silt Observations.*—Among the investigations in connection with the original Cauvery project by Mr. Moss were a series of silt observations undertaken in 1902. Samples of silt carrying water were taken periodically—

From the Cauvery at Neringipet,
,, Bhavani at Kodiveri,
,, Amaravati at Karur,

also from the Cauvery at the Upper Anicut and in two drains in the Cauvery delta. These samples were all analysed quantitatively and some of them qualitatively. The object of the observations as described by Mr. Moss was to obtain a general knowledge of where the silt passing into the delta comes from, its quantity and value as manure and whether any is carried away in the drains.

50. *Conclusions from these observations.*—No very definite conclusions could be drawn from the results.

These, however, show that the quantity of silt per cubic feet of water contributed by Bhavani and Amaravati rivers especially in the north-east monsoon is proportionately large as compared to the Cauvery, while the manurial value of the silts from these rivers is greater than that from the Cauvery. This result confirms the views of the local ryots who prize the silt deposited by Bhavani and Amaravati floods (*vide* Appendix B of Mr. Moss's report).

51. *Sir Thomas Higham's Note on Silt Deposition.*—The question of silt deposition in the *Cauvery Reservoir* was the subject of some correspondence and study prior to the date of Mr. Moss's report and a note was written by Sir Thomas Higham on the subject (dated 24th August 1901 and published—G.O. No. 353 I. of 19th March 1902).

This note was written assuming that water would not be impounded in the reservoir between 15th May and 1st July during which time the reservoir would be empty and all the flow of the Cauvery passed through low level sluices.

The working tables of the reservoir make it clear that it is impossible to work the reservoir economically on such a system and that all the water available must be impounded and the balances over from the previous year held up and utilized in the next year.

The note further assumed (in the absence of any quantitative observations) that the silt annually carried in suspension in the Cauvery was $\frac{1}{7200}$ of the discharge and that this amounted to 41.5 mills. cubic feet in a year. Further investigations show these data to be inaccurate. As the conditions of the reservoir must be absolutely different from the assumptions on which Sir. T. Higham founded his note, the conclusion arrived at, that only 20 mills. cubic feet of silt would be retained annually in the reservoir is not applicable to the present case.

52. *Silt observation of* 1909.—The question of silt deposition in the reservoir has formed the subject of further enquiry last year and daily samples were taken either from Bhavani bridge or from the gauging station at Urachi (3 miles above the bridge) and quantitative analysis made from June to December 1909. The operations lasted from 9th June to 31st December. The early and unseasonable freshes of April and May 1909 were thus not included in the observations and these must have carried an appreciable quantity of silt.

53. *Description of method of taking samples.*—The method of taking the samples of water is described below :—

Samples were taken daily from five selected places across the width of one cross section of the river.

From each of such place, two samples were taken one about 1 foot above the river bed, a second at mid-depth.

The samples were taken in a cast iron bottle with a cone valve at the upper end, which could be opened at will by the observer by a string and which was self-closing. The capacity of the bottle was $2\frac{1}{2}$ quarts.

The samples taken each day were all decanted into a single mixing tub and the mixture was well agitated and two sample 2-lb. bottles filled from the tub and sent to the Chemical Examiner for quantitative analysis.

The result in combination with the recorded discharge of the day gives the weight of "dry silt" carried in suspension.

54. *Relation between weight and volume of silt.*—To get a factor to enable the *weight* of (chemically) "dry silt" to be converted into equivalent *volume* of damp silt the following method was adopted :—

Pits were dug on the margins of the river in land formed by alluvial deposit. From each of three separate pits at a depth when the silt was just moist, a sample of the earth *in situ* was taken by driving a sharp-edged sheet iron cylinder *of known* capacity (about $\frac{1}{8}$ cubit foot) into the soil and digging it out. This sample is assumed to be occupying the same bulk for its weight of dry silt as the silt deposited in the reservoir bed will occupy.

The sample was despatched to the Chemical Examiner, the contents when (chemically) dry weighed. The relation between the volume of damp silt and the weight of the dry was thus established. The average of the samples taken gave the following relation, viz. :—

One cubic foot of damp silt contains 99.28 lb. of chemically dry silt.

