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Government of Madras.

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*Proceedings of the Madras Government, Public Works Department,
21st January 1871.*

No. 366. Read the following letter from the Acting Consulting Engineer for Irrigation and Canal Company, to the Secretary to Government, Public Works Department, dated Camp at Kurnool, 10th October 1870.

AGREEABLY to Order of Government, No. 1,602, 4th July 1870, I have the honour to furnish the information, regarding the Madras Irrigation and Canal Company's Main Canal, which is required by the 5th paragraph of the Despatch from the Government of India to the Secretary of State.

2. The further information specially desired was a complete series of diagrams showing the rise and fall of the Toombuddra at the head of the canal on the up and down-stream sides, and a Statement of the number of days in each month, and the quantity of water at each period, during which the supply of the river falls below 3,000 cubic feet per second, that it may be seen whether there is any deficiency in the supply in October and November before the rice crops sown in June or July is matured, and whether the aid of reservoirs is necessary to allow of 3,000 cubic feet per second being rendered available for the canal during the period required for maturing a single rice crop, or whether they are necessary only so far as a second crop is concerned. I enclose diagrams showing the rise and fall of the Toombuddra above the anicut at Soonkasala for the years 1862 to 1869 inclusive, and similar diagrams for the gauge at Kurnool from 1861 to June 1870. The rise and fall below the anicut has not been gauged, and no necessity for this information has arisen, as the level of the water in the river below the anicut has never been high enough to affect the calculations of the discharge over the anicut.

3. I also forward an interesting report from Mr. Crawford, Assistant Engineer in the Company's service, on the discharge of the Toombuddra, together with a letter from the Chief Engineer as noted

1 Report, dated 18th August 1870.

1 Letter from the Chief Engineer of the Madras Irrigation and Canal Company, dated 30th July 1870, No. 232.

in the margin. This report would chiefly be of use in connection with the question of reservoirs to supplement the

monsoon supply of the Toombuddra, but the tables attached to it are of value also on the present occasion as giving in a convenient form the discharge of the river throughout the year. From the year 1861 to 1869 the number of days during which the discharge fell below 3,000 cubic feet per second in the months of October and November were in all forty, or an average of four days yearly, namely:—

In 1863 ...	...	1 day (30th November.)
„ 1864 ...	...	14 days (17th to 30th.)
„ 1865 ...	...	6 „ (26th Oct. and 26th to 30th Nov.)
„ 1867 ...	...	6 „ (25th to 30th November.)
„ 1868 ...	...	11 „ (20th to 30th.)
„ 1869 ...	...	2 „ (29th to 30th.)

4. The lowest was 1,500 cubic feet a second in 1868, and that was the only occasion on which the discharge fell below 2,300 cubic feet, so that practically it may be said that there is no diminution in the supply of 3,000 cubic feet a second until the end of November. In the month of December the discharge has been recorded as low as 1,000 cubic feet, and the average is about 2,000; after the 31st December the Company are debarred drawing any water from the Toombuddra, as the Kistna District has a claim to all passing down the river in the dry season. It

will thus be seen that there is no doubt as to the sufficiency of water available for one crop, but that, with the exception of the comparatively small quantities stored in tanks along the line which the canal traverses, none will be available for a second crop; also, that the canal will usually be dry for the first six months of each year, when there will be no navigation. These circumstances induced the remark in my former report, to which attention is drawn by the Government of India, that without reservoirs the canal will never be efficient as a line of irrigation, and that its value for navigation will be comparatively small; for the conditions are very different to those attending a new or extra supply of water to a long-established rice growing country, and the prospects of remuneration on the outlay that has been incurred on this line are by no means so good as they would be of a double return had water been provided for a second crop, for many instances will occur when one crop of rice will not be a sufficient inducement to grow that grain though two crops might be.

5. Moreover, the change from dry to wet cultivation requires a good deal more than the necessary provision of water. I have always felt that irrigation under this canal must be of gradual growth with time, and that no considerable extent of land would be irrigated until seven or eight years after the completion of the work. The people must feel assured of the certainty of supply for one or two crops as the case may be, and the effects of the recent calamitous floods must have considerably shaken the confidence of the most sanguine in the stability of the works. Then they will have to learn that it will be to their advantage to substitute rice for the crops they now grow, and they will require to see how much the profit will be; they will then have to tenace their land, and otherwise adapt it for wet cultivation. They must also replace their farm bullocks by buffaloes capable of ploughing while up to their knees in water. Taking all this into consideration, I have no expectation that the luxuriant crops of cotton, indigo, and various seeds, which are produced in the Koondaur Valley, will be replaced by rice unless there was an entire failure of those crops for a series of years; but I have no doubt that the people would be glad in seasons when there is a deficient fall of rain for dry crops to supplement it by water from the canal, if it is made available at a fair price. Where the ryots are familiar with the cultivation of rice, the canal water will no doubt be eagerly sought; but such areas are comparatively small, and it appears to me in the highest degree improbable that the canal will ever pay five per cent. on the Capital expended, unless water for a second crop is provided by means of reservoirs.

Report on the discharge of the River Toombuddra as calculated from the Gauge Registers kept at Kurnool and Soonkasala.

From a cross section of the river taken at the gauge near the old Traveller's bungalow at Kurnool on a line bearing 154° the sectional areas and wetted borders for every half foot in height on the gauge from zero to five feet, and for every foot from five feet to eighteen feet were obtained—*vide* Table A. The river was taken as divided into two parts, namely, from gauge to 420 feet one line of section, and from that point to north bank, on account of the long stretch of shallow water when the depth on gauge reads three feet.

To ascertain the fall of the river, levels were taken of the surface of water when it read 6.23 on the gauge; for 1½ mile up-stream and 1 mile down-stream the result was a fall for the

1½ mile of 2.13 feet, and for the 1 mile of 1.71 feet, or a mean of 1.71 feet per mile. The distances were taken from a plan reduced to one-eighth from the land plans of the Revenue Survey by H. Cardoza, 1st Assistant Superintendent.

The following formula was employed in calculating the discharges in cubic yards of water a day :—

$$D = \frac{24 \times 1,500}{9} \sqrt{f} \times \frac{A^3}{b} = 4,000 \times \sqrt{f} \times \frac{A^3}{b^{\frac{1}{2}}}$$

or Log. D = $\left\{ \begin{array}{l} \log. 4,000 + \frac{1}{2} \log. f + \text{constant.} \\ + \frac{3}{2} \log. A - \frac{1}{2} \log. b. \end{array} \right.$

D = discharge in cubic yards per day of 24 hours.
f = fall per mile in feet taken at 1.92 in Table A.
A = Area in square feet.
B = Wetted border in feet.

The result is Table A. giving the discharge of the River Toombuddra at every half foot in height on gauge from 0 to 5 feet, and for every foot from 5 feet to 18!

From the diagrams of the height of water in the river constructed at the Central Office, tables were made showing the number of days for each year from 1861 to 1869 at which the water stood at heights for which the discharges had been calculated as shown above. These numbers being multiplied by their respective discharges, gave the total discharge for each year in cubic yards as follows :—

							Million Cubic yards.
1862	...	...	...	...	...	...	20,346
1863	...	...	...	...	...	...	22,676
1864	...	...	...	...	...	...	19,646
1865	...	...	...	...	...	...	24,920
1866	...	...	...	...	...	...	22,984
1867	...	...	...	...	...	...	19,224
1868	...	...	...	...	...	...	20,169
1869	...	...	...	...	...	...	16,112
Mean for eight years =							20,759

The year 1861 was not included in the readings of the gauge, were only recorded for 18½ days.

As upon the above the discharge of the river was calculated from the Soonkasala Gauge Registers for the years 1867 and 1869, a table was constructed showing discharge over crest for every three inches in height from 0 to 1 foot, and for every six inches from 1 foot to 6 feet 6 inches—*vide* Table B.

The following formula was employed—

$$D = \frac{60 \times 24}{27} \times c \times b \times \sqrt{d^3} \quad (\&)$$

$$= 53.3 \text{ feet} \times 4,340 \times c \times \sqrt{d^3}$$

Log. D = log. 53.3 feet + log. 4,340 a constant,
+ log. of number corresponding to c = 0.667 and d as taken from Stoddard's Table II.

D = Cubic yards per day of 24 hours.
c = co-efficient = 0.667.
b = length of crest in feet = 4,340 feet.
d = depth of water on crest in feet and inches.

A table was also constructed, giving the discharge through one under-sluice vent at heads on centre of orifice varying by 6 inches from 3½ to 15 feet, and below 3½ feet head when the sluices act as a weir for the following depths on sill, namely :—

5½ feet, 6 feet and 6½ feet—*vide* C.C. Table.

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The formula employed was—

$$D = \frac{60 \times 60 \times 24}{36} \times \frac{13 \times 7 \times 1}{2 \times 9} \times V$$

area of one vent in feet.

$$\text{Log. } D = 2 \log. 20 + \log. 3 \times \log. 7 - \log. 3$$

+ Log. velocity corresponding to head.

Answer co-efficient, 0.581 as given in Stoddard's Table No. IV.

For calculating the discharges at the depths 5½, 6 and 6½ feet on sill formula (d) was employed.

These tables having been constructed, the total discharge of the river was calculated by taking out the number of days at which the water stood at heights for which the discharges had been calculated, these multiplied by their respective discharges as given in Table B., gave the total discharge over crest of anicut.

The total discharge through the under-sluices was obtained in a similar manner, the number of vents open being multiplied by the number of days at which the water stood at a certain head, these numbers being multiplied by their respective discharges as given in Table C.C².

The years 1867 and 1869 were selected as being the only years in which there were no breaches since the completion of the anicut and head works.

The following are the results of these calculations:—

Discharge over crest of anicut (old crest) as taken from Soonkasala gauge-reading during 1867	Million Cubic yards.
...	12,500
Do. do. through under-sluices	2,150
Do. do. do. head-sluices, estimated 2 millions a day for 180 days	360
	15,010

Add for velocity of approach, taking it to be ½ths and 2½ miles an hour for heads of two feet and four feet respectively, the heads corresponding to these velocities being 1½ inches and 2½ inches respectively, the result gives the discharge due to the velocity of approach about 2.8 per cent. of the discharge as calculated for still water:—

For the year 1867 being	355
Grand Total for year 1867 =	15,365

For the year 1869 (new crest) the total discharges are as follow:—

Total over crest of anicut (new)	10,038
Add 2.8 per cent. for velocity of approach	281
Discharge through under-sluices (estimated)	2,500
Do. do. head-sluices (do.)	350

Grand Total for year 1869... 13,169

These figures when compared with the discharges for the same years as obtained from the Kurnool Gauge Register, will be found to be about ½th, less, or more accurately, ½th (1 — ½th) less; this is partly accounted for from the fall of river being taken too high, 1.32 feet per mile, in calculating Table A. The fall corresponding to the reduced discharge is 1.23 feet per mile, which agrees nearly with Mr. Orm's levels taken some months ago under conditions of water not stated above and below the Kurnool gauge, namely, up-stream 0.99 per mile, down-stream 1.18 per mile, or a mean of 1.08 feet per mile, giving a difference of 0.63 feet from the figure given in the commencement of this report (1.71); this may be accounted for from the river being in flood when the latter level was obtained.

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Taking the discharge as obtained from the Soonkasala Register as the most probably correct, and reducing the discharges as calculated from the Kurnool gauge by the amount ½th (1 — ½th), we arrive at the following figures, which may probably be taken as a fair approximation, namely:—

	Million Cubic yards.
1862 ...	16,440
1863 ...	18,322
1864 ...	15,873
1865 ...	20,135
1866 ...	18,570
1867 ...	15,532
1868 ...	16,296
1869 ...	13,018
8) 1,34,186	

Mean Total of eight years... 16,773 Million Cubic yards.

Taking 16,773 million cubic yards as the mean discharge of the River Toombuddra at Kurnool, the following is an attempt to account for it, which, though merely conjectural, based upon so many known facts as to be worth insertion as a guide till more is known.

F.

	Square miles.	Rain-fall.	Million Cubic yards.
Toonga ...	1,080	4 feet	4,461
Buddra ...	1,230	4 "	5,080
Chordee ...	819	1½ "	1,228
Waradah ...	1,983	2½ "	3,966
Hurryhur Nulla from Daverhully tank, deducting catchment basin to tank	741	4 inches	247
Chinna Huggry ...	1,064	2 "	177
Huggry ...	8,775	2 "	1,462
Drainage area from Raichore and Moodgul Districts	3,344	2 "	557
Do. do. Huggry to Soonkasala, south of river	1,588	4 "	529
From Chinna Huggry to Huggry (south side of river), deducting catchment basin of Darjee tank	38	4 "	12
			16,719

The only reliable information with respect to Rain-fall was obtained from Mr. Gordon's report for November 1867, namely:—

	Inches.
" Rain-fall at Shimoga, from January to 31st October 1867	26.63
" Do. at Copp near Ghauts, from 13th May to 31st October 1867.	81.23
" In November 1867 there was no rain-fall at either place; from Mr. Gordon's report for May 1868, rain-fall at Copp, from March to	
" May 1868"	5.28

As the first two figures give a mean of 4½ feet, it is probable that 4 feet is not too much to take as flowing off in the Toonga and Buddra. With respect to the other catchment basins no reliable information was obtainable with respect to rain-fall.

KURNOOL,

18th August 1870.

(Signed) W. F. CRAWFORD,
Assistant Engineer.

From the Chief Engineer of the Madras Irrigation and Canal Company, to the Acting Consulting Engineer, Madras Irrigation and Canal Company, dated Kurnool, 30th July 1870, No. 232.

Your letter, Coenoor, 25th instant.

I HAVE the honour to say that I can supply you with the information you ask in paras. 3 and 4, and will procure the copies as soon as possible. Meantime you may find interest in the following.

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2. The year 1867 offers facilities for calculating the discharge of the Toombuddra at Soonkasala. Little water was run down the canal; no accident interfered with the overfall; and the state of the water above anicut and of the under-slucies was registered twice a day, or at least once, for the morning readings show some signs of guess work. By a careful calculation of Mr. Crawford's, whose report will reach you in due course, and a constant of two-thirds for the anicut discharge, and of 584 for the under-slucies, the discharge in 1867 is ascertained to have

been over anicut 12,500 million cubic yards.
through under-slucies 2,150 " "
and by canal, say, ... 350 " "

Total... 15,000 millions "

The discharge at Kurnool in that year, calculated with a fall of 1.92 feet per mile, and a constant 1,500* from the daily Register, is 19,224 millions.

* V. yards 1,500 $\sqrt{8' \times f'}$.

3. By altering the constant or fall at Kurnool so as to make the two calculations tally, neglecting the drainage of about 250 square miles into the river between Soonkasala and Kurnool, we get the following yearly discharges at Soonkasala, calculated from the daily Register at Kurnool in millions of cubic yards:—

In 1861... .. 16,933
In 1862... .. 15,277
In 1863... .. 18,141
In 1864... .. 15,717
In 1865... .. 19,936 maximum.
In 1866... .. 18,387
In 1867... .. 15,379
In 1868... .. 16,135
In 1869... .. 14,890 minimum.

Total... 1,50,795

or an average of 16,755 million cubic yards; and a minimum, when probably there was no fresh in the Huggry, of 14,890 millions, about double what is needed for the three reservoirs now under investigation.

4. During the months of October and November in the above years, the calculations give a discharge of under 3 000 cubic feet a second in forty days,† or an average of four yearly. The lowest was 1,500 cubic feet a second in 1868; no other below 2,300.

1863, on 30th November 1 day.
1864, 17th to 30th November 14 days.
1865, 26th October and 26th to 30th November 6 "
1867, 25th November to end 6 "
1868, 20th do. 11 "
1869, 29th do. 2 "
40

5. In December the average is about 2,000 cubic feet; the lowest recorded being 1,000 in 1867, and the highest minimum 3,000 in 1866.

6. *The supply regularly falls except in three years, when freshes, succeeded by gradual falls, occurred in January 7th, namely, over 4,000 cubic feet a second on 15th January 1862, 1,500 on 17th January 1864, and 2,000 on 25th January 1865. In 1867, 3,000 cubic feet were running till 25th January. The latest date for the midsummer freshes is 11th July 1866. In half the years the permanent rise takes place before 8th June.