The increase of weight in the samples due to moisture averaged 17.53 per cent of the total weight of damp silt.

The total computation of the bulk in mills. cubic feet of damp silt carried in suspension from 9th June to 31st December is 128.2.

55. *Quantity of silt in suspension.*—The total discharge of the Cauvery during the period of observation was 431,231 mills. cubic feet.

This gives a proportion by volume of silt carried in suspension of one silt to 3,370 water (nearly).

The discharges of the Cauvery at Bhavani bridge year by year (June to January) as recorded in working tables averages 342,472 mills. cubic feet.

Taking the same proportion of silt as for the year 1909 the average silt carried in suspension would be 101.6 mills. cubic feet.

56. *Further operations in progress.*—Silt observations are being again taken daily during the current year on the Cauvery, above the confluence of the Bhaváni, but results are not yet available.

57. *Quantity of silt carried in* 1909.—The quantities of water-flow of 1909 for the silt quantity computations have been taken from the figures of actual gaugings and not from the amended curve.

This will account for the material differences of flow recorded for June and July in the silt observation tables with those of the reservoir working tables.

For purposes of *irrigation supply* the amended curve is safer although probably giving discharges of high gauge readings somewhat below actuals.

58. *Rolled sand.*—The quantity of sand rolled along the bed of the Cauvery annually and which will all of it be impounded in the reservoir has not been made the subject of any computation or measurement and what this is is pure conjecture.

59. *Conclusions.*—Having in view—

(i) That the daily silt observations are only available for one year.

(ii) That while this year's discharge is well above the mean, it is exceeded four years in 20 and further in this year although a good flow was maintained, there were no high floods.

(iii) That it is in abnormal floods rather than during steady although well-maintained flow periods that large proportions of silt in suspension is carried.

(iv) That there is no measure of the quantity of rolled sand.

(v) That the graduation curve (amended curve), Bhaváni bridge gauge, probably gives flood discharges below actuals.

It is considered desirable to compute the total deposition of solids annually in the reservoir at double the quantity deduced above from the observations June to December 1909, that is, 200 mills. cubic feet per year is adopted as a very safe figure for annual deposit of solids in the reservoir.

60. *How the gross and effective capacity of reservoir is affected.*—The reservoir gross capacity may thus be diminished 200 mills. cubic feet per year.

The greater part of the silt in suspension and all the rolled sand will be deposited or drifted into the deepest parts of the reservoir and in the earlier stages of the working of the reservoir the diminution of capacity will nearly all be diminution of non-effective capacity which is approximately 10,000 mills. cubic feet.

The effective capacity 80,000 mills. cubic feet cannot be materially affected for $\frac{10,000}{200}$ or 50 years and cannot at the worst be reduced to 70,000 mills. cubic feet before 100 years.

Abstract of Quantities (Cauvery silt and water, Bhavani bridge, 1909).

Computed from daily samples.

Month.	Water. M. C. FT.	Silt. M. C. FT.
June 9th to 30th	56,099	13·02
July	150,715	29·22
August	82,381	27·99
September	59,244	25·81
October	59,845	30·75
November	15,547	1·16
December	7,400	0·25
Total	431,231	128·20

Proportion $\frac{\text{silt}}{\text{water}} = \frac{1,282}{4,312,310} = \frac{1}{3,370}$ nearly.

STATEMENT showing results of observations of quantities of silt carried in suspension in river Cauvery at Bhavani station.

To be filled in by Department of Chemical Examiner.					To be computed and filled in by Public Works Department.		
Number of sample.	Date of taking sample.	River rising or falling. R. or F.	Surface velocity, feet per second.	Number of grains dry silt per cubic foot of water.	Discharge of river. Millions cubic feet per 24 hours.	Dry silt carried in suspension per day, million grains.	Equivalent million cubic feet damp silt.
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)

June 1909.