7. To your last two paragraphs I can reply. The arable land we can advantageously irrigate from the canal in the first five sections is 48,013 acres.* In other sections the power of irrigating is limited only by the capacity of the canal. The still water canal in the tenth section will irrigate an appreciable area not yet determined.

* In 1st Section 1 386 acres.
" 2nd do. 1,956 "
" 3rd do. 9,837 "
" 4th do. 15,318 "
" 5th do. 9,516 "
Total... 48,013

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8. I have no data of any value to show the most remunerative supply of water per acre irrigated. I have no doubt that 2,000 or 3,000 acres of second crop could be raised under the tanks; indeed, the deep sluices in Kurnool, Maddigutla, Pagadyal, and Tangadancha Tanks are able to supply water sufficient for that area. But no offer to irrigate sugar nor a second crop has yet been made. They might reap in April.

Calculation of Discharges of River Toombuddra at every foot and half foot on Kurnool Gauge.

A.

Height on K. Gauge.	A. Area of water-way up to 420.	B. Wetted up to 420.	A 2. Area of water-way beyond 420 feet.	D.	B 2. Wetted beyond 420.	Discharge in cubic yards per day of 24 hours.
0	272	150				2,030,000
1	349	160				2,857,000
1 1/2	430	174				3,786,000
2	527	200				4,742,000
2 1/2	653	304				5,305,000
3	834	420				6,514,000
3 1/2	1,044	420	1,374	692	1,160	9,123,000 8,288,000 12,010,000 12,970,000 15,150,000 21,195,000 18,525,000 30,675,000 22,115,000 44,065,000 29,910,000 66,400,000 38,450,000 96,795,000 47,680,000 124,200,000 57,515,000 165,500,000 68,010,000 211,200,000 79,040,000 262,200,000 90,615,000 317,700,000 112,700,000 376,900,000 115,300,000 439,400,000 128,350,000 505,050,000 141,800,000 571,700,000 160,200,000 645,150,000 170,200,000 720,000,000
4	1,254	420	2,066	806	1,606	17,411,000 24,980,000
4 1/2	1,464	420	2,872	814	1,620	36,345,000
5	1,674	420	3,686	821	1,635	49,200,000
5 1/2	1,884	420	14,707	1,755	1,650	66,180,000
6	2,304	420	16,462	1,900	1,880	96,310,000
7	2,724	420	18,362	2,100	1,920	135,245,000
8	3,144	420	10,462	2,307	2,280	171,880,000
9	3,564	420	12,769	2,360	2,335	223,045,000
10	3,984	420	15,129	2,395	2,385	279,210,000
11	4,404	420	17,524	2,408	2,405	341,240,000
12	4,824	420	19,932	2,411	2,410	408,315,000
13	5,244	420	22,313	2,413	2,412	489,600,000
14	5,664	420	24,756	2,415	2,414	554,700,000
15	6,084	420	27,171	2,417	2,416	633,400,000
16	6,504	420	29,588	2,419	2,418	713,500,000
17	6,924	420	32,007	2,429	2,420	805,350,000
18	7,344	420	34,436		2,420	890,200,000 84,850,000

KURNOOL,
28th July 1870.

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Reading on gauge.	A. Area of water-way up to 420 feet.	D.	B. Wet out-line.	Wet line north of 420 feet per gauge.	A 2. Area of W. beyond 420 feet.	Wet out-line.	$a = \log. 4,000 \sqrt{\pm}$ $b = \log. 4,000 \sqrt{+}$ $a = 690,105.$	$b = \frac{1}{2} \log. \text{area.}$ $c = \frac{1}{2} \log. \text{wet per}$ $\frac{420}{420}$
0	272		150					
$\frac{1}{2}$	349	77	160					
1	433	84	174					
$1\frac{1}{2}$	527	94	200					
2	653	126	304					
$2\frac{1}{2}$	834	181	420		794			
3	1,044	210	1,580	1,160	580	580		
$3\frac{1}{2}$	1,254	210	2,026	1,606	1,272	692		
4	1,464	210	2,040	1,620	2,078	806		
$4\frac{1}{2}$	1,674	210	2,055	1,635	2,892	814		
5	1,884	210	2,070	1,650	3,713	821		
6	2,304	420	2,300	1,880	5,468	1,755		
7	2,724	420	2,340	1,920	7,368	1,900		
8	3,144	420	2,700	2,280	9,468	2,100		
9	3,564	420	2,755	2,335	11,775	2,307		
10	3,984	...	2,805	2,385	14,135	2,360		
11	4,404	...	2,825	2,405	16,530	2,395		
12	4,824	...	2,830	2,410	18,938	2,408		
13	5,244	...	2,832	2,412	21,349	2,411		
14	5,664	...	2,834	2,414	23,762	2,413		
15	6,084	...	2,836	2,416	26,177	2,415		
16	6,504	...	2,838	2,418	28,594	2,417		
17	6,924	...	2,840	2,420	31,013	2,419		
18	7,344	...	3,840	2,420	33,442	2,429		

Formula used in calculating Table A.

$$D = 4,000 \sqrt{f} \quad \frac{A^3}{b} = \log 4,000 + \frac{1}{2} \log 1.92 + \frac{2}{3} \log A - \frac{1}{3} \log b.$$

$$\log 4,000 = 3.602,060$$
$$\frac{1}{2} \log 1.92 = 0.141,651$$

log C. — 3.743,711

P. FT.

$$\log C = 3.743,711$$
$$3 \log. A = 7.303,707$$

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FROM 1st JULY TO 31st DECEMBER 1861.			1862.			1863.		
Heights on K. Gauge, feet.	Number of days at respective heights.	Total days.	Number of days at respective heights.	Total days.	Number of days at respec- tive heights.	Total days.		
0								
1	...	...	(2) (35)	35	17	17		
1 1/2	7	7	(12) (14) (5) (12)	43	28 9 6 3 5	51		
2	14 4	18	(13) (12) (3) (4) (1) (1) (4)	38	26 4 8 2 3 3 1 12 (8) 2 not plotted.	67		
2 1/2	6 3 2	11	(10) (11) (1) (8) (3) (3) (2) (5)	33	9 3 2 1 7 6 2 5 3 10 3	51		
3	2 2 7 2	13	(7) (4) (2) (1) (13) ...	27	5 2 2 2 2 2 ...	13		
3 1/2	2 6 2 2 4 1	15	(5) (2) (2) (4) (6) (23)	42	3 1 4 ...	8		
4	4 5 3	12	(3) (8) ...	11	12 ...	12		
4 1/2	4 5	9	(4) (3) (3)	10	2 2 6 10	20		
5	3 6 4 2	15	(5) (3) ...	8	2 8 5 1	16		
5 1/2	1 3	4	(2) (1) (3) (2) (4) (2)	14	3 2 5 6 2	18		
6	2 2 2 3	9	(3) (1) (2) (4) (1) (3)	14	1 4 3 ...	8		
7	3 3 2 3	11	(2) (3) (1) (2) (3) (1) (1) (1) (3) (4)	21	2 1 2 4 1 2	12		
8	1 4 1 1 1 1 2 2	14	(1) (5) (3) (4) (2) (1) (1) (2) (2) (1) (1) (2) (1)	26	2 2 4 5 2 4	19		
9	1 2 1 1 2 1 3 2 4	16	(1) (3) (2) (4) (1) (1) (1) (1) (1) (1)	16	7 1 3 2 1 1 3	17		
10	2 5 1 1 1 1	14	(1) (1) (2) (1) (1) ...	6	1 1 2 1 1 4 1	11		
11	2 2 5	9	(2) (5) (2) (3) (2)	14	2 3 1 ...	6		
12	4 3	7	(3) (2) (2)	7	2 1 3 2 1 1 1	11		
13					3 2	5		
14					3	3		
15								
16								
17								
18								
Total days...		184	Total days...		365	Total days...	365	

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1864.			1865.		
Heights on K Gauge, feet.	Number of days at respective heights.	Total days.	Number of days at respective heights.	Total days.	
0	10 32	42	24 (?)	24	
$\frac{1}{2}$	6 1 28 26	73	70	70	
1	5 1 7	13	8	8	
$1\frac{1}{2}$	4 3 7	14	13 6 3 (31) not plotted (?) December	53	
2	2 19	21	1 5 3	9	
$2\frac{1}{2}$	1 29	30	1 1 4 2 42	50	
3	2 2 22	26	2 1 1 8	12	
$3\frac{1}{2}$	7 1	8	4 2 3 6	15	
4	2 1 (3) 6	12	2 5	7	
$4\frac{1}{2}$	4 3 2 12 6	27	1 4 2 5 1 4 2	19	
5	2 5 4 2 3	16	3 3 2	8	
$5\frac{1}{2}$	1 8	9	1 6 1 3 4 3 2 3 4	27	
6	4 1 1 1 1 2 3 5 3 3	24	2 2 6 4 1 2	18	
7	2 2 2 3 2 6 3 1 3	24	1 5 1 2 2 1	12	
8	2 6 2 3 2	15	1 2 2 3	8	
9	1 2	3	1 1 1 1	3	
10	1	1	2 1 1 1	5	
11	1	1	1 1 4 2 2	10	
12	1	1	1 1	2	
13	2	2	1 2 2	5	
14	1	1	...	...	
15	...	...	...	...	
16	3	3	...	...	
Total days...		366	Total days...		365

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1866.													1867.															
Heights on K. Gauge, feet.	Number of days at respective heights.												Total days.	Number of days at respective heights.												Total days.		
0	15	9	:	:	:	:	:	:	:	:	:	:	24															
$\frac{1}{2}$	29	:	:	:	:	:	:	:	:	:	:	:	29															
1	41	78	:	:	:	:	:	:	:	:	:	:	119	6	:	:	:	:	:	:	:	:	:	:	6			
$1\frac{1}{2}$	18	:	:	:	:	:	:	:	:	:	:	:	18	4	17	31	22	11	1	17	:	:	:	:	103			
2	:	:	:	:	:	:	:	:	:	:	:	:	...	6	3	2	14	7	:	:	:	:	:	:	32			
$2\frac{1}{2}$	5	:	:	:	:	:	:	:	:	:	:	:	5	30	1	14	:	:	:	:	:	:	:	:	45			
3	8	21	9	:	:	:	:	:	:	:	:	:	33	1	6	1	4	8	:	:	:	:	:	:	20			
$3\frac{1}{2}$	4	2	4	:	:	:	:	:	:	:	:	:	10	3	1	7	:	:	:	:	:	:	:	:	11			
4	5	1	5	:	:	:	:	:	:	:	:	:	11	1	1	2	1	:	:	:	:	:	:	:	5			
$4\frac{1}{2}$	4	3	1	:	:	:	:	:	:	:	:	:	8	1	3	1	3	1	5	1	:	:	:	:	15			
5	2	1	3	1	5	1	:	:	:	:	:	:	13	1	6	9	7	1	1	1	3	4	:	:	33			
$5\frac{1}{2}$	7	3	2	1	1	:	:	:	:	:	:	:	14	13	2	2	1	1	2	:	:	:	:	:	9 $\frac{1}{2}$			
6	2	4	4	2	2	:	:	:	:	:	:	:	14	1	1	2	1	3	1	7	3	3	1	2	1	1	1	28
7	4	3	3	2	2	1	:	:	:	:	:	:	15	1	3	3	16	2	3	1	1	1	1	:	:	32		
8	1	1	2	1	2	4	1	:	:	:	:	:	12	1	3	1	2	1	1	1	:	:	:	:	10			
9	3	1	1	1	2	1	:	:	:	:	:	:	9	2	1	1	:	:	:	:	:	:	:	:	4			
10	3	2	1	:	:	:	:	:	:	:	:	:	6	1	1	1	1	:	:	:	:	:	:	:	4			
11	1	1	3	:	:	:	:	:	:	:	:	:	5	1	1	1	1	:	:	:	:	:	:	:	4			
12	1	:	:	:	:	:	:	:	:	:	:	:	1	1	1	1	:	:	:	:	:	:	:	:	3			
13	2	2	6	:	:	:	:	:	:	:	:	:	10	1	:	:	:	:	:	:	:	:	:	:	1			
14	2	:	:	:	:	:	:	:	:	:	:	:	2	:	:	:	:	:	:	:	:	:	:	:				
15	:	:	:	:	:	:	:	:	:	:	:	:		:	:	:	:	:	:	:	:	:	:	:				
16	2	:	:	:	:	:	:	:	:	:	:	:	2	:	:	:	:	:	:	:	:	:	:	:				
Total days...													365	Total days...													365	

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1868.			1869.		
Heights on K. Gauge, feet.	Number of days at respective heights.	Total days.	Number of days at respective heights.	Total days.	
0	54	81			
1	29 4 15 12	36	2	2	
1 1/2	5 3 2 1	11	15 45	60	
2	2 8 19 23	52	59 21	80	
2 1/2	16	16	31 2 2 10	45	
3	3	3	4 9	13	
3 1/2	13	13	2 2 3 1 4 3	15	
4	3	3	3 8 2 9	22	
4 1/2	2 1	3	2 1 2 2 5	12	
5	1 2 1 2 5 2 10	23	1 2 6 5	14	
5 1/2	2 4 4 1 3 3 1 3 1 4	26	2 3 3 1 1 3 7 4	27	
6	4 2 2 2 2 4	16	2 3 1 3 1	15	
6 1/2	7 1 2 3 1 1 5 3 3 2 1 1 2 1	34	2 2 1 7 2 3	17	
7	3 1 2 4 1 1 1 1 1	15	1 1 5 2 2 1 2 3	19	
8	2 1 1 4 1 1 1 1	11	2 3 1 3 2	11	
9	1 1 3 1	6	2	2	
10	1 1 2 1	5	1	1	
11	1 2 1	4	7 (3)	10	
12	1 1 4	6			
13	1	1			
14					
15					
16	1	1			
17					
18					
Total days...		366	Total days...		365

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Discharge of River Toombuddra at Kurnool Gauge during 1861 and 1862.

1861, FOR 184 DAYS.				1862, FOR 365 DAYS.			
Heights on K. Gauge in feet.	No. of days at respective heights.	Discharge for one day at respective heights.	Total discharge in cubic yards.	Heights on K. Gauge in feet.	No. of days at respective heights.	Discharge for one day at respective heights.	Total discharge in cubic yards.
1 1/2	...	.....	.....	1 1/2	35	2,857,000	99,995,000
1 1/4	7	4,742,000	33,191,000	1 1/2	43	3,786,000	162,798,000
2	18	5,305,000	95,490,000	2	33	4,742,000	180,196,000
2 1/4	11	6,514,000	71,654,000	2 1/4	27	5,305,000	175,065,000
3	13	17,411,000	228,343,000	3	42	6,514,000	175,878,000
3 1/4	15	24,980,000	374,700,000	3 1/4	11	17,411,000	731,262,000
4	12	36,345,000	436,140,000	4	10	24,980,000	274,780,000
4 1/4	9	49,200,000	442,800,000	4 1/4	8	26,345,000	363,450,000
5	15	66,180,000	992,700,000	5	14	49,200,000	398,600,000
5 1/4	4	81,245,000	324,980,000	5 1/4	14	66,180,000	926,520,000
6	9	96,310,000	866,790,000	6	21	81,245,000	1,137,430,000
7	11	135,245,000	1,487,695,000	7	26	96,310,000	2,022,510,000
8	14	171,880,000	2,406,320,000	8	16	135,245,000	3,316,370,000
9	16	223,045,000	3,568,720,000	9	6	171,880,000	2,750,080,000
10	14	279,210,000	3,908,940,000	10	6	223,045,000	1,338,270,000
11	9	341,240,000	3,071,160,000	11	7	279,210,000	3,908,940,000
12	7	408,315,000	2,858,205,000	12	...	341,240,000	2,388,680,000
			21,165,831,000			408,315,000	.....
							20,345,824,000

Discharge of River Toombuddra at Kurnool Gauge in 1863 and 1864.