1-c	9th	R.	..	398	6,998	2,785,204	4·00
2-c	10th	R.	..	235	7,998	1,879,530	2·71
3-c	11th	F.	..	156	6,984	1,089,504	1·57
4-c	12th	F.	..	162	4,495	728,190	1·05
5-c	13th	F.	..	121	3,261	394,581	0·56
6-c	14th	R.	..	86	3,530	303,580	0·43
7-c	15th	F.	..	72	2,658	191,376	0·27
8-c	16th	F.	..	120	2,195	263,400	0·38
9-c	17th	F.	..	61	1,954	119,194	0·17
10-c	18th	F.	..	44	1,678	73,832	0·11
11-c	19th	F.	..	87	1,084	94,308	0·13
12-c	20th	F.	..	62	1,138	70,556	0·10
13-c	21st	F.	..	28	764	21,392	0·03
14-c	22nd	F.	..	90	645	58,050	0·08
15-c	23rd	F.	..	15	633	9,495	0·01
16-c	24th	F.	..	22	524	11,528	0·02
17-c	25th	F.	..	22	519	11,418	0·02
18-c	26th	F.	..	27	419	11,313	0·02
19-c	27th	R.	..	17	508	8,636	0·01
20-c	28th	R.	..	21	773	16,233	0·02
21-c	29th	R.	..	152	3,567	542,184	0·78
22-c	30th	R.	..	104	3,734	388,336	0·55
	Total	..	..	..	56,099	..	13·02

July 1909.

23-c	1st	F.	..	69	3,317	228,873	0·33
24-c	2nd	F.	..	57	2,692	153,444	0·22
25-c	3rd	F.	..	62	1,948	120,776	0·17
26-c	4th	F.	..	52	1,743	90,636	0·13
27-c	5th	R.	..	60	1,807	108,420	0·15
28-c	6th	R.	..	57	1,786	101,802	0·15
29-c	7th	F.	..	49	1,908	93,492	0·13
30-c	8th	R.	..	60	2,111	126,660	0·18
31-c	9th	R.	..	52	2,218	115,336	0·17
32-c	10th	R.	..	48	1,888	90,624	0·13
33-c	11th	R.	..	92	2,715	249,780	0·36
34-c	12th	R.	..	156	5,776	901,056	1·30
35-c	13th	R.	..	147	6,526	959,322	1.38
36-c	14th	R.	..	134	6,986	936,124	1·35
37-c	15th	R.	..	135	7,543	1,018,305	1·46
38-c	16th	Steady.	..	167	7,300	1,219,100	1·76
39-c	17th	R.	..	173	8,266	1,430,018	2·05
40-c	18th	F.		188	9,046	1,700,648	2·45
41-c	19th	F.	..	176	8,268	1,455,168	2·09
42-c	20th	F.	..	154	6,551	1,008,854	1·45
43-c	21st	F.	..	80	4,862	388,960	0·56
44-c	22nd	F.	..	51	3,551	181,101	0·26
45-c	23rd	F.	..	50	2,796	139,800	0·20
46-c	24th	F.	..	45	2,383	107,235	0·15
47-c	25th	F.	..	64	2,300	147,200	0·21
48-c	26th	R.	..	14	2,333	32,662	0·05
49-c	27th	R.	..	116	5,896	683,936	0·99
50-c	28th	R.	..	295	11,369	3,353,855	4·82
51-c	29th	F.	..	151	10,747	1,622,797	2·34
52-c	30th	..	..	121	8,186	990,506	1·43
53-c	31st	F.	..	95	5,896	560,120	0·80
	Total	..	..	..	150,715	..	29·22

REMARKS.—Figures in column 8 obtained by dividing the number of million grains of silt by 99·28 × 7,000 = 694,960.

Statement showing results of observations of quantities of silt carried in suspension in river Cauvery at Bhavani station—*cont.*

To be filled in by Department of Chemical Examiner.					To be computed and filled in by Public Works Department.		
Number of sample.	Date of taking sample.	River rising or falling. R. or F.	Surface velocity, feet per second.	Number of grains dry silt per cubic foot of water.	Discharge of river. Millions cubic feet per 24 hours.	Dry silt carried in suspension per day, million grains.	Equivalent million cubic feet damp silt.
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)

August 1909.