1863.				1864.	
Height on K. Gauge in feet.	Number of days at respective heights.	Discharge for one day at respective heights.	Total discharge in cubic yards.	Number of days at respective heights.	Total discharge in cubic yards.
0	...	2,030,000	.....	42	85,260,000
1 1/2	17	2,857,000	48,569,000	73	208,561,000
1 1/4	51	3,786,000	193,086,000	13	49,218,000
2	67	4,742,000	49,218,000	14	66,388,000
2 1/4	51	5,305,000	270,555,000	21	111,405,000
3	13	6,514,000	84,682,000	30	195,420,000
3 1/4	8	17,411,000	139,288,000	26	452,686,000
4	12	24,980,000	299,760,000	8	199,840,000
4 1/4	20	36,345,000	726,900,000	12	433,140,000
5	16	49,200,000	787,200,000	27	2,543,400,000
5 1/4	18	66,180,000	1,191,240,000	16	1,058,880,000
6	8	81,245,000	649,960,000	9	731,205,000
7	12	96,310,000	1,155,720,000	24	2,311,440,000
8	19	135,245,000	2,569,655,000	24	3,245,880,000
9	17	171,880,000	2,921,960,000	15	2,578,200,000
10	11	223,045,000	2,453,495,000	3	669,135,000
11	6	279,210,000	1,675,260,000	1	279,210,000
12	11	341,240,000	3,753,640,000	1	341,240,000
13	5	408,315,000	2,041,575,000	1	408,315,000
14	...	489,600,000	.....	2	979,200,000
15	3	551,700,000	1,664,100,000	1	554,700,000
16	...	633,400,000	.....	...	.....
17	...	713,500,000		3	2,140,500,000
18	...	805,350,000		...	
	...	890,200,000		...	
	365		22,675,863,000	366	19,646,223,000

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Discharge of River Toombuddra at Kurnool Gauge during 1865, 1866, and 1867.

1865.				1866.		1867.	
Heights on K. Gauge in feet.	No. of days at respective heights.	Discharge for one day at respective heights.	Total discharge in cubic yards.	No. of days at respective heights.	Total discharge in cubic yards.	No. of days at respective heights.	Total discharge in cubic yards.
...	24	2,030,000	48,720,000	24	48,720,000	...	.....
1	70	2,857,000	.....	29	.....	...	.....
1½	8	3,786,000	265,020,000	119	450,534,000	6	22,716,000
2	53	4,742,000	37,936,000	18	85,356,000	103	488,426,000
2½	9	5,305,000	281,165,000	...	.....	32	169,760,000
3	50	6,514,000	58,626,000	5	32,570,000	45	293,130,000
3½	12	17,411,000	870,550,000	38	661,618,000	20	348,220,000
4	15	24,980,000	299,760,000	10	249,800,000	11	274,780,000
4½	7	36,345,000	545,175,000	11	399,795,000	5	181,725,000
5	19	49,200,000	344,400,000	8	393,000,000	15	738,000,000
5½	8	66,180,000	1,259,420,000	13	860,340,000	33	2,183,940,000
6	27	81,245,000	649,960,000	14	1,137,430,000	9	731,205,000
7	18	96,310,000	3,600,370,000	14	1,348,340,000	28	2,696,680,000
8	12	135,245,000	2,434,410,000	15	2,028,675,000	32	4,287,840,000
9	8	171,880,000	2,062,560,000	12	2,062,560,000	10	1,718,800,000
10	3	223,045,000	1,784,360,000	9	2,067,405,000	4	892,180,000
11	5	279,210,000	837,630,000	6	1,675,260,000	4	1,116,840,000
12	10	341,240,000	1,706,200,000	5	1,706,200,000	4	1,364,960,000
13	2	408,315,000	4,083,150,000	1	408,315,000	3	1,224,945,000
14	5	489,600,000	979,200,000	10	4,890,600,000	1	489,600,000
15	...	554,700,000	2,773,500,000	2	1,109,400,000	...	.....
16	...	633,400,000	.....	...	.....	...	.....
17	...	713,500,000		2	1,427,000,000	...	
18	...	805,350,000		...		...	
...	...	890,200,000		...		...	
...	...		24,920,112,000	...	22,983,518,000	...	19,223,747,000

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Discharge of River Toombuddra at Kurnool Gauge during 1868-69.

1868.				1869.	
Height on K. Gauge in feet.	No. of days at respective heights.	Discharge for one day at respective heights.	Total discharge in cubic yards.	Height on K. Gauge in feet.	Total discharge in cubic yards.
...	81	2,030,000	164,430,000	...	.....
1	36	2,857,000	102,852,000	2	5,714,000
1½	11	3,786,000	41,646,000	60	227,160,000
2	52	4,742,000	246,584,000	80	379,360,000
2½	16	5,305,000	84,880,000	45	238,725,000
3	3	6,514,000	19,542,000	13	84,682,000
3½	13	17,411,000	223,343,000	15	261,165,000
4	3	24,980,000	74,940,000	22	549,560,000
4½	3	36,345,000	109,035,000	12	436,140,000
5	23	49,200,000	1,131,600,000	14	688,800,000
5½	26	66,180,000	1,720,680,000	27	1,786,860,000
6	16	81,245,000	1,299,920,000	15	1,218,675,000
7	34	96,310,000	3,274,540,000	17	1,637,270,000
8	15	135,245,000	2,028,675,000	19	2,569,655,000
9	11	171,880,000	1,890,680,000	11	1,890,680,000
10	6	223,045,000	1,338,270,000	2	446,090,000
11	4	279,210,000	1,396,050,000	1	279,210,000
12	6	341,240,000	1,364,960,000	10	3,412,400,000
13	1	408,315,000	2,449,890,000	...	.....
14	...	489,600,000	489,600,000	...	.....
15	...	554,700,000	.....	...	.....
16	...	633,400,000	.....	...	.....
17	1	713,500,000	713,500,000	...	.....
18	...	805,350,000	.....	...	.....
...	...	890,200,000	.....	...	.....
...	.....	.....	20,168,617,000	...	16,112,146,000

ABSTRACT.

Years.	Cubic yards.	Deduct $\frac{1}{4}$ (1— $\frac{1}{4}$)
1861.....	.....	
1862.....	20,345,824,000	
1863.....	22,675,863,000	
1864.....	19,646,223,000	
1865.....	24,920,112,000	
1866.....	22,983,518,000	
1867.....	19,223,747,000 ×	
1868.....	20,168,617,000	
1869.....	16,112,146,000 ×	

8 166,076,050,000

20,759,503,000 mean of eight years' discharge in cubic yards.

Taking whole numbers.

Million Cubic yards.	Deduct $\frac{1}{8}$ (1— $\frac{7}{8}$) Million Cubic yards.	As fall taken too large (1.92) to agree with discharge as calcu- lated from Soonka- sala Gauge should be reduced to 1.23 feet per mile.
1862.....20,346	16,440	
1863.....22,676	18,322	
1864.....19,616	15,873	
1865.....24,920	20,135	
1866.....22,984	18,570	
1867.....19,224	15,532	
1868.....20,169	16,296	
1869.....16,112	13,018	

8	134,186
---	---------

20,759

Mean of eight years = 16,773 million cubic yards.

Heights on under-sluiice sill.	Number of $\frac{1}{2}$ sluiice days.	Discharge at respective heights on under-sluiice sill.	Discharge cubic yards.	
5 $\frac{1}{2}$	96	838,200	80,467,200	
6	139	655,100	91,008,900	
6 $\frac{1}{2}$	238	1,077,000	256,326,000	
7	93	1,277,000	118,761,000	
7 $\frac{1}{2}$				
8	38	1,447,500	55,005,000	
8 $\frac{1}{2}$		1,526,000		
9	92	1,600,000	147,200,000	
10	38	1,740,000	66,120,000	
11	38	1,869,000	71,022,000	
12	268	1,989,500	533,186,000	
13	644	2,100,600	1,352,786,400	
14	406	2,210,900	897,623,400	
15	55	2,311,200	127,116,000	
16	7	2,412,500	16,887,500	
17	3	2,505,300	7,515,900	
18		2,595,200		
		2	3,821,077,300	Canal discharge say—2,000,000 a day for 180 days = 360 millions.
			1,910,538,000	
Height on K. Gauge.	No. of days.			Total, 1867.
11 $\frac{1}{2}$	26	4,742,000	123,292,000	Fall over crest... 12,500 millions.
2	22	5,305,000	116,710,000	Under-sluiice ... 2,150 "
				Canal, say ... 350 "
				15,000 "
		Grand Total...	2,150,540,000	Do. K. calculation... 19,223,747
			12,000,000,000	Deduct 10 per cent. 1,922
			14,150,540,000	17,301,000

Under-Sluices, 1867.

[illegible]

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Anicut over fall for 1869 over new Crest.

Log of velocity corresponding to $2\frac{1}{2}$ " head = log 19,196 =	6,227,393 1,283,210 5,364,489
--	-------------------------------------

1,283,210
5,364,489

$$6,647,699 = 4,443.2$$

Do.	account velocity of approach	...	...	...	= 12,600 thousand mill.
Do.	do. due to velocity of approach	...	...	=	355 " "

12,955

Canal, say	...	...	...	350
------------	-----	-----	-----	-----

Grand Total...	=	15,350
At K....	... =	17,301

[illegible]

Add 2·8 per cent. for velocity of approach=	281,000
Do. joining through under-sluites	= 2,500,000

	12,819,374
Canal...	350

13,169,374

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For 0 feet. Log C' = 3,743,711 Log A = 2,434,569 ‡ Log A = 1,217,284 ‡ Log B = 7,395,564 ‡ Log B = 1,088,046 No. = 2,030,000	For 3½ feet. Log C' = 2,432,086 Log A = 3,098,300 ‡ Log A = 1,519,150 7,079,536 No. = 12,010,000	For 9 feet. Log C' = 2,432,086 Log A = 3,551,938 1,775,968 7,759,992 No. = 57,515,000	For 16 feet. Log C' = 2,432,086 Log A = 3,813,181 1,906,590 8,151,757 No. = 141,800,000	For 5 feet. Log C' = 3,743,711 Log A = 3,672,744 1,836,372 ‡ Log B2 = 9,252,827 ‡ Log B2 = 1,608,742 No. = 440,65,000	For 12 feet. Log C' = 3,743,711 Log A2 = 4,299,551 2,149,775 ‡ Log B2 = 10,193,037 ‡ Log B2 = 1,691,008 No. = 317,700,000
For ½ foot. Log C' = 3,743,711 Log A = 2,542,825 ‡ Log A = 1,271,412 ‡ Log B = 7,557,948 ‡ Log B = 1,102,060 6,455,888 No. = 2,857,000	For 4 feet. Log C' = 2,432,086 Log A = 3,165,541 1,582,770 7,180,397 No. = 15,150,000	For 10 feet. Log C' = 2,432,086 Log A = 3,600,319 1,800,159 7,832,564 No. = 68,010,000	For 17 feet. Log C' = 2,432,086 Log A = 3,848,357 1,924,178 8,204,621 No. = 160,200,000	For 6 feet. Log C' = 3,743,711 Log A2 = 3,810,367 1,905,183 ‡ Log B2 = 9,459,261 ‡ Log B2 = 1,637,079 No. = 66,400,000	For 13 feet. Log C' = 3,743,711 Log A2 = 4,349,142 2,174,571 ‡ Log B2 = 10,267,424 ‡ Log B2 = 1,691,188 No. = 376,900,000
For 1 foot. Log C' = 3,743,711 Log A = 2,636,488 ‡ Log A = 1,318,244 ‡ Log B = 7,698,443 ‡ Log B = 1,120,275 6,578,168 No. = 3,786,000	For 4½ feet. Log C' = 2,432,086 Log A = 3,223,756 1,611,878 7,267,720 No. = 18,525,000	For 11 feet. Log C' = 2,432,086 Log A = 3,643,847 1,821,923 7,897,856 No. = 79,040,000	For 18 feet. Log C' = 2,432,086 Log A = 3,865,933 1,932,966 8,230,985 No. = 170,200,000	For 7 feet. Log C' = 3,743,711 Log A2 = 3,922,310 1,961,155 ‡ Log B2 = 9,627,176 ‡ Log B2 = 1,641,650 No. = 96,795,000	For 14 feet. Log C' = 3,743,711 Log A2 = 4,393,681 2,196,840 ‡ Log B2 = 10,334,232 ‡ Log B2 = 1,691,368 No. = 439,400,000

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21st January 1871.*

For 1½ feet. Log C' = 3,743,711 Log A = 2,721,811 ‡ Log A = 1,360,905 ‡ Log B = 7,826,427 ‡ Log B = 1,150,515 6,675,912 No. = 4,742,000	For 5 feet. Log C' = 2,432,086 Log A = 3,275,081 1,637,540 7,344,707 No. = 22,115,000	For 12 feet. Log C' = 2,432,086 Log A = 3,683,407 1,841,703 7,957,196 No. = 906,615,000	For 3 feet. Log C' = 3,743,711 Log A2 = 3,137,987 1,568,993 8,450,691 1,532,229 6,918,462 No. = 8,288,000	For 8 feet. Log C' = 3,743,711 Log A2 = 4,019,615 2,009,807 9,773,133 1,678,967 8,094,166 No. = 124,200,000	For 15 feet. Log C' = 3,743,711 Log A2 = 4,434,106 2,217,053 ‡ Log B2 = 10,394,870 ‡ Log B2 = 1,691,548 No. = 505,050,000
For 2 feet. Log C' = 3,743,711 Log A = 2,814,913 ‡ Log A = 1,407,456 ‡ Log B = 7,966,080 ‡ Log B = 1,241,437 6,724,643 No. = 5,305,000	For 6 feet. Log C' = 2,432,086 Log A = 3,362,483 1,681,241 7,475,810 No. = 29,910,000	For 13 feet. Log C' = 2,432,086 Log A = 3,719,663 1,859,831 8,011,580 No. = 112,700,000	For 3½ feet. Log C' = 3,743,711 Log A2 = 3,314,710 1,657,355 8,715,776 1,602,873 7,112,903 No. = 12,970,000	For 9 feet. Log C' = 3,743,711 Log A2 = 4,106,157 2,053,078 9,902,946 1,684,143 8,218,803 No. = 165,500,000	For 16 feet. Log C' = 3,743,711 Log A2 = 4,470,116 2,235,058 ‡ Log B2 = 10,448,885 ‡ Log B2 = 1,691,728 No. = 571,700,000
For 2½ feet. Log C' = 3,743,711 Log A = 2,921,166 ‡ Log A = 1,460,583 ‡ Log B = 8,125,460 ‡ Log B = 1,311,625 6,813,835 No. = 6,514,000	For 7 feet. Log C' = 2,432,086 Log A = 3,435,207 ‡ Log A = 1,717,603 7,584,893 No. = 38,450,000	For 14 feet. Log C' = 2,432,086 Log A = 3,753,123 1,876,561 8,061,770 No. = 115,800,000	For 4 feet. Log C' = 3,743,711 Log A2 = 3,458,184 1,729,092 8,930,987 1,604,758 7,326,229 No. = 21,195,000	For 10 feet. Log C' = 3,743,711 Log A2 = 4,179,810 2,089,905 10,013,426 1,688,744 8,324,682 No. = 211,200,000	For 17 feet. Log C' = 3,743,711 Log A2 = 4,505,245 2,252,622 ‡ Log B2 = 10,501,578 ‡ Log B2 = 1,691,907 No. = 645,150,000
For 3 feet. Log C' = 2,432,086 Log A = 3,018,701 ‡ Log A = 1,509,350 6,960,137 No. = 9,123,000	For 8 feet. Log C' = 2,432,086 Log A = 3,497,483 ‡ Log A = 1,748,741 7,678,310 No. = 47,680,000	For 15 feet. Log C' = 2,432,086 Log A = 3,784,189 1,892,094 8,108,369 No. = 128,350,000	For 4½ feet. Log C' = 3,743,711 Log A2 = 3,566,555 1,783,277 9,093,543 1,606,759 7,486,784 No. = 30,675,000	For 11 feet. Log C' = 3,743,711 Log A2 = 4,243,633 2,121,816 10,109,160 1,690,557 8,418,603 No. = 262,200,000	For 18 feet. Log C' = 3,743,711 Log A2 = 4,537,013 2,268,506 ‡ Log B2 = 10,549,230 ‡ Log B2 = 1,691,907 No. = 857,323 No. = 720,000,000

*Proceedings of the Madras Government, Public Works Department,
21st January 1871.*

B.

Total Discharges at Soonkasala over Anicut and through one Under-sluiice at various heads.