54-c	1st	F.	..	57	4,298	244,986	0·35
55-c	2nd	F.	..	99	4,149	410,751	0·59
56-c	3rd	R.	..	38	4,373	166,174	0·24
57-c	4th	F.	..	54	4,103	221,562	0·32
58-c	5th	R.	..	97	4,638	449,886	0·64
59-c	6th	F.	..	122	4,293	523,746	0·76
60-c	7th	F.	..	104	3,702	385,008	0·55
61-c	8th	F.	..	214	3,385	724,390	1·04
62-c	9th	F.	..	147	3,069	451,143	0·64
63-c	10th	F.	..	147	3,005	441,735	0·63
64-c	11th	F.	..	173	2,773	479,729	0·69
65-c	12th	F.	..	67	2,269	152,023	0·22
66-c	13th	F.	..	153	2,192	335,376	0·48
67-c	14th	F.	..	90	1,912	172,080	0·25
68-c	15th	F.	..	149	1,785	265,965	0·38
69-c	16th	F.	..	54	1,446	78,084	0·11
70-c	17th	F.	..	33	1,152	38,016	0·05
71-c	18th	F.	..	47	1,152	54,144	0·08
72-c	19th	R.	..	32	1,016	32,512	0·05
73-c	20th	F.	..	430	1,318	566,740	0·82
74-c	21st	R.	..	121	977	118,217	0·17
75-c	22nd	R.	..	518	1,627	839,781	1·21
76-c	23rd	R.	..	215	1,916	411,940	0·59
77-c	24th	F.	..	218	1,650	359,700	0·51
78-c	25th	R.	..	228	2,159	492,252	0·71
79-c	26th	F.	..	355	2,114	750,470	1·08
80-c	27th	R.	..	250	2,179	544,750	0·79
81-c	28th	R.	..	907	4,238	3,843,866	5·53
82-c	29th	R.	..	835	2,937	2,452,395	3·52
83-c	30th	R.	..	545	3,292	1,794,140	2·58
84-c	31st	R.	..	515	3,252	1,674,780	2·41
	Total	..	..	..	82,381	..	27·99

September 1909.

85-c	1st	R.	..	613	2,782	1,705,866	2·46
86-c	2nd	R.	..	801	5,789	4,636,989	6·67
87-c	3rd	F.	..	758	5,105	3,869,590	5·57
88-c	4th	Steady.	..	487	4,048	1,971,376	2·84
89-c	5th	F.	..	357	4,804	1,715,028	2·47
90-c	6th	F	..	286	3,351	796,836	1·14
91-c	7th	F.	..	167	2,819	470,773	0·67
92-c	8th	F.	..	182	2,628	478,296	0·68
93-c	9th	F.	..	106	2,718	287,578	0·41
94-c	10th	F.	..	78	2,176	169,728	0·24
95-c	11th	F.	..	59	1,731	102,129	0·15
96-c	12th	F.	..	81	1,548	125,388	0·18
97-c	13th	R.	..	76	1,860	141,360	0·20
98-c	14th	R.	..	257	2,125	546,125	0·78
99-c	15th	F.	..	208	1,726	359,008	0·51
100-c	16th	..	..	100	1,540	154,000	0·22
101-c	17th	F.	..	59	1,309	77,231	0·11
102-c	18th	F.	..	72	1,068	76,896	0·11
103-c	19th	..	..	82	1,041	33,812	0·05
104-c	20th	F.	..	81	910	28,210	0·04
105-c	21st	F.	..	64	810	51,840	0·07
106-c	22nd	F.	..	89	746	29,094	0·04
107-c	23rd	F.	..	18	703	12,654	0·02
108-c	24th	F.	..	12	684	8,208	0·01
109-c	25th	Steady.	..	18	709	12,762	0·02
110-c	26th	R.	..	22	780	17,160	0·02
111-c	27th	R.	..	45	970	43,650	0·06
112-c	28th	R.	..	23	1,009	23,207	0·03
113-c	29th	F.	..	15	810	12,150	0·02
114-c	30th	F.	..	17	750	12,750	0·02
	Total	..	..	..	59,244	..	25·81

REMARKS.—Figures in column 8 obtained by dividing the number of million grains of silt by 99·28 × 7,000 = 694,960.