Million.	Discharge over anicut crest in cubic yard per day.	Height upon Crest d.	—	Log of constant + log of No. corresponding to d, as found in Stoddard's Table II. d. c. being = 0.667.	—
	6,195,3	3"	1,427,567 5,364,489 6,792,056		
	17,522,0	6"		7,243,573	1,879,084 5,364,489
	32,190,0	9"	2,143,234 5,364,489 7,507,723		
	49,559,0	12"		7,695,126	2,330,637 5,364,489
	91,045,0	18"		7,959,257	2,594,768 5,364,489
	140,1700	24"		8,146,668	2,782,179 5,364,489
	195,90	30"		8,292,028	2,927,539 5,364,489
	257,51	36"		8,410,789	3,046,300 5,364,489
	324,49	42"		8,511,206	3,146,717 5,364,489
	396,46	48"		8,598,196	3,233,707 5,364,489
	473,09	54"		8,674,948	3,310,495 5,364,489
	552,81	60"		8,742,577	3,378,088 5,364,489
	639,24	66"		8,805,665	3,441,176 5,364,489
	728,35	72"		8,862,344	3,497,855 5,364,489
	786,43	98"	66"	8,895,661	3,531,172 5,364,489

MEMORANDUM.

HEREWITH, by desire of the Assistant, the Chief Engineer forwards copy of Mr. Crawford's report on Toombuddra Gauge for Consulting Engineer.

CENTRAL OFFICE,
8th October 1870.

To the Chief Engineer.

(Signed) J. W. PEPPIN,

MEMORANDUM.

HEREWITH the detail of Mr. Crawford's report upon the Toombuddra.

CENTRAL OFFICE,
10th October 1870.

To Colonel J. Carpendale, R. E.

(Signed) E. D. MACKENZIE,
Assistant to Chief Engineer.

*Proceedings of the Madras Government Public Works Department,
21st January 1871.*

C.-1.

Total Discharge of Soonkasala over Anicut and through one Under-sluiice at various heads.

Head-sluiice gauge.	Head on old crest.	Head on under-sluiices.	Log of inches per second.	Log constant + log of No. corresponding to b as found in Stoddard's Table IV. C = 0.584.	Million.	Discharge through one under-sluiice in cubic yards per day.	—
93	0	8' 9"	2,220,049 4,083,980	6,304,029		20,138	
	6"	9' 3"	2,232,123 4,084,980	6,316,103		2,070,600	2,100,600
	1'	9' 9"	2,244,549 4,084,980	6,328,529		2,130,700	
	1½	10' 3"	2,255,417 4,084,980	6,339,397		2,184,4	2,210,960
	2	10' 6"	2,265,761 4,084,980	6,349,741		2,237,4	
	2½	11' 3"	2,275,634 4,084,980	6,359,614		2,288,8	2,311,200
	3	11' 6"	2,284,062 4,084,980	6,368,042		2,333,7	
	3½	12' 3"	2,294,113 4,084,980	6,378,093		2,388,4	2,412,500
	4	12' 6"	2,302,807 4,084,980	6,386,787		2,436,6	
	4½	13' 3"	2,311,160 4,084,980	6,395,140		2,480,4	2,505,300
	5	13' 6"	2,319,189 4,084,980	6,403,169		2,530,2	
	5½	14' 3"	2,326,930 4,084,980	6,410,910		2,575,8	2,595,200
	6	14' 6"	2,333,434 4,054,980	6,417,414		2,614,6	
	6½	15' 3"	2,341,672 4,084,980	6,425,652		2,664,8	

*Proceedings of the Madras Government, Public Works Department,
21st January 1871.*

C.-2.

Discharge through one Vent of Under-slucices when water is below crest of Anicut.

Height on head-slucice sill.	Head on under-slucice vents.	Log constant + log velocity as taken from Table IV. under cubic feet 0.584.	Log of discharge.	Discharge in cubic yards per day.
9'	8½	2,214,764 4,083,980	6,298,744	1,989,500
8½	8	2,201,588 4,083,980	6,285,568	1,930,000
8	7½	2,187,577 4,083,980	6,271,557	1,869,000
7½	7	2,172,603 4,083,980	6,256,583	1,805,500
7	6½	2,156,519 4,083,980	6,240,499	1,740,000
6½	6	2,139,123 4,083,980	6,223,103	1,671,000
5½	5	2,099,542 4,083,980	6,183,522	1,526,000
5	4½	2,076,640 4,083,980	6,160,620	1,447,500
4½	4	2,051,075 4,083,980	6,135,055	1,365,000
4	3½	2,022,098 4,083,980	6,106,078	1,277,000
	Depth on under-slucice sill.			
3½	6½		6,032,223	1,077,000
3	6	3,440,137 2,539,912	5,980,049	655,100
2½	5½	3,383,456 2,539,912	5,923,368	838,200

*Proceedings of the Madras Government, Public Works Department,
21st January 1871.*

No. 367.

ORDER THEREON, 21st January 1871, No. 178.

IRRIGATION, No. 19.

ORDERED that the following letter
be sent:—

(Here enter No. 179, dated 21st January 1871.)

(True Extract.)

(Signed) CHARLES A. ORR, Colonel, R. E.,

Secretary to Government.

Exd. A. S. Rodgers.

Govt. of {1871} Madras

PUBLIC WORKS.

To

Dated January 21st.

Recd.

Encl.

G. O., 21st January 1871, No. 178.

JANUARY
Nos. 366-367

Canal.—Passing orders on the letter from the Consulting Engineer for the Madras Irrigation and Canal Company furnishing the information called for regarding the discharge of water into the Company's canal from the Toombuddra

14
PUBLIC WORKS DEPARTMENT,
FORT ST. GEORGE, 21st January 1871.

No. 368.

No. 179.

To

THE SECRETARY TO THE GOVERNMENT OF INDIA,

PUBLIC WORKS DEPARTMENT.

IRRIGATION, No. 20.

• No. 72, dated 24th June 1870.

SIR,—In paragraph 4 of their despatch to the Secretary of State* reviewing the report on the financial position and the state and prospects of the works of the Madras Irrigation and Canal Company, the Government of India, after remarking that the information afforded in the papers submitted by the Madras Government was, in some respects, deficient, expressed a desire to be furnished with diagrams of the rise and fall of the Toombuddra and with a statement of its discharge with reference to the sufficiency of the supply available for the Company's canal during the period for maturing a single rice crop. I am accordingly directed to forward the accompanying letter from the Consulting Engineer furnishing the required information, and giving cover to a complete series of diagrams exhibiting the rise and fall of the river above the anicut at Soonkasala from the year 1862 to 1869, and similar diagrams for the gauge at Kurnool between 1861 and June 1870.

2. The accompanying statements show four days in the year to be the general average for the nine years previous to 1869 during which the discharge of the Toombuddra, being under 3,000 feet per second, was insufficient to afford a full supply to the canal throughout the months of October and November, and that only on one occasion in 1868, for a period of eleven days, did the river fall so low as to give a discharge of no more than 1,500 cubic feet per second, the lowest quantity gauged at any other time between June and the 30th November being 2,300 cubic feet. It will thus be seen that, practically, the full supply of 3,000 cubic feet per second can be obtained without appreciable diminution until the end of November. There is, therefore, no doubt as to the sufficiency of water under ordinary circumstances for maturing one rice crop in the year.

3. As, however, the water of the Toombuddra cannot be made use of by the Company after the 31st December, no second crop cultivation will be practicable, nor will it be possible to maintain navigation after that date unless a dry weather supply be provided by the storage of a large reserve quantity of water in capacious reservoirs. The construction of such works has always been considered a most essential part of the Company's undertaking, and has, in fact, been its distinguishing feature; but, owing partly to the difficulty of finding sites at which suitable storage basins could be formed at a reasonably remunerative outlay and partly to its being found that the whole of the Company's capital was needed for the completion of their main canal as far as Cuddapah in accordance with their agreement, no works of the kind have been ever commenced. Good progress has, however, been made with the examination of three somewhat promising sites on the head waters of the Toombuddra, and, although the establishment of reservoirs upon them may

not be necessary, as far as is at present known, for the supply of the Company's canal for the six months during which first crop irrigation is in progress, the Madras Government have no doubt that without some means of supplementing the flow of that river the full advantages of the Company's works, as respects their usefulness either for the extension of irrigation or the opening up of a line of much-needed cheap inland navigation, can never be obtained.

I have the honour to be,

Sir,

Your most obedient servant,

Colonel, R.E.,

Secretary to Government.

Exd. A. S. Rodgers.

Consulting Engineer's Office
Irrigation and Canal Co.
Camp Kurnool 10th October 1870
15

From

Colonel J. Harpendale R.E.
Acting Consulting Engineer I.C.C.

To

Colonel C. A. O. R.E.
Secretary to Government P.W.D.

Sir,

Agreeably to order of Government No. 1062
4th July 1870 I have the honor to furnish the in-
formation regarding the Madras Irrigation and
Canal Company's Main Canal which is required
by the fifth paragraph of the despatch from the
Government of India to the Secretary of State.

The further information specially desired was
a complete series of diagrams showing the rise
and fall of the Tombuddra at the head of the
Canal on the up and down stream sides, and a
statement of the number of days in each month,
and the quantity of water at each period, during
which the supply of the river falls below 3000
Cubic feet per second, that it may be seen
whether there is any deficiency in the supply
in October and November before the rice crops
sown in June or July is matured, and in the
the aid of reservoirs is necessary to the

of 3000 Cubic feet per second being rendered available for the Canal during the period required for maturing a single Rice crop, or whether they are necessary only so far as a second crop is concerned. Enclose diagrams showing the rise and fall of the Tombuddra above the Anicut at Sankavala for the years 1862 to 1869 inclusive and similar diagrams for the gauge at Hurmoal from 1861 to June 1870. The rise and fall below the Anicut has not been gauged and no necessity for this information has arisen as the level of the water in the river below the Anicut has never been high enough to affect the calculations of the discharge over the Anicut.

I also forward an interesting report from Mr. Crawford Assistant Engineer in the Company's service on the discharge of the Tombuddra together with a letter from the Chief Engineer as noted in the margin. This report would chiefly be of use in connection with the question of reservoirs to supplement the monsoon supply of the Tombuddra but the tables attached to it are of value also on the present occasion as giving in a convenient form the discharge of the river throughout the year. From the year 1861 to 1869 the number of days during which the discharge fell below 3000 Cubic feet per second in the month of October and November were in

* Report of 1870
Letter from Chief Engineer
MS & Co. of 30th July
No. 232.

all 14, or an average of four days yearly.
Namely in 1863. 1 day. 30 November
1864. 14 days 17 to 30.
1865. 6 — 26 Oct. 8 to 30 Nov.
1867. 6 — 25 to 30 November.
1868. 11 — 20 to 30 —
1869. 2 — 29 to 30 —

The lowest was 1500 Cubic feet a second in 1868, and that was the only occasion on which the discharge fell below 2300 Cubic feet so that practically it may be said that there is no diminution in the supply of 3000 Cubic feet a second until the end of November. In the month of December the discharge has been recorded as low as 1000 Cubic feet, and the average is about 2000, after the 31 December the Company are debarred drawing any water from the Tombuddra as the Kistna District has a claim to all passing down the river in the dry season. It will thus be seen that there is no doubt as to the sufficiency of water available for one crop, but that, with the exception of the comparatively small quantities stored in tanks along the line which the Canal traverses none will be available for a second crop: also, that the Canal will usually be dry for the first six months of each year when there will be no navigation. These circumstances indeed the

my former report to which attention is drawn by the Government of India, that without reservoirs the Canal will never be efficient as a line of irrigation, and that its value for navigation will be comparatively small, for the conditions are very different to those attending a new or extra supply of water to a long established rice growing country, and the prospects of remuneration on the outlay that has been incurred on this line are by no means so good as they would be of a double return had water been provided for a second crop, for many instances will occur when one crop of rice will not be a sufficient inducement to grow that grain though two crops might be.

Moreover, the change from dry to wet cultivation requires a good deal more than the necessary provision of water. I have always felt that irrigation under this Canal must be of gradual growth with time, and that no considerable extent of land would be irrigated until seven or eight years after the completion of the work. The people must feel assured of the certainty of supply for one or two crops as the case may be and the effects of the recent calamitous floods must have considerably shaken the confidence of the people in the utility of the works.

Now, they will have to learn that it will be to their advantage to substitute rice for the crops they now grow, and they will require to see how much the profit will be - they will then have to tenace their land and otherwise adapt it for wet cultivation. They must also replace their farm bullocks by buffaloes capable of ploughing while up to their knees in water. Taking all this into consideration I have no expectation that the luxuriant crops of Cotton, Indigo, and various seeds, which are produced in the Hoondaw Valley will be replaced by rice - unless there was an entire failure of those crops for a series of years. But I have no doubt that the people would be glad in seasons when there is a deficient fall of rain for dry crops to supplement it by water from the Canal if it is made available at a fair price. Where the Ryots are familiar with the cultivation of Rice the Canal water will no doubt be eagerly sought, but such areas are comparatively small and it appears to me in the highest degree improbable that the Canal will ever pay five per cent on the Capital expended unless water for a second crop is provided by means of reservoirs.

I have the honor to be
Your most obedient servant

From.

The Young Ladies
for Maria D. C. C.

5 (H. E. 20 80 g 10 Oct 170)

To
The Cong. Engr for the M. & C. Co.
Agent and Manager of the M. & C. Co.

Desp. 25/1/71.

Ordered that the
following letter be sent.
H. E. R. 179 of 21st Jan'y/71.

17

The Secy. to the Govt.
of India, P. W. D.

In para 4 of their
despatch to the Secretary
of State, reviewing the report
on the financial position
and the state and prospects
of the works of the Madras
Irrigation and Canal
Company, the Govt. of India

* Recd 72 of 24 June 1940

Ad. Ad.

24th March 1870. A. J. Williams
 101 of Goodwin St. New
 York N.Y. 100
 28-1-287
 The same info as the
 101 of Goodwin St.
 The Secretary of the A. J. Williams

Paid in 3
 Dec. 27th
 1866. 3
 A. H. 10.

Cons: 1

Subm. by information
regarding the H. W. C. Co's
then (and required by H. C.
D. 1002-4 July 190

Ms. 178-179-21 Jan

Da. C. H. H. H. H. 1870 Da. 30th Dec
e. 9. 1870 1870 Da. 12th Dec

of no more than 1600 Cubic feet per second, the lowest quantity gauged at any other time between June and the 30 November being 2300 Cubic feet. It will thus be seen that, practically, the full supply of 3000 Cubic feet per second can be obtained without appreciable diminution until the end of November. There is therefore no doubt as to the sufficiency of water under ordinary circumstances for maturing one rice crop in the year.

It is however the water of the Sambudra cannot be made use of by the Company after the 31st of October, no

cultivation will be practicable nor will it be possible to maintain navigation after that date unless a dry weather supply be provided by the storage of a large reserve quantity of water in capacious Reservoirs. The construction of such works has always been considered a most essential part of the Company's undertaking and has in fact been its distinguishing feature but, owing partly to the difficulty of finding sites at which suitable storage basins could be formed at a reasonably remunerative outlay and partly to its being found that

the whole of the Company's
Capital was needed for the
completion of their main
canal as far as Cuddapah,
in accordance with their
agreement, no works of
the kind have been ever
commenced. Good progress
has however been made
with the examination
of three somewhat pro-
mising sites on the head
waters of the Sambudra
and although the esta-
blishment of Reservoirs
upon them may not be
necessary as far as at-
present known for the
supply of the Company's
canal for the six months
drying which first crop

the Madras Govt. have no
doubt that without some
means of supplementing
the flow of that river—
the full advantages
of the Company's works,
as respects their usefulness
either for the extension
of irrigation or the opening
up of a line of much
needed cheap inland
navigation can never be
obtained.

Recd 25/1/71 with 26
copies of Govt 178 of 1871

Four diagrams recd
26/1/71 in a tin canister -

W.B.

C/4294

Govt. of Madras.
1871

PUBLIC WORKS.

To the Secretary to the Govt.
Madras

Dated

Recd.

Encl.

G. 02/Jan/178-179.

Nos. 366-367 & 368

Final. Paper orders in the
letter from the Secy to the
Madras S. M. C. furnishing
the information called for re-
garding the discharge of water
into the Co's Canal from the
Lombard Dr.

(Letter)

Forwarding, with remarks,
a complete series of diagrams
exhibiting the use & fall of
the Lombard Dr. above the
aqueduct at Sookkasala from
1861 to 1869 & similar diagrams
for the same at Karnool
from 1861 and June 70.