Statement showing results of observations of quantities of silt carried in suspension in river Cauvery at Bhavani station—*cont.*

To be filled in by Department of Chemical Examiner.					To be computed and filled in by Public Works Department.		
Number of sample.	Date of taking sample.	River rising or falling. R. or F.	Surface velocity, feet per second.	Number of grains dry silt per cubic foot of water.	Discharge of river. Millions cubic feet per 24 hours.	Dry silt carried in suspension per day, million grains.	Equivalent million cubic feet damp silt.
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	October 1909.						
115-o	1st	F.	..	13	728	9,464	0·01
116-o	2nd	R.	..	30	752	22,560	0·03
117-o	3rd	R.	..	252	1,182	297,864	0·43
118-o	4th	F.	..	213	992	211,296	0·30
119-o	5th	R.	..	333	1,535	517,815	0·75
120-o	6th	R.	..	240	1,933	463,920	0·66
121-o	7th	R.	..	1,269	6,056	7,685,064	11·06
122-o	8th	F.	..	420	3,463	1,454,460	2·09
123-o	9th	F.	..	405	3,310	1,340,550	1·93
124-o	10th	F.	..	358	2,656	950,848	1·37
125-o	11th	F.	..	374	2,720	1,017,280	1·45
126-o	12th	R.	..	408	3,225	1,316,392	1·89
127-o	13th	R.	..	309	3,709	1,146,081	1·65
128-o	14th	F.	..	432	2,949	1,273,968	1·83
129-o	15th	F.	..	124	2,438	302,314	0·43
130-o	16th	F.	..	212	2,265	480,180	0·70
131-o	17th	R.	..	299	2,681	793,689	1·14
132-o	18th	F.	..	335	2,615	876,025	1·26
133-o	19th	F.	..	175	2,567	449,225	0·65
134-o	20th	F.	..	130	2,192	284,960	0·41
135-o	21st	F.	..	86	2,107	181,202	0·26
136-o	22nd	F.	..	62	1,502	93,124	0·13
137-o	23rd	F.	..	51	1,180	60,180	0·09
138-o	24th	F.	..	45	938	42,210	0·06
139-o	25th	F.	..	42	784	32,928	0·05
140-o	26th	F.	..	27	698	18,846	0·03
141-o	27th	F.	..	28	634	17,752	0·03
142-o	28th	F.	..	21	580	12,180	0·02
143-o	29th	F.	..	23	530	12,190	0·02
144-o	30th	F.	..	9	476	4,284	0·01
145-o	31st	F.	..	14	447	6,258	0·01
	Total ..	..	..	..	59,845	..	30·75
	November 1909.						
146-o	1st	F.	..	35	433	15,155	0·023
147-o	2nd	R.	..	36	600	21,600	0·032
148-o	3rd	..	..	53	932	49,396	0·071
149-o	4th	R.	..	94	1,088	102,272	0·150
150-o	5th	R.	..	120	1,226	147,120	0·212
151-o	6th	R.	..	106	1,286	136,316	0·200
152-o	7th	F.	..	71	1,061	75,331	0·110
153-o	8th	F.	..	58	926	53,708	0·078
154-o	9th	F.	..	45	724	32,580	0·047
155-o	10th	F.	..	29	586	16,994	0·024
156-o	11th	F.	..	17	521	8,857	0·013
157-o	12th	F.	..	27	445	12,015	0·017
158-o	13th	F.	..	38	405	18,865	0·020
159-o	14th	F.	..	21	365	7,665	0·011
160-o	15th	F.	..	18	316	4,134	0·006
161-o	16th	F.	..	15	350	5,250	0·008
162-o	17th	R.	..	120	388	46,560	0·067
163-o	18th	F.	..	22	319	7,018	0·010
164-o	19th	F.	..	13	303	3,939	0·006
165-o	20th	F.	..	13	298	3,874	0·006
166-o	21st	F	..	22	290	6,380	0·009
167-o	22nd	F.	..	18	277	4,986	0·007
168-o	23rd	F.	..	14	293	4,102	0·006
169-o	24th	Steady.	..	9	298	2,682	0·004
170-o	25th	,,	..	8	287	2,246	0·003
171-o	26th	,,	..	9	299	2,691	0·004
172-o	27th	F.	..	11	286	3,146	0·005
173-o	28th	Steady.	..	11	283	3,113	0·005
174-o	29th	,,	..	9	293	2,637	0·004
175-o	30th	F.	..	9	267	2,403	0·003
	Total ..	..	..	..	15,547	..	1·16

REMARKS.—Figures in column 8 obtained by dividing the number of million grains of silt by 99·28 × 7,000 = 694,960.

Statement showing results of observations of quantities of silt carried in suspension in r ver Cauvery at Bhavani station—*cont.*

To be filled in by Department of Chemical Examiner.					To be computed and filled in by Public Works Department.		
Number of sample.	Date of taking sample.	River rising or falling. R. or F.	Surface velocity, feet per second.	Number of grains dry silt per cubic foot of water.	Discharge of river. Millions cubic feet per 24 hours.	Dry silt carried in suspension per day, million grains.	Equivalent million cubic feet dam silt.
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	December 1909.						
176-o	1st	R.	..	26	273	7,098	0·010
177-o	2nd	R.	..	149	280	41,720	0·060
178-o	3rd	Steady.	..	9	283	2,547	0·004
179-o	4th	,,	..	9	280	2,520	0·004
180-o	5th	,,	..	30	278	8,340	0·012
181-o	6th	F.	..	10	268	2,680	0·004
182-o	7th	F.	..	10	249	2,490	0·004
183-o	8th	F.	..	7	256	1,792	0·003
184-o	9th	F.	..	13	233	3,029	0·004
185-o	10th	F.	..	16	220	3,520	0·005
186-o	11th	F.	..	9	212	1,908	0·003
187-o	12th	Steady.	..	23	216	4,968	0·007
188-o	13th	,,	..	4	215	860	0·001
189-o	14th	,,	..	8	213	1,704	0·002
190-o	15th	R.	..	13	254	3,302	0 005
191-o	16th	R.	..	9	246	2,214	0·003
192-o	17th	R.	..	4	280	1,120	0·002
193-o	18th	R.	..	8	326	2,608	0·004
194-o	19th	F.	..	115	304	34,960	0·050
195-o	20th	R.	..	14	320	4,480	0-006
196-o	21st	F.	..	14	279	3,906	0-006
197-o	22nd	F.	..	8	257	2,056	0·003
198-o	23rd	F.	..	31	230	7,130	0·010
199-o	24th	F.	..	41	210	8,610	0 012
200-o	25th	F.	..	14	183	2,562	0·004
201-o	26th	Steady.	..	5	191	955	0·001
202-o	27th	,,	..	13	188	2,444	0·003
203-o	28th	F.	..	10	169	1,690	0·002
204-o	29th	F.	..	23	169	3,887	0·006
205-o	30th	F.	..	9	160	1,440	0·002
206-o	31st	F.	..	33	150	4,950	0·007
	Total ..	..	..	..	7,400	..	0 250

REMARKS.—Figures in column 8 obtained by dividing the number of million grains of silt by 99·28 × 7,000 = 694,960.

J. L. VANGEYZEL, Lieut.-Col., I.M.S.,
Chemical Examiner.

10th January 1910.

PART VIII (Not printed).

Tables of half-monthly discharges of Cauvery.

PART IX (1) (Not printed).

Statement of monthly rainfalls from June to January inclusive of the various stations of the Tanjore district for the years 1890 to 1910.

PART IX (2) (Not printed).

Extracts from registers of rainfalls for certain stations showing the ten heaviest rainfalls on any one day in order of magnitude and rainfall for twenty days before and nine days after such fall.